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MEMORANDUM

To:	Tiffany Schmid, Director, Planning and Building Department
From:	Michael Henry, PhD, Senior Ecologist, Dudek
Subject:	El Dorado County General Plan Biological Resources Policy Update Project EIR - Relevance of Biological Reports to Master Response 2
Date:	October 7, 2020
cc:	Kathleen Ann Markham, Senior Deputy County Counsel, El Dorado County; William W. Abbott, Abbott & Kindermann, Inc.; Katherine Waugh, Dudek
Attachment(s):	1. Merenlender et al. 1998 2. Merenlender et al. 2009 3. Stralberg and Williams 2002 4. Tietje et al. 1997 5. Donnelly and Marzluff 2004 6. Lenth et al. 2006 7. Odell and Knight 2001 8. Hansen and Rotella 2002 9. Maestas et al. 2003 10. Hansen et al. 2005 11. Blair 1996 12. Santa Clara County 2012 13. Conservation Plan Maps from East Contra Costa Habitat Conservation Plan/Natural Community Conservation Plan (HCP/NCCP), Butte Regional Conservation Plan, Placer County Conservation Program, and South Sacramento HCP 14. Qualifications for Michael Henry, PhD, Senior Ecologist

This memorandum is provided in support of El Dorado County's response to the Writ of Mandate for the General Plan Biological Resources Policy Update Project EIR ("EIR"). I served as Senior Ecologist for Dudek in preparing the EIR (both draft and final), and I am familiar with the research, analysis, and conclusions of the EIR as they relate to the conservation strategy. A statement of my professional qualifications is included as Attachment A to this memorandum.

This memorandum describes how each of the 12 references cited in Master Response 2 (MR2), but not included in the administrative record, are relevant to the EIR analysis and support the conclusions presented in the EIR analysis and in MR2. The analysis in question in MR2 relates to the County's determination that focusing on preservation of oak woodlands habitat in the Highway 50 corridor was not the best course of action and that it was not feasible to focus on preserving the oak woodland within the Highway 50 corridor. Each of the 12 references (included as attachments) and their relevance to MR2 is discussed separately below. Many of these references focus on bird species diversity and abundance, which is representative of the ecological literature in general. Birds are typically selected as targets for ecological studies because of their ease of detection and identification, well-developed survey methods, high local diversity, and presence of both resident and migratory species. Trends that are detected in bird species diversity, abundance, and composition can often be applied to other groups such as insects and mammals. Some of the studies referenced in MR2 also examine responses of plants, insects, reptiles, and small mammals to human presence and development. Further, the regional conservation plans that are referenced or named in MR2 are multispecies plans, each including dozens of plant, invertebrate, reptile, amphibian, bird, and mammal species.

The EIR's conclusions regarding the location of conservation areas away from Highway 50 reflected the evidence that extensive urban and suburban development had already occurred within the Highway 50 corridor, and that the 2004 General Plan provided for much of the County's future growth within the Highway 50 corridor. As is supported by the attached reports, the existing and planned growth would create conflicts with first principles of conservation biology, as well as with the conservation objectives of the General Plan policies, due to loss of habitat, disruption of wildlife corridors, indirect effect of human presence and noise, collisions with vehicles on roadways, and spread of non-native plant species, along with increased presence of domestic predators and human-adapted predators/competitors attracted to the urban/suburban setting. As the supervising consultant at Dudek responsible for the analysis of biological impacts and the identification of mitigation measures in the EIR, it was my conclusion at the time of EIR certification that focusing on preservation of oak woodlands habitat in the Highway 50 corridor was not the best course of action and that it was not feasible to focus on preserving the oak woodland within the Highway 50 corridor. My conclusion is based upon my professional experience, the attached reports, the analysis contained in the EIR, staff reports and Dudek reports prepared in support of the EIR, and related County approvals.

1 Merenlender et al. 1998

Merenlender, A.M., K.L. Heise, and C. Brooks. 1998. "Effects of Subdividing Private Property on Biodiversity in California's North Coast Oak Woodlands." *Transactions of the Western Section of the Wildlife Society* 34:9–20.

Abstract

Much of California's biodiversity is found in oak (*Quercus* spp.) woodland vegetation. Residential development is expanding in northwestern California, resulting in a larger number of houses and roads in wooded areas. To examine the effects of this type of habitat fragmentation on biodiversity, 12 low-elevation oak woodland sites with gentle slopes were identified using remote sensing and a geographic information system. These sites were stratified across a gradient of differing lot sizes including large continuous parcels of relatively undisturbed hardwood rangeland in private parcels greater than 122 hectares; ranchettes on 4 to 16-hectare lots; and suburban areas with single-family homes on 0.20 to 1.0 hectare lots. Level of development was shown to have a significant effect on plant and bird species composition, and to be independent of stand structure and tree cover in the surrounding landscape.

Key Findings

- Page 2: Study conducted within an oak woodland study area in Sonoma County, examining species richness, composition, and abundance for birds and butterflies in three treatments (study area sizes and conditions): suburban (lot size 0.5 to 2.5 acres), ranchette (10- to 40-acre lots, generally configured into contiguous 40-acre sites), and undeveloped (greater than 300 acres). The suburban lot sizes in the study capture the majority of expected development within the Community Regions, but a smaller number of "ranchette" size developments would also occur in these areas.

- Page 5: Measures of overall bird species diversity was not significantly different in suburban or rural residential settings versus undeveloped areas, but species composition was significantly different. Observations of neotropical migrant birds was significantly higher at undeveloped sites than at the other two treatments. Winter resident bird species were observed more often at suburban and ranchette sites as opposed to undeveloped sites.
- Pages 5 and 6: Butterfly species richness was not significantly different in suburban or rural residential settings versus undeveloped areas, but observations of each species were significantly more frequent at the undeveloped areas as compared to the other two sites. The only observations of an uncommon butterfly were made at the undeveloped sites.
- Page 5: The percentage of exotic plant species was significantly higher at suburban and ranchette sites as compared to undeveloped sites.

Summary of How Research Provides Support for Conclusions Regarding the Most Appropriate Location of Conservation Lands

This study supports the contention that larger lots that are farther removed from human disturbance support greater abundance of some species (here butterflies) and more native species composition for birds and plant species. This supports the EIR's conclusions regarding on-site retention and preservation within the Highway 50 corridor as an appropriate mitigation measure, and the importance of minimizing habitat fragmentation and indirect effects of urban development.

2 Merenlender et al. 2009

Merenlender, A.M., S.E. Reed, and K.L Heise. 2009. "Exurban Development Influences Woodland Bird Composition." *Landscape and Urban Planning* 92:255–263.

Abstract

One of the fastest growing types of land-use change is exurban development—low-density housing outside urban service boundaries. However, how individual species are responding to exurban development remains uncertain. We monitored birds for 5 years across three housing density levels in northern California oak woodlands. We compared community and species responses to exurban development (4–16 ha parcels) with suburban and undeveloped natural areas. We found that individual species and groups of species exhibited variable responses to exurban development. Some species and guilds were impacted by exurban development to the same extent as suburban development while others were less sensitive to this type of land use. For example, the proportion of the bird community composed of tree-and-shrub feeders was similar between exurban and natural areas, whereas proportions of temperate migrants showed significant reductions at both suburban and exurban sites. Similarly, Northern Flicker, Hutton's Vireo, and Orange-crowned Warbler were equally rare in exurban and suburban sites, making large, undeveloped parcels essential for their conservation. By explicitly measuring ecological changes associated with parcel size and density this research provides valuable information to land-use planners on the consequences of zoning for biodiversity conservation.

Key Findings

- Pages 2 and 3: This follow-up study to the Merenlender 1998 study compared three different treatments similar to those in that older study, but over a 5-year period.
- Page 5: Consistent with the 1998 study, the proportion of detections of temperate migrant species was twice as high at undeveloped sites as compared to ranchette sites, and three times as high as at suburban sites. These species are often those that have seen the greatest declines on a regional basis as they are more likely to avoid humans and need larger intact habitat areas to breed successfully.
- Page 5: Shrub-nesting and ground-feeding species are a larger proportion of the bird community in suburban and ranchette sites, potentially due to higher proportion of shrub cover and food subsidies from human development.
- Page 5: Sensitive species that are known to avoid human interaction such as northern flicker, orange-crowned warbler, and Hutton's vireo were significantly more abundant in undeveloped sites. These species also occur in El Dorado County.

Summary of How Research Provides Support for Conclusions Regarding the Most Appropriate Location of Conservation Lands

The proportion of detections of temperature migrant bird species in undeveloped areas highlights the importance of protecting core woodlands from exurban development and minimizing habitat fragmentation. Human development appears to cause a shift in the bird community from temperate migrant to winter resident, and from ground-nesting aerial or tree-feeding species to shrub-nesting ground feeders. By preserving habitat further from human development, the likelihood of preserving a bird community more representative of historic pre-development conditions is increased.

3 Stralberg and Williams 2002

Stralberg, D., and B. Williams. 2002. "Effects of Residential Development and Landscape Composition on the Breeding Birds of Placer County's Foothill Oak Woodlands." In *Proceedings of the Fifth Symposium on Oak Woodlands: Oaks in California's Changing Landscape,* edited by R.B. Standiford, D. McCreary, and K.L. Purcell, 341–366. General Technical Report PSW-GTR-184. Albany, California: Pacific Southwest Research Station, U.S. Forest Service, U.S. Department of Agriculture. February 2002.

Abstract

This study examines the effect of rural residential development and landscape composition on breeding birds in Placer County's foothill oak woodlands. Point count survey data were used to construct generalized linear models for individual species' abundance or probability of occurrence, based on two sets of variables: GIS-derived landscape characteristics, including development density, oak woodland proportion, and habitat diversity; and field-collected local habitat parameters. We found that many species examined were sensitive to either development density or landscape composition at some distance between 250 and 4,000 m. Of the 48 breeding species common enough to analyze statistically, the occurrence of 24 species was significantly associated with landscape characteristics. Species shown to be associated with development density and/or urban edge proximity included the lark sparrow (-), Rufous crowned

sparrow (-), western meadowlark (-), black Phoebe (+), house finch (+) and western scrub-jay (+). Several other species were not development-sensitive but were positively associated with the proportion of oak woodland found in the surrounding landscape. For a subset of locations, some species also exhibited responses to local habitat variables, suggesting that further investigation of the importance of landscape vs. local factors is warranted. The diversity of responses observed across a range of species requires the recommendation of a multifaceted conservation strategy for oak woodland birds and their habitat.

Key Findings

- Pages 10 through 15: Lark sparrow and rufous-crowned sparrow abundances were negatively associated with development density, as was the occurrence of ash-throated flycatcher, western kingbird, tree swallow and western meadowlark. Conversely, the western scrub-jay, house finch, and other species were positively associated with development density. The species that were positively associated are either human-tolerant species or those that benefit from food subsidies of residential development.
- Page 16: Other species such as orange-crowned warbler, Hutton's vireo, Pacific-slope flycatcher, and spotted towhee are affected more by the amount, configuration, and diversity of oak woodland habitat in the surrounding landscape rather than by the number of built structures in the vicinity.
- Page 17: Overall, the bird species most affected by the proportion of oak woodland in the surrounding landscape were the short-distance and neotropical migrants.

Summary of How Research Provides Support for Conclusions Regarding the Most Appropriate Location of Conservation Lands

Provides additional support for effects of habitat fragmentation and preserve size on bird species composition. Additional development and more fragmented oak woodlands shifts bird species composition away from the historic short-distance and neotropical migrant species toward greater abundance of human-tolerant winter resident species. Preservation of habitats that benefit migrant species is of greater conservation concern due to their historic habitat loss and ongoing pressures on habitat availability and quality. This category also includes many special-status species.

4 Tietje et al. 1997

Tietje, W.D., J.K. Vreeland, N.R. Siepel, and J.L. Dockter. 1997. "Relative Abundance and Habitat Associations of Vertebrates in Oak Woodlands in Coastal-Central California." In *Proceedings of a Symposium on Oak Woodlands: Ecology, Management, and Urban Interface Issues*, edited by N.H. Pillsbury, J. Verner, and W.D. Tietje, 391–400. General Technical Report PSW-GTR-160. Albany, California: Pacific Southwest Research Station, U.S. Forest Service, U.S. Department of Agriculture. December 1997. http://www.fs.fed.us/psw/publications/documents/psw_gtr160/psw_gtr160_04d_tietje2.pdf.

Abstract

We estimated relative abundance and assessed habitat associations of small mammals, birds, amphibians, and reptiles in oak (*Quercus* spp.) woodlands from 1993 to 1995 at Camp Roberts in California's central coast. Within taxa, relative abundance was highest for dusky-footed woodrats (*Neotoma fuscipes*) (9.7 percent trap success), plain titmice (*Parus inornatus*) (49.4 territories per 40 ha), slender salamanders (*Batrachoseps* spp.) (2.2 percent detection rate) and skinks (*Eumeces* spp.) (3.1 percent detection rate). Percent cover of shrubs, grass, and downed wood were the three strongest correlated habitat components (mean of the absolute value of all correlation coefficients [|rs|] = 0.64, 0.62, and 0.59, respectively) for abundant species of small mammals. Percent shrub cover and litter weight were correlated with abundant birds, and herpetofauna, respectively (mean |rs| = 0.57 and 0.49, respectively). Within taxa, woodrats, dark-eyed juncos (*Junco hyemalis*), and slender salamanders exhibited the strongest habitat associations across all habitat components (mean |rs| = 0.74, 0.73, and 0.44, respectively). Dense oak woodlands with shrubby understory and downed woody material supported the greatest numbers of vertebrate fauna.

Key Findings

- Page 9: Dense oak woodlands with shrubby understory and downed woody material supported the greatest numbers of vertebrate fauna.

Summary of How Research Provides Support for Conclusions Regarding the Most Appropriate Location of Conservation Lands

This study did not examine effects of development on species richness or abundance. However, it does provide support for the contention that dense stands of oak woodland have increased abundance and diversity of a wide range of wildlife, including reptiles and small mammals, as compared to less dense oak woodland areas.

5 Donnelly and Marzluff 2004

Donnelly, R. and J.M. Marzluff 2004. "Importance of Reserve Size and Landscape Context to Urban Bird Conservation." *Conservation Biology* 18(3): 733–745.

Abstract

We tested whether reserve size, landscape surrounding the reserve, and their interaction affect forest songbirds in the metropolitan area of Seattle, Washington (U.S.A.), by studying 29 reserves of varying size (small, medium, large) and surrounding urbanization intensity (urban, suburban, exurban). Larger reserves contained richer and less even bird communities than smaller reserves. These size effects disappeared when we removed the positive correlation of shrub diversity with reserve size, suggesting that greater habitat diversity in large reserves supported additional species, some of which were rare. Standardizing the number of individuals detected among all reserve size classes reversed the effect of size on richness in exurban landscapes and reduced the magnitude of the effect in suburban or urban landscapes. The latter change suggested that richness increased with reserve size in most landscapes because larger areas also supported larger samples from the regional bird species pool. Most bird species associated with native forest habitat (native forest species) and with human activity (synanthropic species) were present in reserves larger than 42 ha and surrounded by >40% urban land cover, respectively. Thus, we recommend these thresholds as means for conserving the composition of native bird communities in this mostly forested region. Native forest species were least abundant and synanthropic species most abundant in urban landscapes, where exotic ground and shrub vegetation was most common. Therefore, control of exotic vegetation may benefit native songbird populations. Bird

nests in shrubs were most dense in medium (suburban) and large reserves (urban) and tended to be most successful in medium (suburban) and large reserves (exurban), potentially supplying another mechanism by which reserve size increased retention of native forest species.

Key Findings

- Page 7: Larger reserves had greater bird species richness and variability than did smaller reserves.
- Page 10: Most bird species were present when preserves were larger than 42 hectares; this appeared to be a threshold value beyond which increases in species richness was minimal.
- Pages 10 and 11: Large reserves embedded in more urban landscapes (>40% urban land cover) had high species richness, but the added species were synanthropic (human-adapted) ones that colonized from urban areas.
- Page 10: Reserves nearer urban areas had more exotic plant species, which correlated with a greater abundance of synanthropic bird species.
- Page 11: As reserves decreased in size, native forest species disappeared at predictable rates.

Summary of How Research Provides Support for Conclusions Regarding the Most Appropriate Location of Conservation Lands

The findings of this report are less applicable than others due to the study location in Seattle within coniferous forest rather than oak woodland. However, it does provide support for some of the first-order principles of reserve design mentioned in MR2, which is to maximize the size of preserves, minimize habitat fragmentation, and minimize adjacent urbanization in order to maximize native species richness.

6 Lenth et al. 2006

Lenth, B.A., R.L. Knight, and W.C. Gilgert. 2006. "Conservation Value of Clustered Housing Developments." *Conservation Biology* 20(5): 1445–1456.

Abstract

Traditionally, exurban lands in Colorado have been subdivided into a grid of parcels ranging from 2 to 16 ha. From an ecological perspective, this dispersed pattern of development effectively maximizes the individual influence of each home on the land. Clustered housing developments, designed to maximize open space, are assumed to benefit plant and wildlife communities of conservation interest. They have become a popular alternative for rural development despite the lack of empirical evidence demonstrating their conservation benefits. To better inform rural land-use planning, we evaluated clustered housing developments by comparing their spatial pattern with that of dispersed housing developments and by comparing their conservation value with that of both dispersed housing developments and undeveloped areas in Boulder County, Colorado. We used four indicators to assess conservation value: (1) densities of songbirds, (2) nest density and survival of ground-nesting birds, (3) presence of mammals, and (4) percent cover and proportion of native and non-native plant species. Clustered and dispersed housing developments did not differ on the majority of variables we examined. Both types of housing development had significantly higher densities of non-native and human-commensal species and significantly lower densities of native and human-sensitive species

than undeveloped areas. More rigorous ecological guidelines and planning on a regional scale may help create clustered developments with higher conservation value.

Key Findings

- Pages 6 through 8: Preserved areas that are intermixed with dispersed housing show similar patterns in species composition compared to more continuous preserve areas surrounding clustered developments.
- Pages 6 through 8: Compared to undeveloped areas, both clustered and dispersed development patterns led to significantly higher densities of non-native and synanthropic species and significantly lower densities of native and human-sensitive species

Summary of How Research Provides Support for Conclusions Regarding the Most Appropriate Location of Conservation Lands

Neither clustered development patterns nor dispersed development patterns correlated with a species composition of native human-sensitive species that have the greatest conservation need. Although this research was conducted in Colorado, the habitats have similar tree density to the oak woodland in El Dorado County. This supports preservation of habitat that is more remote from development, rather than on-site retention of small or moderate-sized preserves nearer the Highway 50 corridor where a greater density of non-native and synanthropic species is likely to occur.

7 Odell and Knight 2001

Odell, E.A. and R.L. Knight. 2001. "Songbird and Medium-Sized Mammal Communities Associated with Exurban Development in Pitkin County, Colorado." *Conservation Biology* 15(4): 1143–1150.

Abstract

Residential development is occurring at unprecedented rates in the Rocky Mountain region of the United States, with unknown ecological consequences. We conducted our research in exurban development in Pitkin County, Colorado, between May and June in 1998 and 1999. Unlike suburban development, exurban development occurs beyond incorporated city limits, and the surrounding matrix remains the original ecosystem type. We surveyed songbirds and medium-sized mammals at 30, 180, and 330 m away from 40 homes into undeveloped land to examine the effect of houses along a distance gradient, and in developments of two different housing densities as well as undeveloped sites to examine the effect of housing density. We placed bird species into one of two groups for the house-distance effect: (1) human-adapted species, birds that occurred in higher densities close to developments and lower densities farther away and (2) human-sensitive species, birds that occurred in highest densities farthest from homes and in lowest densities close to development. For both groups, densities of individual species were statistically different between the 30- and 180-m sites. Six species were classified as human-adapted, and six were classified as human-sensitive for the house-distance effect. Dogs (*Canis familiaris*) and house cats (*Felis domesticus*) were detected more frequently closer to homes than farther away, and red foxes (*Vulpes vulpes*) and coyotes (*Canis latrans*) were detected more frequently farther away from houses. With respect to the effect of housing density, most avian densities did not differ significantly between high- and low-density development but were statistically different from undeveloped sites. Six species were present in higher

densities in developed areas, and eight species were present in higher densities in undeveloped parcels. Similar results were found for mammalian species, with dogs and cats detected more frequently in high-density developments and red foxes and coyotes detected more frequently in undeveloped parcels of land. From an ecological standpoint, it is preferable to cluster houses and leave the undeveloped areas in open space, as opposed to dispersing houses across the entire landscape.

Key Findings

- Page 5: Study conducted in shrub-oak of Pitkin County, Colorado, which is roughly similar to the oak woodland of El Dorado County. High- and low-density development had similar effects on songbird species density in adjacent habitat, and both were different from undeveloped areas.
- Page 6: All of the human-sensitive songbird species occurred in higher densities in the undeveloped areas than they did in habitat near high-density housing development.
- Pages 5 and 6: Detections of human-avoiding mammal species (fox, coyote) were also much higher in sites that were farther removed from development.

Summary of How Research Provides Support for Conclusions Regarding the Most Appropriate Location of Conservation Lands

This reference demonstrates the adverse effects of proximity to development on occurrence of native species, as would occur under an on-site retention scenario. Proximity to development such as along the Highway 50 corridor shifts the species assemblage to species more tolerant of or co-adapted with humans and these species are less in need of conservation.

8 Hansen and Rotella 2002

Hansen, A.J. and Jay J. Rotella. 2002. "Biophysical Factors, Land Use, and Species Viability in and around Nature Reserves." *Conservation Biology* 16(4): 1112–1122.

Abstract

Many nature reserves are located in landscapes with extreme biophysical conditions. We examined the effects of interactions between biophysical factors and land use on bird population viability inside and outside of Yellowstone National Park. Our hypotheses were as follows: (1) biophysical factors constrain bird species richness and bird reproduction at higher elevations; (2) nature reserves are located at higher elevations, whereas private lands and more intense land use occur mostly at lower elevations with more mild climates and fertile soils; and (3) intense land use at lower elevations favors nest predators and brood parasites and thereby reduces reproductive output for some bird species. We used simulation models to evaluate whether favorable habitats outside reserves are population source areas and whether intense land use can convert these habitats to population sinks and reduce population viability within reserves. Bird species richness and abundance were high in small hotspots in productive, low-elevation habitats. Length of breeding season—and opportunity for re-nesting—was greatest at the lowest elevations for both American Robins (*Turdus migratorius*) and Yellow Warblers (*Dendroica petechia*). Nature reserves were higher in elevation than private lands, so hotspots for bird richness

and abundance occurred primarily on or near private lands, where rural residential development was concentrated. Brown-headed Cowbirds (*Molothrus ater*) were significantly more abundant near rural homes, but nests of American Robins were not parasitized and their nest success did not differ with home density. Nests of Yellow Warblers were commonly parasitized by cowbirds, and their nest success was significantly lower near rural homes. Estimated intrinsic population growth (λ) for American Robins suggested that low-elevation hotspots were population source areas for this species. Estimated λ for the Yellow Warbler suggested that the entire study area was a population sink, likely due to the effects of intense land use at lower elevations and climate constraints at higher elevations. Removing the effect of land use from the simulations revealed that high-elevation hotspots were population sinks, whereas low-elevation hotspots were source areas. Our results are consistent with the possibility that bird-population source areas outside nature reserves can be converted to population sinks by intense human use, thereby reducing the viability of subpopulations within reserves.

Key Findings

- Page 3: Sites in Montana, Idaho, and Wyoming were within a matrix of forests, shrublands, and grasslands.
- Pages 7 and 8: Sampling of bird species and subsequent modeling suggests that when preserves are located near areas of intense human use, those adjacent areas can be population sinks for the species within the preserves.
- Page 7: Modeling indicated that greater density of homes near undeveloped areas correlated with a higher abundance of nest predators or parasites such as cowbirds compared to undeveloped areas near lower home densities. The modeling used inputs from suburban and rural residential communities surrounding Yellowstone National Park, a reasonable analog to the densities seen in western El Dorado County.
- Page 9: If preserves are established in areas where more adjacent development will occur, areas that were formerly sources for bird populations in those preserves may become population sinks.

Summary of How Research Provides Support for Conclusions Regarding the Most Appropriate Location of Conservation Lands

This research provides support for the concept expressed in MR2 that it is important to minimize development near preserved areas, and that creating a pocket of preserved land within an urbanizing landscape can result in the eventual extirpation of some species within those preserves.

9 Maestas et al. 2003

Maestas, J.D., R.L. Knight, and W.C. Gilgert. 2003. "Biodiversity Across a Rural Land-Use Gradient." *Conservation Biology* 17(5)" 1425–1434.

Abstract

Private lands in the American West are undergoing a land-use conversion from agriculture to exurban development, although little is known about the ecological consequences of this change. Some nongovernmental organizations are working with ranchers to keep their lands out of development and in ranching, ostensibly because they believe biodiversity is better protected on ranches than on exurban developments. However, there

are several assumptions underlying this approach that have not been tested. To better inform conservation efforts, we compared avian, mesopredator, and plant communities across the gradient of intensifying human uses from nature reserves to cattle ranches to exurban developments. We conducted surveys at randomly selected points on each type of land use in one Colorado watershed between May and August of 2000 and 2001. Seven bird species, characterized as human commensals or tree nesters, reached higher densities (all $p < 0.02$) on exurban developments than on either ranches or reserves. Six bird species, characterized as ground and shrub nesters, reached greater densities (all $p < 0.015$) on ranches, reserves, or both of these types of land use than on exurban developments. Domestic dogs (*Canis familiaris*) and house cats (*Felis catus*) were encountered almost exclusively on exurban developments, whereas coyotes (*Canis latrans*) were detected more frequently ($p = 0.047$) on ranchlands than exurban developments. Ranches had plant communities with higher native species richness and lower non-native species richness and cover than did the other types of land use (all $p < 0.10$). Our results support the notion that ranches are important for protecting biodiversity and suggest that future conservation efforts may require less reliance on reserves and a greater focus on private lands.

Key Findings

- Page 6: Exurban (low-density residential) open space had increased abundance of human-adapted mesopredators such as domestic cats and dogs, and fewer detections of coyote and bobcat as compared to ranches and reserves
- Page 6: Ranches had higher species richness of native plant species as compared to exurban or reserves, likely due to the beneficial effects of grazing. In addition, the nature reserves under study had extensive trails systems open to the public for motorized and non-motorized recreationists, which likely spread non-native plant seeds.
- Page 6: Exurban developments also supported greater densities of tree-nesting and human-commensal bird species, likely because of the presence of non-native tree species and food subsidies.

Summary of How Research Provides Support for Conclusions Regarding the Most Appropriate Location of Conservation Lands

Provides further support for the difference in species composition between areas that are proximal to urban or suburban development and those more remote such as ranches and reserves. This supports the rejection of on-site retention as a valid strategy for mitigating effects to oak woodland species presented in MR2.

10 Hansen et al. 2005

Hansen, A.J., R.L. Knight, J.M. Marzluff, S. Powell, K. Brown, P.H. Gude, and K. Jones. 2005. “Effects of Exurban Development on Biodiversity: Patterns, Mechanisms, and Research Needs.” *Ecological Applications* 15(6): 1893–1905.

Abstract

Low-density rural home development is the fastest-growing form of land use in the United States since 1950. This “exurban” development (~6–25 homes/km^2) includes urban fringe development (UFD) on the periphery of cities

and rural residential development (RRD) in rural areas attractive in natural amenities. This paper synthesizes current knowledge on the effects of UFD and RRD. We present two case studies and examine the patterns of biodiversity response and the ecological mechanisms that may underlie these responses. We found that many native species have reduced survival and reproduction near homes, and native species richness often drops with increased exurban densities. Exotic species, some human-adapted native species, and species from early successional stages often increase with exurban development. These relationships are sometimes nonlinear, with sharp thresholds in biodiversity response. These effects may be manifest for several decades following exurban development, so that biodiversity is likely still responding to the wave of exurban expansion that has occurred since 1950. The location of exurban development is often nonrandom relative to biodiversity because both are influenced by biophysical factors. Consequently, the effects on biodiversity may be disproportionately large relative to the area of exurban development. RRD is more likely than UFD to occur near public lands; hence it may have a larger influence on nature reserves and wilderness species. The ecological mechanisms that may underlie these responses involve alteration of habitat, ecological processes, biotic interactions, and increased human disturbance. Research on the patterns and mechanisms of biodiversity remains underdeveloped, and comparative and experimental studies are needed. Knowledge resulting from such studies will increase our ability to understand, manage, and mitigate negative impacts on biodiversity.

Key Findings

- Page 5: There is a broad trend in reduced native biodiversity across insects, bird, lizards, and plants as one moves from wildland toward urban land uses. There is an opposite effect for non-native biodiversity, with increases seen when moving from wildland toward urban land uses.
- Page 6: Effects of exurban development may be manifest for several decades, so that biodiversity is likely still responding to the wave of exurban expansion that has occurred since 1950.
- Page 9: Along an urban–rural gradient in New York, nitrogen and phosphorous levels in oak forest soils increased with increasing urbanization. Increased nitrogen availability tends to simplify biotic communities and favor exotic species.
- Page 11: Many native species incur reduced survival and reproduction near homes and consequently native species richness generally drops with increased exurban densities. At the same time, some exotic species and some human-adapted native species generally increase with intensity of exurban development.
- Page 11: Areas nearer development experience greater vehicle traffic, which can lead to greater likelihood for wildlife collisions when compared to habitat more distant from urbanization.

Summary of How Research Provides Support for Conclusions Regarding the Most Appropriate Location of Conservation Lands

This review article summarizes important findings from many other articles, but focuses on two case studies of exurban and urban fringe development. The findings summarized in the review provide broad support for establishing preserves in locations removed from urban development, as noted in the key finding presented above. The strongest reason provided is the increased native biodiversity and reduced non-native species in areas farther away from urban development. This favors reduced habitat fragmentation and avoidance of on-site retention, as suggested in MR2.

11 Blair 1996

Blair, R. 1996. "Land Use and Avian Species Diversity along an Urban Gradient." *Ecological Applications* 6(2): 506–519.

Abstract

I examined the distribution and abundance of bird species across an urban gradient, and concomitant changes in community structure, by censusing summer resident bird populations at six sites in Santa Clara County, California (all former oak woodlands). These sites represented a gradient of urban land use that ranged from relatively undisturbed to highly developed, and included a biological preserve, recreational area, golf course, residential neighborhood, office park, and business district. The composition of the bird community shifted from predominantly native species in the undisturbed area to invasive and exotic species in the business district. Species richness, Shannon diversity, and bird biomass peaked at moderately disturbed sites. One or more species reached maximal densities in each of the sites, and some species were restricted to a given site. The predevelopment bird species (assumed to be those found at the most undisturbed site) dropped out gradually as the sites became more urban. These patterns were significantly related to shifts in habitat structure that occurred along the gradient, as determined by canonical correspondence analysis (CCA) using the environmental variables of percent land covered by pavement, buildings, lawn, grasslands, and trees or shrubs. I compared each formal site to four additional sites with similar levels of development within a two-county area to verify that the bird communities at the formal study sites were representative of their land use category.

Key Findings

- Page 2: Examined a wide gradient of urban and suburban land uses, from biological preserve to business district.
- Page 6: Moderate levels of development increased overall species diversity, but that increase was from non-native species and synanthropic species; native bird species abundance was reduced as they moved across the gradient from preserve to business district.
- Page 9: Even when a developed site had high bird abundance, researchers noted that these areas may simply be drawing birds that actually require habitats outside the developed areas, and that simply travel to the developed areas for food subsidies.

Summary of How Research Provides Support for Conclusions Regarding the Most Appropriate Location of Conservation Lands

This earlier study emphasizes that total biodiversity should not be a primary metric for assessing reserve quality. Rather, native species diversity and abundance should be emphasized as these are most under threat from development pressures and are the target of habitat preservation benefits. This study also introduces the idea that preserved habitat in more urban or suburban areas, such as that provided under on-site retention, may provide a population sink for native species rather than a benefit.

12 Santa Clara County 2012

The Santa Clara County Habitat Plan is typical of regional conservation plans, including Habitat Conservation Plans (HCPs) under Section 10 of the federal Endangered Species Act and Natural Community Conservation Plans (NCCPs) under the state NCCP Act. This plan permits development within the urban growth areas of the local jurisdictions (City of Gilroy, City of Morgan Hill, City of San Jose, and County of Santa Clara). Because the fundamental basis for the Habitat Plan includes avoidance of urban edge effects and establishment of large preserve blocks, extensive portions of the Habitat Plan are supportive of MR2 and its contention that preserving oak woodland within the Highway 50 corridor would not be feasible to maximize preservation of biological resources. However, some notable text from Chapter 5, the Conservation Strategy of the Habitat Plan, is excerpted below:

- Page 10: “Areas without extensive rural development were favored over areas with such development, all else being equal, due to the habitat incursions and edge effects around rural development.”
- Page 11: “The Reserve System will preserve the highest-quality natural communities and habitat for covered species in the study area. Highest quality is defined using various parameters and differs according to community type, but highest-quality habitats are frequently characterized by a high abundance and diversity of native species, intact natural processes, and few roads or other evidence of human disturbances.”
- Page 12: “The Reserve System will share a minimum amount of edge (i.e., will have the greatest possible area-to-perimeter ratio) with nonpreserve land, especially urban development, to minimize the indirect effects of adjacent land uses on the preserve resources and to minimize management costs.”
- Page 12: “When adjacent to existing urban areas or planned urban areas (i.e., areas zoned for urban development), the Reserve System will include buffer lands within its boundaries. The purpose of this buffer land is to reduce indirect effects on covered species and natural communities from urban development and to provide a zone for fuel load management to reduce the risk of wildland fire spreading to adjacent development. The size of the buffer will depend on site-specific conditions such as topography, the intensity of adjacent urban development, the natural community being separated from the development, the condition of the buffer lands, and whether covered species are or will be present near these lands.”
- Page 13: “Reserves will be manageable. That is, desired management treatments such as livestock grazing, prescribed burning, or invasive species control must be feasible on the reserve units and within the Reserve System. In general, larger reserves are easier to manage on a per-acre basis, but other factors such as adjacent land uses, topography, and parcel configuration must also be considered. Management needs may be driven by factors on or off site (e.g., adjacent land uses, watershed processes such as upstream erosion or ongoing contamination).”

13 Conservation Plan Maps from East Contra Costa Habitat Conservation Plan/Natural Community Conservation Plan (HCP/NCCP), Butte Regional Conservation Plan, Placer County Conservation Program, and South Sacramento HCP

These four regional conservation plans were not formally cited in MR2, but were named as examples of regional conservation strategies that avoid establishing small preserves near human development as a fundamental conservation principle. These maps are included as attachments for review.

Attachment 1

Merenlender et al. 1998

EFFECTS OF SUBDIVIDING PRIVATE PROPERTY ON BIODIVERSITY IN CALIFORNIA'S NORTH COAST OAK WOODLANDS

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ABSTRACT: Much of California's biodiversity is found in oak (*Quercus* spp.) woodland vegetation. Residential development is expanding in northwestern California, resulting in a larger number of houses and roads in wooded areas. To examine the effects of this type of habitat fragmentation on biodiversity, 12 low-elevation oak woodland sites with gentle slopes were identified using remote sensing and a geographic information system. These sites were stratified across a gradient of differing lot sizes including large continuous parcels of relatively undisturbed hardwood rangeland in private parcels greater than 122 hectares; ranchettes on 4 to 16-hectare lots; and suburban areas with single-family homes on 0.20 to 1.0 hectare lots. Level of development was shown to have a significant effect on plant and bird species composition, and to be independent of stand structure and tree cover in the surrounding landscape.

Key Words: birds, butterflies, suburban, indicator taxa, disturbance, Sonoma County.

1998 TRANSACTIONS OF THE WESTERN SECTION OF THE WILDLIFE SOCIETY 34:9-20

INTRODUCTION

Throughout the United States there has been an increase in non-metropolitan human populations that exceeds that expected by the national population growth rate (Long and DeAre 1982). In California, increased demand for property in rural areas has raised property values and resulted in land fragmentation and conversion of oak woodlands to housing, roads, and recreational development (Standiford et al. 1987). The majority of oak woodlands in the north coast are privately owned (Thorne 1997), making them especially vulnerable to habitat fragmentation. Historically, persons interested in natural habitat and resource conservation were primarily preservationists attempting to set aside undeveloped land in protected areas (Beazley 1997, Lockwood et al. 1997). Protected-area planning is only part of the solution and alone will not ensure the long-term preservation of California's wildlands or wildlife (Forbes et al. 1996, Wear et al. 1996). A more effective approach to habitat and wildlife conservation in areas such as the California's north coast is to reduce the impacts of habitat fragmentation and detrimental land-use practices on rural private lands. Developing a better understanding of the consequences of widespread reductions in parcel size and resulting habitat fragmentation is essential for developing policy and educational programs that will minimize the loss of biodiversity on private land.

A large number of new residences in California are being developed in oak woodlands because these areas are predominately in private ownership and are often near population centers (Standiford et al. 1987, Scott et al. 1995). The amount of development and degree of habitat fragmentation that results from scattered subdivisions in California's oak woodlands threaten wildlife conservation (Tietje et al. 1996). However, degradation of oak woodlands often goes unnoticed by state resource agencies because oaks do not have a high commercial value (e.g., $30 per thousand board feet compared to $300 to $600 for conifers; Anonymous 1998), and most of this vegetation type is found beyond state and federal protected areas (Thorne 1997).

Many state and federal wildlife habitat monitoring efforts are using remote sensing, geographic information systems (GIS), and urban expansion modeling to address the consequences of population growth on natural resources and to improve county planning strategies (Landis and Zhao 1994). This most likely is a result of many public agencies and non-governmental organizations relying on remote sensing as a tool to measure the extent and connectivity of natural habitat. In particular, Landsat Thematic Mapper (TM) satellite imagery with a 30-m resolution is most commonly used to identify areas of forest cover as distinct from urban or deforested areas. Most of these efforts consider non-urban areas as homogeneous wildlands (Cogan 1997). This type of remote monitoring does not permit detection of land-use and population density changes in areas with large amounts of tree cover. Clearly, however, property size and related human population density are variables that influence natural resource use and management and in turn influence habitat quality and wildlife abundance. For example, oak woodlands are no longer reserved for livestock ranchers but are now home to many suburban residents. This change is not being effectively monitored because of the limitations of widely used remote sensing techniques.

The research for this study was conducted in Sonoma County, located in northwestern California. This is one of the fastest growing counties in California with a population increase of 282% from 1960 to 1995 according to the Bureau of the Census (Information Services Oregon State University, (unpubl.) report, 1997). Approximately 30% of Sonoma County supports hardwood forest (122,193 hectares) (Pillsbury et al. 1991). In addition, over 90% of Sonoma County is privately owned, making integration of wildlife conservation with private land management imperative. Continuing subdivision or "parcelization" of large private ranches to meet the housing needs of a growing population has led to increased habitat fragmentation and land modification. Additional buildings, higher road density, more fences, the spread of exotic plants and animals, and clearing of vegetation are some of the impacts associated with property parcelization and influences on habitat quality.

To examine the effects of this type of parcelization on biodiversity in Sonoma County's oak woodlands, we measured vegetative structure and collected biodiversity data in suburban neighborhoods, ranchettes, and undeveloped sites in low-elevation oak woodlands. These three treatment areas were studied to determine if property parcelization significantly affects: (1) hardwood cover measured from TM satellite data; (2) tree density measured in the field; (3) plant species richness and composition; (4) bird species richness, abundance, and composition; and (5) butterfly species richness.

Our selection of plants, birds, and butterflies as indicator taxa was influenced by the limitations that sampling on small private land parcels presents. Trees and shrubs account for habitat structure, and plant community composition is often sensitive to fragmentation (Van Jaarsveld et al. 1998). Also, vegetation cover across large landscapes and stand structure can affect animal and plant community composition (Bolger et al. 1997). Therefore, we examined vegetation structure at each sampling point and percent cover of the entire surrounding study site.

Bird communities were selected because they are well studied, expertise was readily available, and bird habitat requirements span a wide range of landscape scales (Patton 1993, O'Connor 1990). Butterflies were used as indicator taxa because their life history traits can make them good indicators of habitat condition and therefore useful for conservation planning (Kremen et al. 1993). Another important advantage to using butterflies is that the data can be collected reliably, quickly, and inexpensively.

METHODS

Site Selection

We used a GIS to stratify sampling sites across a gradient of varying lot sizes in study areas with the same elevation range, slope class, and vegetation type. The GIS database included: (1) digital elevation models for the study area (USGS, 1:100,000); (2) a vegetation map based on TM satellite imagery classified by Pacific Meridian Resources (Anonymous 1994); and (3) parcel lot lines (Sonoma County Information Systems Department). Using ARC/INFO software (Environmental Systems Research Institue, Inc., Redlands, CA USA), we identified areas with hardwood tree cover within 5-15 degrees slope and between 100-200-m elevation. Within this vegetation type and physiography, areas with property sizes in three different treatments were identified from the county lot line data: (1) suburbs consisting of 0.20 ha to 1.0 ha home lots; (2) ranchettes 4 to 16 ha in size; and (3), undeveloped private land parcels of > 122 ha. Each suburban site was comprised of a neighborhood consisting of multiple single-family residents (Fig 1). Every ranchette site encompassed an area approximately 16 ha in size, comprised of contiguous properties that themselves were between 4 and 16 ha in size (Fig 1). Each undeveloped site was located on a property > 122 ha under single ownership.

Since the objective of this study was to examine the effects of property subdivision on biodiversity in areas that have retained substantial tree cover, all sites selected had some amount of hardwood cover. After we identified these sites using GIS, we made field visits to measure variables that are difficult to assess from satellite imagery, such as dominant oak species and extent of shrub cover. We selected sites with an overstory of mixed oak species dominated by live oak (*Quercus agrifolia* and *Quercus wislizenii*). This process resulted in 12 study sites, four within each of the three treatments - suburban, ranchette, and undeveloped (Fig 2). All undeveloped sites selected had no livestock grazing for the past five or more years. Permission to conduct our study on private property was obtained from the individual property owners with the exception of the small lot subdivisions (0.20 - 1.0 ha lots) where data was collected immediately adjacent to the private parcel rather than on the private land.

These sites were located in the foothills of the Mayacmus Mountains. A mix of dense hardwood forests and more open oak woodland were common at lower elevations; chamise (*Adenostaoma fasciculatum*) (chaparral) was more common at higher elevations. The predominant land uses in the surrounding areas were rural residential, vineyards, rangeland, and wildlands.

Flora

We calculated percent of hardwood cover that existed across the landscape for each study area by combining the percent cover for the following vegetation classes from classified satellite imagery: blue oak

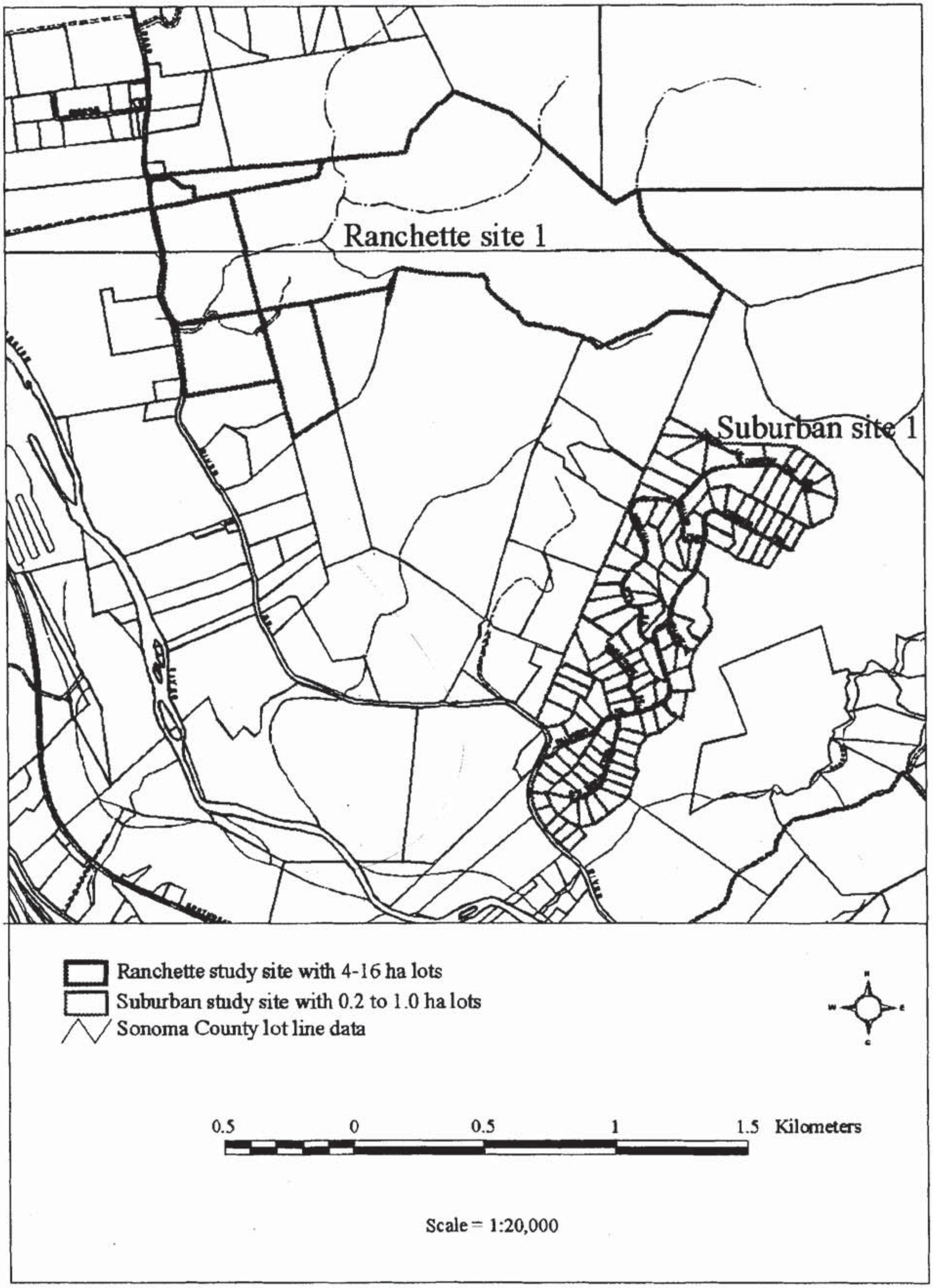

Figure 1. Example of typical lot sizes for a ranchette and suburban study site.

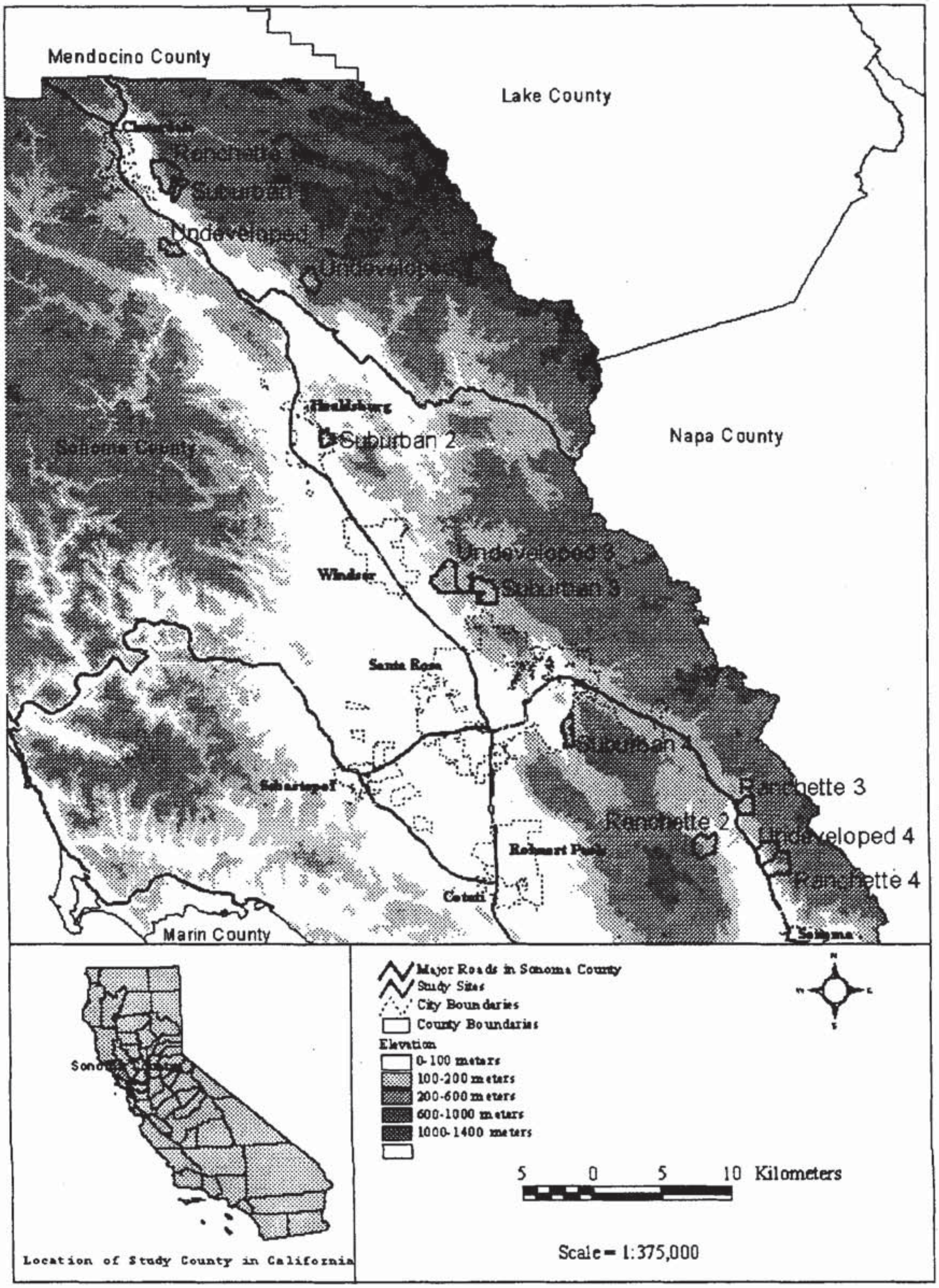

Figure 2. Location of study sites in Sonoma County, California

(*Quercus douglasii*) woodland, coastal oak (*Quercus agrifolia*) woodland, montane hardwood, and potential hardwood (Anonymous 1994). Potential hardwood areas have the spectral signature for hardwoods but fall outside the Pillsbury hardwood polygons (Pillsbury et al. 1991). The study areas encompassed contiguous parcels with similar lot sizes within the designated elevation and slope cutoffs. Therefore, the landscape level measure of percent hardwood cover was based on different sized areas for each of the 12 study sites.

We established 8 sampling points at least 250 m apart at each study site in 1997 to collect field data. At each point, we estimated cover percent for all vascular plant species within a 10 x 10-m macroplot. Tree density at each point was calculated using the point-centered quarter method (Cottam and Curtis 1956). We also measured tree height, canopy diameter, and diameter at breast height (dbh). This resulted in a plant species list with cover scores for 8 points within each site, and tree height, canopy diameter, and dbh for 64 trees per site.

Fauna

We sampled birds using 10 minute point counts (Ralph et al. 1993) conducted at all 96 sampling points once during the spring breeding season (May) and once in the winter (Juanuary-February) 1997. This resulted in 32 sample points for each of the three property-size treatments. One very experienced bird observer noted all bird species and numbers seen or heard within a 50-m radius of the plot center for 10 minutes.

We recorded the presence of butterfly species at each sampling point and collected individuals using a butterfly net when necessary for species identification. This was done through visual observation three times at all 96 sampling points from April through June 1997 within 50 m of plot centers for 15 minutes.

Plant and animal diversity and abundance were analyzed using nested analyses of variance with treatment as level one and replicated sites within each treatment as level two. The arc-sine square root transformation was used on percent data (Sokal and Rohlf 1995). Kruskal-Wallace statistics were used when significant heteroscedasticity could not be corrected by transforming the data (Sokal and Rohlf 1995). Differences were considered significant when $P \leq 0.05$.

RESULTS

Flora

The dominant hardwood vegetation types found at all sites were coastal oak woodland (23.4%±18%) and montane hardwood (17.2% ± 21.8%) followed by potential hardwood (9.6% ± 7.4%) and blue oak (0.24% ± 0.63%) woodland classes. Mean percent hardwood cover calculated from the TM pixel data (Anonymous 1994) was 55.5% ± 29.9% for the suburban sites, 42.4% ± 6.5% for ranchette sites, and 71.2% ± 15.3% for undeveloped. Percent hardwood cover for each study site could not be explained by treatment type ($F_{2,9} = 2.00$, $P = 0.19$).

Three hundred and sixty-four plant species were identified from all 96 sampling points. The average number of plants observed for each treatment is presented in Fig 3. Plant species richness was similar among treatments. However, a significant effect of lot size treatment on vegetation structure and composition was observed: smaller lot sizes had lower tree density than ranchettes; and large undeveloped woodlands had the greatest overall stand tree density (Adjusted H = 32.62, df = 2, $P<0.01$). Percent of exotic plant species was significantly higher in suburban areas, and ranchettes had significantly more exotic species than undeveloped sites ($F_{2,9} = 15.8$, $P < 0.001$) (Fig 4). Percent shrub cover was not significantly different between treatments ($F_{2,9} = 3.17$, $P = 0.09$). There was a trend for more shrubs in suburban sites due to planting by residents.

Fauna

Eighty-five bird species were identified among the 96 sampling points (Table 1). The average number of birds and butterflies observed for each treatment is presented in Fig 3. Species richness for birds ($F_{2,9} = 0.70$, $P = 0.52$) identified in spring 1997 was similar among treatments. However, species composition was significantly affected by the lot size: percent of neotropical migrant birds, species that winter in Central and South America, was significantly higher ($F_{2,9} = 5.0$, $P = 0.03$) at undeveloped sites (32.5% ± 15.2%) than at ranchettes (24.4% ± 12.4%) and small suburban lots (13.9% ± 11.3%). Other variables such as percent shrub cover and tree density did not help explain the bird species richness or composition differences between sites. Winter bird species richness differed by treatment ($F_{2,9} = 8.23$, $P < 0.01$), with more winter resident species found in suburban areas as compared to ranchettes, and with the fewest species observed in undeveloped woodland sites (Fig 3). Several bird species were more abundant in suburban than in undeveloped sites (Table 2). However, we did find more Cassin's vireos (*Vireo cassini*) in undeveloped woodlands (16) than in ranchettes (2) and suburban areas (2) during the spring census. No butterfly species demonstrated a similar trend across the study sites.

Only 29 butterfly species were identified in total (Table 3). While total species richness for butterflies was not significantly different between treatments ($F_{2,9} = 2.48$, $P = 0.14$), each species was observed more often at sampling points in undeveloped sites (mean = 7.48 ± 10.86) as compared to ranchette (mean = 5.48 ± 7.87) and suburban sites (mean = 4.45 ± 7.87) (paired t-test for undeveloped and ranchette: t_{28}=-2.25, P = 0.03). Twenty six of the species detected are considered common butterflies in California (Stewart 1997). One of the less common species, editha checkerspot (*Occidryas editha*), was only found in undeveloped areas.

DISCUSSION

GIS applications

A geographic information system was used to stratify sampling sites across a gradient of varying lot sizes in areas with the same elevation range, slope class, and vegetation type. This selection method resulted in sites that were as homogeneous as possible with respect to slope, aspect, and overstory vegetation given the heterogeneity that exists across Sonoma County. This is an essential step in a study such as this, because other urban gradient studies often have control sites at higher elevation and therefore in a different vegetation type than where the effects of development are measured (Blair 1994).

Percent hardwood cover detected on the TM imagery and the various vegetation classifications varied; however, no difference was detected among treatments. This verifies that remote imagery estimates of percent hardwood cover should not be used as a surrogate measure of disturbances such as housing density, and cannot always provide an accurate estimate of fragmentation in oak woodlands.

Biodiversity Data

Stand structure differences among treatments were documented by a trend of decreasing tree density in areas of greater housing density. Tree density calculated from field measurements differed among treatments, whereas percent tree cover, based on TM data, did not. This was most likely due to the limited 30-m resolution of the TM data that is commonly used for vegetation mapping.

Plant composition also was affected by treatment. As expected, suburban neighborhoods had a marked increase in exotic plants due to residential gardens. However, we did not expect that exotic plants would be significantly more prevalent in ranchettes as compared to un-

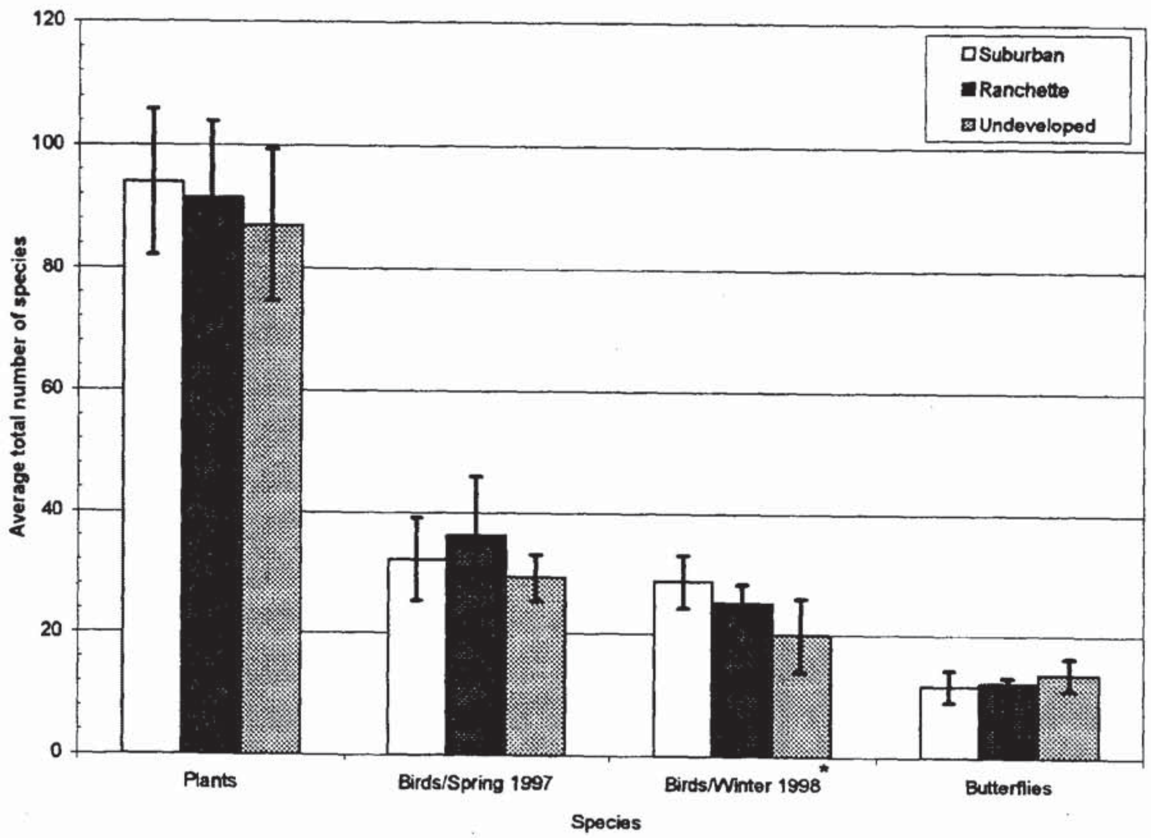

Figure 3. Average total number of plant, bird, and butterfly species found in the four replicates for the three treatments. Values include error bars showing +/- one standard deviation. The star indicates a significant effect of treatment on total number of species.

developed sites. This likely is the result of increased road density (Tinker et al. 1998) and the impact of a variety of land use activities on vegetation community integrity. Shrub cover was not useful in differentiating treatments in oak woodlands. This may be due to the fact that historical grazing and fire suppression has lead to a widespread depletion of shrub cover across California's oak woodlands (Callaway and Davis 1993).

The shrub layer has been shown to be an important structural component for bird assemblages (Lloyd et al. 1998, Sanders and Edge 1998). However, it is not common in upland oak-dominated woodlands in our study area, and therefore provides little explanatory power for bird species richness or community composition. Likewise, tree density had no relationship with bird richness or composition.

The number of plants, birds, or butterfly species was not significantly affected by the three treatments. Many researchers have pointed out the difficulties of using species richness to detect changes in ecosystem health or effects of disturbance (Schluter and Ricklefs 1993, Conroy and Noon 1996). Often, species adapted to a higher level of disturbance replace species that require undisturbed habitat leading to a change in species composition without an overall change in richness. In addition, habitat that is more frequently disturbed or has a greater mosaic of vegetation types within it will often support a larger number of species as a result of the increased habitat diversity (Abugov 1982, Wiens 1985).

Plant and bird species composition was different among treatments, illustrating the consequences of subdividing private land. Declining neotropical bird populations have been a concern in North America for the past 15 years (Furness and Greenwood 1993). Many explanatory variables for these declines have been proposed, including habitat fragmentation in both breeding and non-breeding locations (Robinson and Wilcove 1994). Oak woodland fragmentation often is caused by continued subdivision of private land in California. Therefore, smaller property sizes and associated disturbances (e.g., increased road density, impact of house cats [*Felis catus*], and human activity) likely reduce the diversity and abundance of sensitive bird species such as some of the neotropical migrants. This effect is clearly demonstrated by our data where suburban lots supported a lower percent of neotropical birds than ranchette properties, and the greatest number of neotropical species was observed in undeveloped woodlands.

Certain bird species were found to be more common in suburban neighborhoods than in ranchettes or undeveloped oak woodlands. Some of these species are associated with human disturbance and their increase may serve as indicators of disturbance. This type of research is worth pursuing for monitoring ecosystem health because these indicator species will be easier to find, quantify, and manipulate, and might provide data over a larger

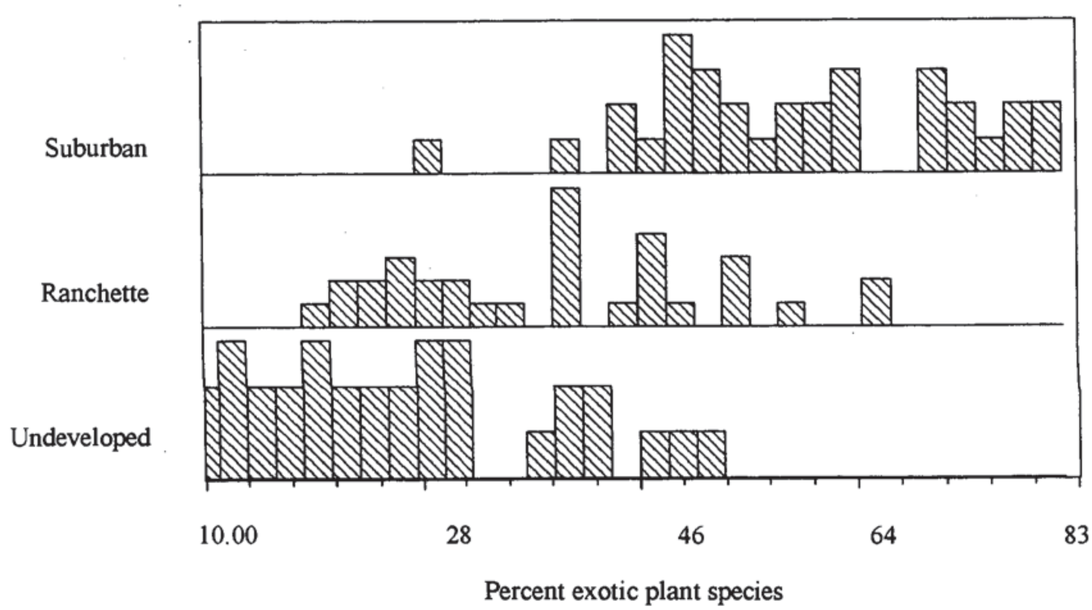

Figure 4. Histogram of number of sampling points with a certain percent exotic plant species in each treatment. This demonstrates that a higher percent of exotic plants were found at more sampling points in suburban sites than in ranchette sites, and the same was true for ranchette sites as compared to undeveloped sites.

Table 1. Bird species identified across all study sites during May, 1997 and January-February, 1998.

Common Name	Scientific Name	Common Name	Scientific Name
Acorn Woodpecker	*Melanerpes formicivorus*	Mallard	*Anas platyrhynchos*
Allen's Hummingbird	*Selasphorus sasin*	Mourning Dove	*Zenaida macroura*
American Crow	*Corvus brachyrhynchos*	Mountain Quail	*Oreortyx pictus*
American Robin	*Turdus migratorius*	Northern Flicker	*Colaptes auratus*
Anna's Hummingbird	*Calypte anna*	Northern Mockingbird	*Mimus polyglottos*
Ash-throated Flycatcher	*Myiarchus cinerascens*	Northern Oriole	*Icterus galbula*
Band-tailed Pigeon	*Columba fasciata*	Nuttall's Woodpecker	*Picoides nuttallii*
Barn Swallow	*Hirundo rustica*	Olive-sided Flycatcher	*Contopus borialis*
Bewick's Wren	*Thryomanes bewickii*	Orange-crowned Warbler	*Vermivora celata*
Black Phoebe	*Sayornis nigricans*	Pacific-slope Flycatcher	*Empidonax difficilis*
Black-throated Gray Warbler	*Dendroica nigrescens*	Pileated Woodpecker	*Dryocopus pileatus*
Black-headed Grosbeak	*Pheucticus melanocephalus*	Oak Titmouse	*Baeolophus inornatus*
Blue-gray Gnatcatcher	*Poliopila caerulea*	Purple Finch	*Carpodacus purpureus*
Brewer's Blackbird	*Euphagus cyanocephalus*	Red-breasted Sapsucker	*Sphyrapicus ruber*
Brown Creeper	*Certhia americana*	Red-shouldered Hawk	*Buteo lineatus*
Brown-headed Cowbird	*Molothrus ater*	Red-tailed Hawk	*Buteo jamaicensis*
Bushtit	*Psaltriparus minimus*	Red-winged Blackbird	*Agelaius phoeniceus*
California Quail	*Callipepla californica*	Ring-necked Pheasant	*Phasianus colchicus*
California Towhee	*Pipilo fuscus*	Ruby-crowned Kinglet	*Regulus calendula*
Canada Goose	*Branta canadensis*	Rufous-crowned Sparrow	*Aimophila ruficeps*
Cedar Waxwing	*Bombycilla cedrorum*	Rufous-sided Towhee	*Pipilo erythropthalmus*
Chestnut-backed Chickadee	*Parus rufescens*	W. Scrub Jay	*Aphelocoma californica*
Chipping Sparrow	*Spizella passerina*	Song Sparrow	*Melospiza melodia*
Cliff Swallow	*Hirundo pyrrhonota*	Steller's Jay	*Cyanocitta stelleri*
Common Raven	*Corvus corax*	Towsend's Warbler	*Dendroica townsendi*
Cooper's Hawk	*Accipiter cooperii*	Tree Swallow	*Tachycineta bicolor*
Cassin's Vireo	*Vireo cassini*	Turkey Vulture	*Cathartes aura*
Dark-eyed Junco	*Junco hyemalis*	Violet-green Swallow	*Tachycineta thalassina*
Downy Woodpecker	*Picoides pubescens*	Warbling Vireo	*Vireo gilvus*
European Starling	*Sturnus vulgaris*	Western Bluebird	*Sialia mexicana*
Fox Sparrow	*Passerella iliaca*	Western Kingbird	*Tyrannus verticalis*
Golden-crowned Kinglet	*Regulus satrapa*	Western Meadowlark	*Sturnella neglecta*
Golden-crowned Sparrow	*Zonotrichia atricapila*	Western Tanager	*Piranga ludoviciana*
Grasshopper Sparrow	*Ammodramus savannarum*	Western Wood Pewee	*Contopus sordidulus*
Great Blue Heron	*Ardea herodias*	White-breasted Nuthatch	*Sitta carolinensis*
Hairy Woodpecker	*Picoides villosus*	White-crowned Sparrow	*Zonotrichia leucophrys*
Hermit Thrush	*Catharus guttatus*	White-tailed Kite	*Elanus leucurus*
House Finch	*Carpodacus mexicanus*	Wild Turkey	*Meleagris gallopavo*
House Wren	*Troglodytes aedon*	Winter Wren	*Troglodytes troglodytes*
Hutton's Vireo	*Vireo huttoni*	Wood Duck	*Aix sponsa*
Lark Sparrow	*Chondestes grammacus*	Wrentit	*Chamaea fasciata*
Lesser Goldfinch	*Carduelis psaltria*	Yellow Warbler	*Dendroica petechia*
		Yellow-rumped warbler	*Dendroica coronata*

Table 2. Bird species more commonly detected in Suburban areas. Numbers reflect number of individuals detected at all four study sites. Suburban (0.10 to 1.0 ha lots), Ranchette (8-16 ha parcels), and Undeveloped (>122 ha parcels), designations reflect the three treatments.

Common Name	Spring			Winter		
	Suburban	Ranchette	Undeveloped	Suburban	Ranchette	Undeveloped
American Crow	31	11	9	55	12	3
Anna's Hummingbird	31	11	9	33	19	16
Bushtit	41	12	7	60	27	16
California Towhee	23	8	6	23	7	3
Common Raven	20	4	1	0	4	0
European Starling	34	11	0	0	0	0
Golden-crowned Sparrow	0	0	0	33	6	0
House Finch	25	16	1	32	10	2
Plain Titmouse	48	24	26	37	34	24
Scrub Jay	48	12	9	38	15	5
Turkey Vulture	13	5	0	24	31	5
Violet-green Swallow	70	72	27	0	0	0
White-crowned Sparrow	0	0	0	11	0	0
Wood Duck	10	0	0	0	0	0

range of habitat disturbance. These are traits that may increase the statistical power of single-species monitoring programs. While American crows (*Corvus brachyrhynchos*) and turkey vultures (*Cathartes aura*) often are sighted flying over a woodland census point, they often roost in relatively disturbed areas such as livestock ranches and suburban neighborhoods. Some birds find a greater amount of food resources in suburban areas. For example, Anna's hummingbirds (*Calypte anna*) are attracted to nectar that may be more abundant in cultivated garden plants or at feeders. In addition, other species such as house finches (*Carpodacus mexicanas*) and European starlings (*Sturnus vulgaris*) find suitable nesting sites in disturbed surroundings (Trozer 1997, Veit and Lewis 1996).

We did not detect an overall effect of treatment on butterfly richness or composition with the exception of one species. There did appear to be a higher probability of detecting a species at sampling points in undeveloped sites, and this may suggest that butterflies are more abundant in undeveloped sites. However, this should not be overstated since determining butterfly abundance in the field is difficult. While the use of butterflies as indicators presents several advantages, they proved not to be effective indicators of habitat disturbance due to housing density in upland oak woodlands. Only a limited number of species use woodland habitat away from riparian zones; therefore, detecting the presence of particular species requires extensive sampling, and butterfly abundance could not be detected reliably across a large number of sampling points. The low number of butterfly species detected severely limited our ability to analyze the butterfly data.

Conclusions

This study demonstrates that the size of private property lots affected plant and bird species composition in a mixed rural-suburban landscape. It is important to note that vegetation maps based on classified TM satellite data did not allow us to differentiate between areas with high housing densities or to quantify the effect of land parcelization. Therefore, one should not use these types of data to assess oak woodland integrity.

The future of California's oak woodlands depends on maintaining large continuous parcels of privately owned land. Therefore, reducing habitat fragmentation and employing practices that maintain continuous habitat is important. Economic incentive programs and county planning initiatives that minimize property subdivision are ways for Californians to maintain the ecological integrity of privately owned oak woodland vegetation.

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Table 3. Butterfly species identified across all study sites during April-June, 1997.

Common Name	Scientific Name	Common Name	Scientific Name
Anise Swallowtail	*Papilio zelicaon*	Leanira Checkerspot	*Thessalia leanira*
Cabbage White	*Pieris rapae*	Monarch	*Danaus plexippus*
California Hairstreak	*Satyrium californicum*	Mournful Duskywing	*Erynnis tristis*
California Ringlet	*Coenonympha californica*	Mourning Cloak	*Nymphalis antiopa*
California Sister	*Adelpha bredowii*	Mustard White	*Pieris napi*
Common Buckeye	*Junonia coenia*	Mylitta Crescent	*Phyciodes mylitta*
Common Wood-Nymph	*Cercyonis pegala boopis*	Northern Checkerspot	*Chlosyne palla*
Common-Checkered Skipper	*Pyrgus communis*	Orange Sulfur	*Colias eurytheme*
Crown Fritillary	*Speyeria coronis*	Pale Swallowtail	*Papillo eurymedon*
Dusky Wing	*Erynnis* sp.	Pipevine Swallowtail	*Battus philenor*
Editha Checkerspot	*Occidryas editha*	Propertius Duskywing	*Erynnis propertius*
Farmer (orange skipper)	*Ochlodes agricola*	Purplish Copper	*Lycaena helloides*
Green Hairstreak	*Callophrys dumetorum viridis*	Spring Azure	*Celastrina ladon echo*
		Tiger Swallowtail	*Papillo rutulus*
Large Marble	*Euchloe ausonides*	Variable Checkerspot	*Euphydryas chalcedona*

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Attachment 2

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Exurban development influences woodland bird composition

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ABSTRACT

One of the fastest growing types of land-use change is exurban development—low-density housing outside urban service boundaries. However, how individual species are responding to exurban development remains uncertain. We monitored birds for 5 years across three housing density levels in northern California oak woodlands. We compared community and species responses to exurban development (4–16 ha parcels) with suburban and undeveloped natural areas. We found that individual species and groups of species exhibited variable responses to exurban development. Some species and guilds were impacted by exurban development to the same extent as suburban development while others were less sensitive to this type of land use. For example, the proportion of the bird community composed of tree-and-shrub feeders was similar between exurban and natural areas, whereas proportions of temperate migrants showed significant reductions at both suburban and exurban sites. Similarly, Northern Flicker, Hutton's Vireo, and Orange-crowned Warbler were equally rare in exurban and suburban sites, making large, undeveloped parcels essential for their conservation. By explicitly measuring ecological changes associated with parcel size and density this research provides valuable information to land-use planners on the consequences of zoning for biodiversity conservation.

1. Introduction

Habitat loss through land-use change represents one of the most serious threats to terrestrial biodiversity (Sala et al., 2000), and although most land-use decisions are made at the local level (Theobald et al., 2000), the results are of global importance (Foley et al., 2005). In fact, spatial analysis demonstrates that land use may be the strongest factor affecting endangered species densities in developed regions (Kerr and Cihlar, 2004). Recent estimates show that 60% of the world's population is projected to live in urban and suburban densities by the year 2030 (United Nations, 2005). These land-use types currently cover only 1.9% of the land area in the United States (Burchfield et al., 2006). In contrast exurban development occupied 15 times the land area of higher-density development in the United States in 2000 (Brown et al., 2005). Exurban development primarily results from minor subdivision of large, rural land parcels into smaller "ranchettes" that rely on private septic systems and groundwater wells. Across the United States nearly 80% of new housing construction between 1994 and 1997 occurred on lots larger than 1 acre (0.4 ha), and 57% were built on lots 10 acres (4 ha) or larger (Heimlick and Anderson, 2001). California has the greatest recorded number of housing units in the wildland–urban interface (Radeloff et al., 2005), and oak woodlands are particularly susceptible to continued subdivision, because more than 80% of this ecosystem type is in private ownership in California (Pavlik et al., 1991).

Despite calls for more research on the impacts of human settlement (Miller and Hobbs, 2002), particularly beyond the urban fringe (Theobald, 2005; Fraterrigo and Wiens, 2005), attempts to quantify the impacts of exurban development on biodiversity in the field have only just begun. By its very nature, low-density residential development is difficult to map and monitor using existing land-cover databases because natural vegetation cover often remains dense in areas surrounding homes (Sutton et al., 2006). Hence, the consequences of exurban development for biodiversity cannot be easily predicted from landcover analysis of remotely sensed imagery.

Conversion of privately owned ranches and wildlands to exurban developments results in increased anthropogenic disturbances such as the introduction of domestic animals and non-native plant, and the construction and increased use of rural roads. Additionally, the extent and intensity of land use on exurban lots is highly variable, ranging from infrequently occupied second homes to grazing, small-scale agriculture, or wetland creation—activities that result in

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different levels of habitat modification and produce heterogeneous landscapes (Bock et al., 2006a).

The few field studies that have been conducted reveal variable responses of wildlife to exurban development among different species, taxonomic groups and ecosystem types. For example, in southeast Arizona, lizards were scarce in exurban areas likely due to their vulnerability to domestic predators (Audsley et al., 2006), while no effect of exurbia was detected in rodent community composition or species abundance (Bock et al., 2006b). Butterflies and grasshoppers also responded to the conversion of large ranches to exurban ranchettes, with the latter increasing in abundance (Bock et al., 2006a, 2007). Two of the most comprehensive field studies completed to date demonstrate significant effects of subdividing private ranches on bird, carnivore, and plant communities in Colorado (Odell and Knight, 2001; Maestas et al., 2001). On the other hand, differences in the presence of native ant species were not detected in southern Florida, despite marked increases in exotic ants found at exurban sites (Forys and Allen, 2005). The same was true for ants and small mammals in the Sierra Nevada, California (Manley et al., 2006), although the lack of detectable effect could represent an extinction debt that will lead to the loss of native species over time (Tilman et al., 2002). Disturbances associated with exurban development are likely to correspond to a more gradual change to the environment than more intense land uses, and the impacts to wildlife may need to be monitored over a longer time period.

The studies referenced above demonstrate that certain species tolerate human residential landscapes and their associated disturbances ('urban adapters') while other species are rare or not detected ('urban avoiders'). Here, we directly examine how bird communities respond to exurban developments (1 unit per 10–40 acres (4–16 ha) Theobald, 2001), as compared to suburban and undeveloped areas. We collected data on bird community composition and abundance over 5 years in sites located within suburban (0.2–1.0 ha home lots), exurban (4–16 ha lots) and undeveloped (>122 ha lots) land uses. Our specific objectives were to: (1) examine how guilds and species respond differently to the three land-use types, and (2) identify which species respond to exurban development similarly to suburban developments and may require protection from all types of residential development. To account for variability within the land-use treatments, we also measured a range of other site- and landscape-level characteristics that could influence the bird community. Unlike previous work, this study takes into account seasonal and year to year variability in species abundances, which can be especially high in Mediterranean-climate regions.

By sampling multiple sites within three different land-use types (suburban, exurban, and undeveloped) distinguished by parcel size classes, and that fall into residential zoning categories commonly found across rural areas, the results of our research are more easily transferable to land-use planners who seek measured environmental thresholds to guide decisions about development density (Environmental Law Institute, 2003). Fraterrigo and Wiens (2005) aptly point out that most of the insights about bird community response to land use is from urban and suburban areas. Little is know about the impacts of exurban development and how this compares with what we know from urban/suburban studies. Consequently, we focus on the particular impacts of exurban development on the bird community, compared to suburban development and undeveloped woodlands. For example, our research reveals that in exurban areas, the abundance of some species or representation of some guilds changes to a similar degree as in suburban areas, despite the lower development density associated with exurban areas. We refer to this as a "suburban" response as compared to an "intermediate" response where the detection rates fell between what we observed in suburban and wildland areas. Additionally, we use the term 'undeveloped response' when we did not detect a difference in the abundance of a species or representation of a guild between exurban development and undeveloped woodlands. This information can be used to inform planning decisions and justify the need for policies designed to curtail the continued sprawl of low-density development into privately owned wildlands.

2. Materials and methods

2.1. Study area: Sonoma County, California

Counties surrounding the San Francisco Bay Area in northern California are experiencing extensive exurban growth. For example, more than half of Sonoma County's 1 million acres (404 ha) is an intermix of low-density housing, vineyards, and undeveloped forests and woodlands, resulting in a growing interface between human-dominated landscapes and wildlands. The Mediterranean climate and complex geology of the Coast Ranges that run through Sonoma County have produced a rich flora and a diverse mix of vegetation types and plant communities, including mixed conifer forest, mixed conifer–hardwood forest, oak woodland, mixed hardwood forest, grasslands, and a variety of riparian and other wetland habitats (Barbour et al., 1993). Due to the mild climate and exceptionally high diversity of oak and other hardwood species, the mixed oak woodlands in the study area support a diverse assemblage of birds and other wildlife (Stebbins and Hrusa, 1995).

2.2. Site selection

We used a geographic information system (GIS) database to identify suburban, exurban, and undeveloped sites with similar habitat characteristics in the foothills of the Mayacmas Mountains. Our database included: (1) digital elevation models for the study area (USGS, 30 m resolution); (2) a vegetation map based on classification of Thematic Mapper satellite imagery taken in 1990 (Pacific Meridian Resources, 1994); and (3) parcel lot lines (Sonoma County Information Systems Department). Because plant community composition varies considerably within areas referred to as mixed oak woodland (Sawyer and Keeler-Wolf, 1995), we restricted our study to low-elevation, gently sloped areas to reduce the amount of variation in vegetation characteristics among potential sites. Using ARC/INFO software (Environmental Systems Research Institute, Inc., Redlands, CA USA), we identified areas with hardwood tree cover that had slope values between 5° and 15° and elevation between 100 and 200 m.

Next, we used the county lot line data to identify potential sites that fell within three different land-use type treatments: (1) suburban developments, consisting of 0.20–1.0 ha home lots; (2) exurban developments, with parcels ranging from 4 to 16 ha in size; and (3) undeveloped private land parcels with areas greater than 122 ha. Each suburban site was comprised of a neighborhood consisting of multiple single-family residences. Every exurban site encompassed an area approximately 16 ha in size, comprised of contiguous properties that were each between 4 and 16 ha in size. Each undeveloped site was located on a property >122 ha under single ownership and adjacent to large expanses of public and privately owned wildlands.

After we identified potential sites using GIS, we made field visits to these sites in order to assess site characteristics that are difficult to assess from satellite imagery, such as dominant oak species and extent of shrub cover. This process resulted in the selection of 12 oak (*Quercus*) dominated study sites, 4 within each of the 3 treatments—suburban, exurban, and undeveloped (Fig. 1).

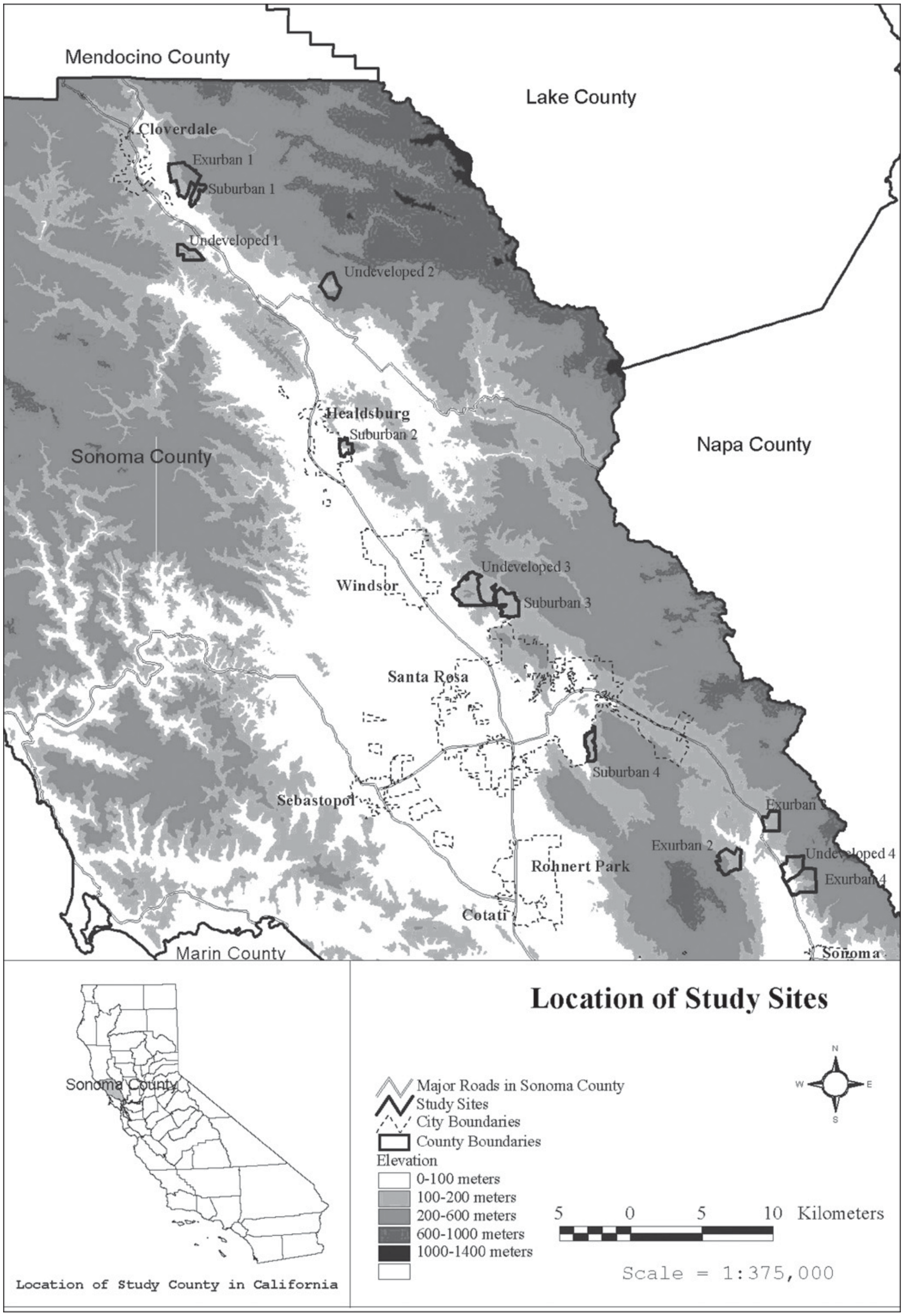

Fig. 1. Location of study sites in Sonoma County.

We included only undeveloped sites that had no livestock grazing for a minimum of 5 years. Two of the exurban sites had horses in a restricted area, which is common for this type of land use, but otherwise no sites had other types of livestock. Permission to conduct our study in the selected sites was obtained from the individual property owners, with the exception of the small lot subdivisions (0.20–1.0 ha lots) where data were collected on public right-of-ways such as sidewalks immediately adjacent to private parcels (for more information on accessing private land for research see Hilty and Merenlender, 2003).

2.3. Field data collection

We established eight sampling points at least 250 m apart from one another in the field at each of the 12 study sites, resulting in a total of 32 sampling points per land-use treatment. For each of the 96 points, we estimated percent cover for all vascular plant species within a 10 m × 10 m macroplot. Tree density at each point was calculated using the point-centered quarter method (Cottom and Curtis, 1956). Based on the data collected in the macroplots, we calculated the following site-level variables for each sampling

Table 1
Landscape variables and their source data.

Variable code	Calculation used	Source data
%F500	% forested within 500 m of bird count points	"Calveg" landcover data, 1994, from CDF-FRAP
Durban	Euclidian distance to urban areas	Urban areas from "Calveg" landcover data, 1994, from CDF-FRAP
%V500	Average % vineyard within 500 m of bird count points	1997 vineyard boundaries, from Sonoma County Grape Growers Assocation, as digitized by Circuit Rider Productions, Inc.
LOT500	Average lot size within 500 m of bird count points	County parcel layer from the Sonoma County Information Systems Department
DH2024	Euclidean distance to nearest 1:240,000 scale stream or body of water	USGS 1:24,000 scale Digital Line graph data
RoadD	Road density within 500 m of bird count points	US Census Bureau 1998 "TIGER/line" 1:100,000 scale data
DH500	Simple diversity of landcover types within 500 m of bird count points	"Calveg" landcover data, 1994, from CDF-FRAP

point: (1) number of plant species, (2) number of exotic species, (3) percent non-native plant species, (4) percent absolute cover of all vegetation, (5) tree density (# trees/100 m^2), and (6) percent shrub cover.

At each survey point, bird species and number of individuals heard or seen were recorded for 10 min within a fixed 50 m radius during the early morning hours (Ralph et al., 1995). Point counts were conducted by one very experienced bird observer at all 96 sampling points once during the spring breeding season (May/June) for 5 years; thereby preventing observer bias.

2.4. Landscape variables and data analysis

Arc/Info and ArcView 3.2 (ESRI) were used to calculate several landscape variables at a fixed distance from each sampling point. The spatial databases used to develop these variables are listed in Table 1. Rather than using multiple buffer distances (Bolger et al., 1997) which could result in problems with multi-collinearity in the final models, we used a fixed 500 m radius circle to calculate all landscape variables. Preliminary linear regression models indicated that variables calculated at this buffer distance were more strongly correlated with bird community indices than those calculated at 100, 250, and 1000 m, and buffer distances greater than 1000 m would have yielded substantial overlap among areas sampled to calculate variables for different study sites.

Because large, intact woodlands may be important to certain species, "core" habitat was defined and delineated using 1994 TM satellite data of hardwood cover. These core habitat areas were defined as 100 ha or more of contiguous habitat. Individual habitat patches were considered to be not continuous if they were separated by at least 2 pixels. To eliminate edge habitat from consideration, a 1-pixel buffer (25 m) was removed around each identified habitat patch. Core habitat was delineated using a modified version of the "core.aml" habitat analysis program (S. Saving, California's Fire and Resource Assessment Program, pers. comm.).

We limited our analyses to species that comprised at least 0.5% of all observations within a site, to remove non-resident species and occasional sitings. We also omitted feral domesticated birds and waterfowl (Blair, 1996). Thus, a total of 71 species were retained for statistical analysis. Concerns have been raised that bias in bird detection rates can result from differences in habitat (Thompson, 2002) or in this case land-use types, since all study sites were located in oak woodland habitat. To address these concerns, we examined possible relationships between tree density and the mean number of detections within each land-use treatment through regression analysis. Tree density at each sampling point was measured in the field using the point-centered quarter method (Cottom and Curtis, 1956; see Merenlender et al., 1998 for more details).

The bird species were classified into the following guilds or groups and their respective forms: (1) nest type (cavity, open cup), 2) nest location (cliff/ledge, ground, shrub, tree canopy), (3) feeding location (ground, tree/shrub, aerial, water), (4) migratory status (neotropical, temperate, resident), and (5) origin (native, exotic). This information was determined for each species based on their known behavior in Sonoma County using various references (Ehrlich et al., 1988; Burridge, 1995; Fix and Bezener, 2000; Sibley, 2000; Elphick et al., 2001; USGS Breeding bird survey web site 2003) and local expert knowledge (Emily Heaton, Chuck Vaughn, Robert Keiffer, pers. comm.). Species were classified as 'urban adapters' and 'urban avoiders' based on published results from previous studies conducted in California's oak woodlands (Stralberg and Williams, 2001; Bolger et al., 1997; Blair, 1996). Canonical correspondence analysis (CCA) (McCune and Mefford, 1999) was used to explore how observed variation in the bird community is partitioned relative to housing density and the site and landscape environmental variables. Next, we examined the influence of three different land-use types or treatments (suburban, exurban, and undeveloped) on observed variation in the entire bird community (in terms of species composition and relative abundances of different species). We used permutational multivariate analysis of variance (NPMANOVA), a nonparametric method that compares the variance within and between a distance matrix calculated from distances between each pair of observations. This analysis is similar to using a Fisher's *F*-ratio for a distance matrix generated from the entire bird community data matrix and *P*-values are a result of multiple permutations. (Anderson, 2000; Anderson, 2001). We selected this method because it partitions the variation between our treatments and within sites using a two-way analysis similar to ANOVA and does not require any assumptions about the distribution or correlations among the data (Anderson, 2001). We ran this test for a two-way nested design (level 1 = land-use type, level 2 = site, replicates = sampling points) so that differences in bird communities could be examined relative to both treatment and site differences. To examine whether 'site' contributed to differences in bird communities, permutations of raw data were done randomly across sites but were restricted to occur within the appropriate land-use type. The number of individuals detected for each species over 5 years of sampling was transformed due to the presence of zero detections with a $\ln(x+1)$ transformation. The chi-square distance measure was used to emphasize compositional differences over differences in abundances. Pair-wise *a posteriori* comparisons were conducted to test for differences in bird communities between different pairs of treatments (e.g., suburban vs. exurban).

The proportion of species detected within each of the guilds listed above, relative to all species detected at each sampling point, provides us with a closer examination of shifts in community composition among the treatment types. Because we were most interested in how land-use type influences bird community composition, we used a three-level nested analysis of variance (ANOVA) with land-use type as the primary factor. Sites were nested within each treatment, sampling points were nested within sites, and the five annual visits were treated as repeated measures. In addition, we used nested ANOVA to explore variation in observed abundance for the most commonly detected species. We used the arc-sine square root transformation for all proportional data, and differences were considered significant when $P < 0.05$. The Tukey multiple comparison procedure was performed with a harmonic mean at $P < 0.05$ level to examine all pair-wise comparisons when the nested ANOVA tests found a significant effect of land-use treatment.

3. Results

The mean number of bird detections per site each year (±s.d. over 5 years) varied from 385.8 (±32.2) in the undeveloped sites to 485.0 (±61.3) in the exurban sites and 532.4 (±56.3) in the suburban sites. We detected a mean of 48.0 (±2.1) species in the undeveloped sites, 54.0 (±5.1) species in the exurban sites, and 46.2 (±6.1) species in the suburban sites each year. The cumulative number of species detected roughly leveled off during the final three sampling years, with only one additional species detected during the final year of monitoring (a full list of species results can be obtained from the lead author). We found no evidence for a relationship between tree density and mean detections among sampling points in the suburban ($R^2 = 0.045$, $P = 0.24$) or exurban sites ($R^2 = 0.034$, $P = 0.31$), and a very weak negative relationship between tree density and mean detections among sampling points in the undeveloped sites ($R^2 = 0.144$, $P = 0.04$). These results suggest that our comparisons among land-use treatments were not substantially influenced by variation in detection rates due to differences in local hardwood forest tree density. Also, no differences in shrub cover were detected among treatments (Merenlender et al., 1998).

In the canonical correspondence analysis, the eigenvalue for axis 1 was 0.208 and for axis 2 was 0.172, explaining 8.9% and 7.3% of the species–environment relationship, respectively (Fig. 2). In Fig. 2 we see some partitioning between treatment types (triangles, X's, diamonds) with a greater amount of spread among the exurban sites. Though, the various landscape variables we measured do not explain much of the variation observed between bird communities in the three land-use types. The NPMANOVA analysis did reveal a significant effect of land-use [treatment ($F = 2.1$, $P < 0.01$)] and a significant effect of site on the observed variation in the relative abundance of different species within the bird communities [site ($F = 3.4$, $P < 0.01$)]. The pair-wise *a posteriori* comparisons revealed a significant difference between the suburban sites as compared to exurban ($t = 1.28$, $P < 0.08$) and undeveloped sites ($t = 1.96$, $P < 0.03$) using a multivariate version of the t-statistic. However, differences between undeveloped and exurban were not significant ($t = 1.11$, $P < 0.29$).

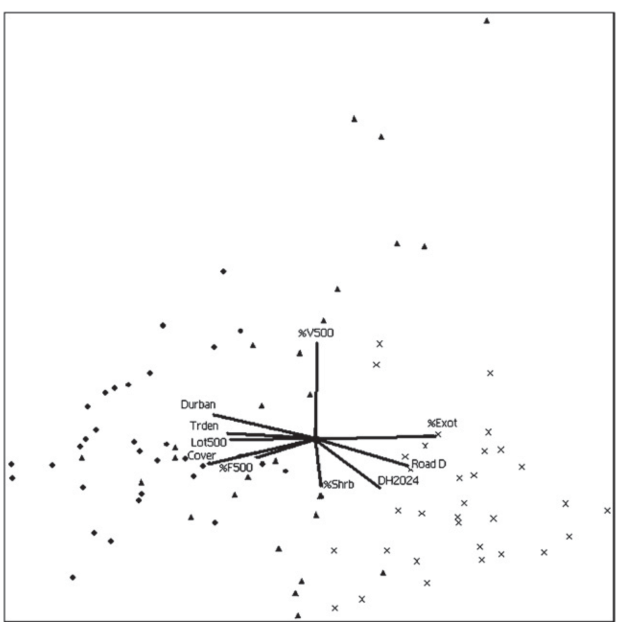

Fig. 2. Ordination diagram of canonical correspondence analysis depicting the sampling points in a space defined by two ordination axes. The points are coded according to the housing density (circle = undeveloped, triangle = exurban, X = suburb). The intracorrelations (Ter Brack 1986) for the environmental variable vectors shown are as follows (axis 1, axis 2): percent non-native species (%Exot 0.839, 0.047), percent absolute cover of all vegetation (cover −0.742, −0.200), number of trees/100 m^2 (Trden −0.581, 0.048), percent shrub cover (%SHRB 0.070, −0.492), percent forest cover in 500 m radius (%F500 −0.599, −0.233), distance from urban (Durban −0.710, 0.222), percent vineyard in 500 m (%V500 0.022, 0.863), average lot size in 500 m (Lot500 −0.614, 0.008), distance from nearest stream (DH2024 0.453, −0.410), road density (RoadD 0.611, −0.222). The arrows are oriented toward the direction of increasing change in that variable and the length represents the relative contribution that this variable made to the model.

The response of some guilds to exurbia was indistinguishable from their response to suburban sites (suburban response), while the proportion of detections of other guilds did not reveal significant differences between exurban and undeveloped sites (undeveloped response) (Fig. 3 and Table 2). The proportion of species detected in the following guilds was significantly related to the different land-use treatments and also to sites (unless noted). The guild analysis was conducted based on the proportions of total detections that fell into each guild, and therefore any differences in total numbers of detections among land-use treatments will not influence these comparisons. Tree-and-shrub feeders had no detectable difference between exurban and undeveloped sites. The same was true for shrub nesters and ground feeders, but in these cases relative abundance was greater in suburban sites. Ground nesters have lower relative abundance in exurban sites as compared to undeveloped sites but still remain more common in exurbia than suburban sites (intermediate response, Fig. 3). The relative abundance of temperate migrants was equally depressed in exurban and suburban sites from that observed in undeveloped sites.

The proportion of detections of species classified as 'urban avoiders' appear to be impacted by exurban development to the same extent as suburban development (Fig. 3). Nested ANOVA analyses of three individual species abundances mirrored the larger community pattern. Northern Flickers ($F_{2,9} = 14.18$, $P < 0.01$; not sig. for sites), Orange-crowned Warblers ($F_{2,9} = 7.08$, $P < 0.05$), and Hutton's Vireos ($F_{2,9} = 5.11$, $P < 0.05$; not sig. for sites) were detected significantly more often at undeveloped sites and declined to similar levels in exurban and suburban sites (Fig. 4).

The proportion of detections of species classified as 'urban adapters,' or positive indicators of human development and its associated disturbances, was also significantly affected by the land-use treatment, with exurban sites having levels of detections intermediate to undeveloped and suburban sites (Fig. 3). The responses of two individual species abundances mirrored the larger assemblage of urban adapters. House Finch ($F_{2,9} = 24.88$, $P < 0.001$; not sig. for sites) and California Towhee ($F_{2,9} = 25.18$, $P < 0.001$) were detected at intermediate levels of abundance between that observed in suburban and undeveloped sites (Fig. 4). California Quail were significantly more abundant in the suburban and exurban sites than the undeveloped sites ($F_{2,9} = 7.51$, $P < 0.05$; not sig. for sites). Five species were only found to be more abundant in the suburban sites and are not dominating exurban sites to the same extent. These are Oak Titmouse ($F_{2,9} = 7.86$, $P < 0.05$; not sig. for sites), Western Scrub-Jay ($F_{2,9} = 33.41$, $P < 0.001$), Northern Mockingbird ($F_{2,9} = 5.77$, $P < 0.05$), American Crow ($F_{2,9} = 7.13$, $P < 0.05$), and Turkey Vulture ($F_{2,9} = 6.29$, $P < 0.05$). Lastly, one species had a different abundance pattern from any other species that responded to exurban development. Steller's Jays were significantly less abundant in exurban sites, compared to undeveloped and suburban sites ($F_{2,9} = 13.67$, $P < 0.01$; not sig. for sites).

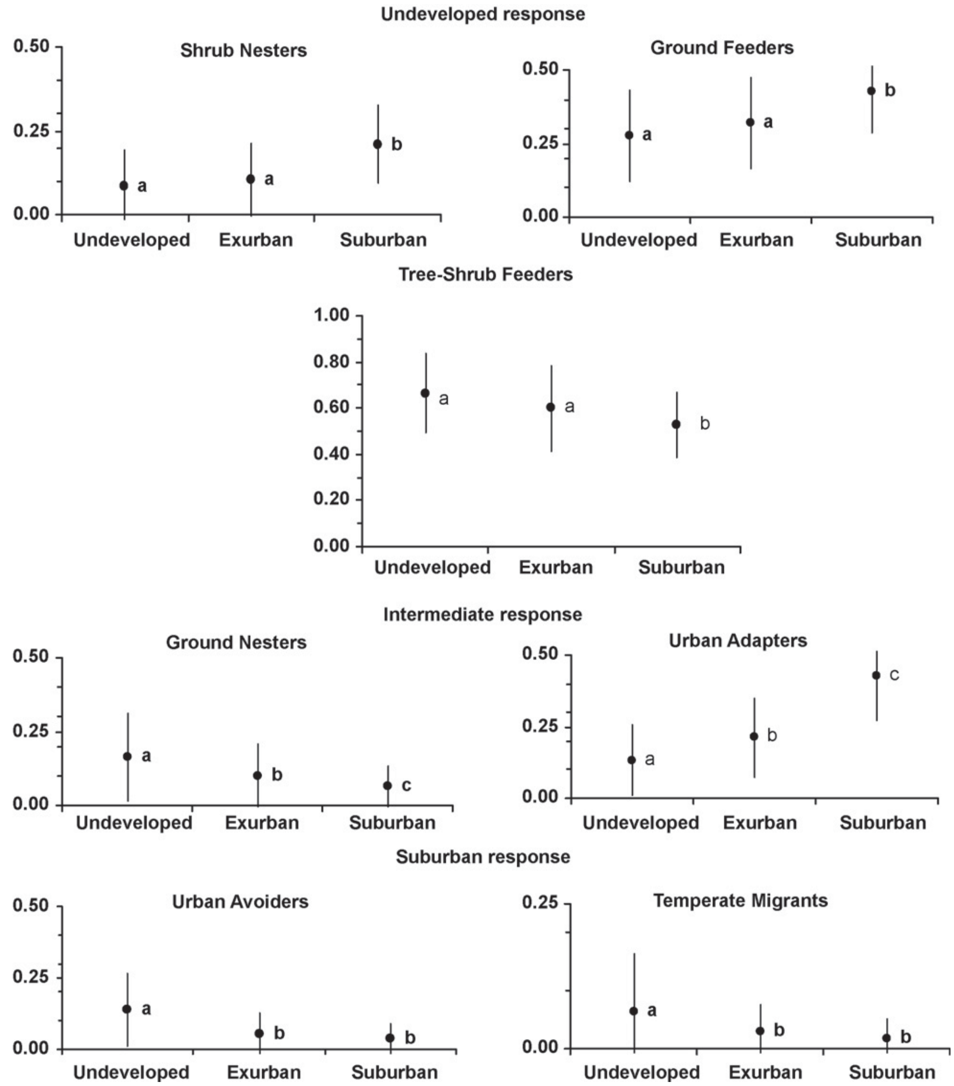

Fig. 3. Guild comparisons among land-use types. The proportions of total detections in each guild are represented on the *y*-axis; points represent the means and bars the standard deviations. The species assemblages are clustered as whether the proportion of detections in exurban sites was similar to the undeveloped sites (undeveloped response) or intermediate between undeveloped and suburban (intermediate response), or not significantly different from the suburban sites (suburban response); with different letters indicate significant differences between treatments.

4. Discussion

Despite high variability among sites, analysis of our 5-year bird survey effort demonstrated significant differences among the three land-use treatments. The landscape variables offered little explanatory power when trying to partition the variance observed in bird communities (Fig. 2). The larger landscape variables taken from 500 m surrounding each sampling point do result in some spatial autocorrelation that can overestimate the effect of habitat when developing predictive models using regression analysis. However, removing this type of autocorrelation did not influence predictive models for forest birds (Betts et al., 2006).

Our results reveal how groups of species responding to exurban development compare to more developed suburban areas and undeveloped wildlands. For example, the proportion of detections of temperate migrants was two times greater in the undeveloped than the exurban sites and three times greater than the suburban sites, with no significant effect of differences among sites, highlighting the importance of protecting core woodlands from exurban development.

The proportion of detections of tree-and-shrub feeders at exurban sites was similar to that detected in undeveloped sites; while the relative abundance of ground nesters detected fell in between that observed at suburban and undeveloped sites. These ground nesters are likely more susceptible to predation by non-native animals such as cats, dogs, and rats which are more frequently detected near homes (Odell and Knight, 2001; Lenth et al., 2006). Adverse impacts of domestic cats on birds are well-documented (Burbidge and Manly, 2002; Churcher and Lawton, 1987). Shrub nesters and ground feeders, however, such as the California Towhee, comprised a larger part of the bird community at the suburban sites which had higher overall shrub cover than larger, less-developed parcels (Merenlender et al., 1998). The ground feeders may be taking advantage of supplemental feeding by suburban residents.

The proportion of the bird community comprised of urban avoiders was similarly low in both the exurban and suburban sites (Fig. 3), and we expect that the species listed as urban avoiders will be negatively impacted by additional development of low-density housing that has been forecasted for the Mayacamas range (Merenlender et al., 2005). Urban adapter species comprised

Table 2
Mean (s.d.) proportion of bird detections in each guild, by land-use treatment, with results for nested ANOVA analyses for treatment- and site-level effects.

Guild	Undeveloped	Exurban	Suburban	Treatment		Site	
				$F_{2,9}$	P	$F_{9,84}$	P
Nest type							
Cavity	0.338 (0.200)	0.394 (0.169)	0.357 (0.145)	1.55	0.264	4.29	<0.001
Open cup	0.516 (0.185)	0.426 (0.177)	0.498 (0.153)	2.96	0.103	5.25	<0.001
Nest location							
Cliff/ledge	0.053 (0.072)	0.057 (0.095)	0.073 (0.082)	1.17	0.354	4.83	<0.001
Ground	0.164 (0.149)	0.100 (0.105)	0.064 (0.067)	7.26	0.013	2.94	0.004
Shrub	0.083 (0.109)	0.102 (0.109)	0.210 (0.115)	7.34	0.013	7.32	<0.001
Tree canopy	0.729 (0.171)	0.776 (0.150)	0.767 (0.115)	0.73	0.507	4.60	<0.001
Feeding location							
Ground	0.276 (0.155)	0.321 (0.155)	0.427 (0.139)	21.73	<0.001	1.49	0.166
Tree/shrub	0.664 (0.174)	0.598 (0.188)	0.528 (0.140)	26.12	<0.001	0.58	0.809
Aerial	0.063 (0.102)	0.102 (0.126)	0.079 (0.091)	0.12	0.888	59.48	<0.001
Water	0.003 (0.023)	0.002 (0.017)	0	0.50	0.621	2.46	0.015
Migratory status							
Neotropical migrant	0.211 (0.198)	0.231 (0.179)	0.133 (0.107)	0.94	0.425	12.14	<0.001
Temperate migrant	0.063 (0.101)	0.029 (0.047)	0.018 (0.034)	9.48	0.006	1.49	0.164
Resident	0.726 (0.218)	0.740 (0.184)	0.849 (0.114)	2.35	0.151	7.95	0.000
Origin							
Native	0.985 (0.050)	0.975 (0.062)	0.965 (0.065)	1.20	0.346	5.32	<0.001
Exotic	0.015 (0.050)	0.025 (0.062)	0.035 (0.065)	1.20	0.346	5.32	<0.001
Human association							
Urban adapter	0.132 (0.123)	0.212 (0.137)	0.429 (0.156)	40.65	<0.001	3.66	0.001
Urban avoider	0.139 (0.128)	0.055 (0.072)	0.038 (0.052)	12.68	0.002	3.67	0.001

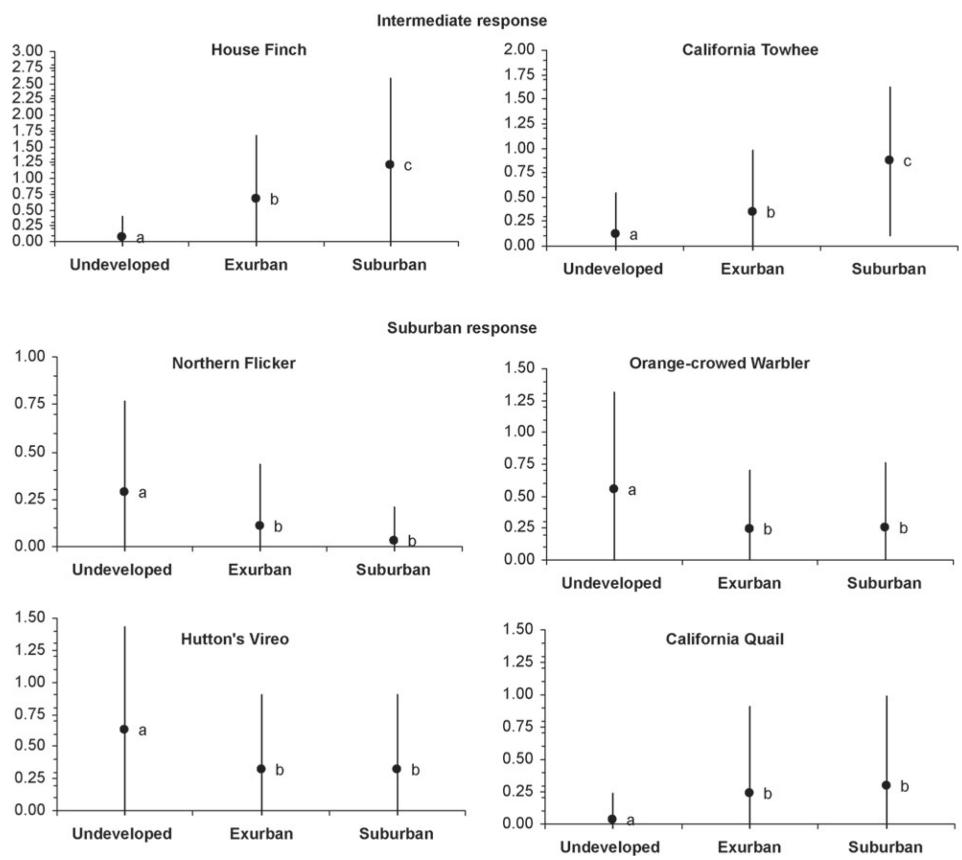

Fig. 4. Comparisons among land-use types for a subset of individual species. Points represent mean numbers of detections (values along the *y*-axis) by land-use treatment each year, and bars represent the standard deviations around the means. The species are clustered as whether the relative abundance detected in exurban sites was intermediate between undeveloped and suburban (intermediate response) or not significantly different from the suburban sites (suburban response); with different letters indicate significant differences between treatments. The other urban adapters (Oak Titmouse, Western Scrub-Jay, Northern Mockingbird, American Crow, and Turkey Vulture) demonstrated a suburban response (not shown).

approximately 10% of detections in the undeveloped sites, while their proportion was twice as great in the exurban and over four times as great in the suburban sites.

Individual species that respond to development densities in the same manner as the entire assemblage of urban avoiders and urban adapters have the potential to serve as good indicator taxa (Hilty and Merenlender, 2000). Approximately half of the urban adapter species were found at intermediate levels of abundance in exurban sites, leading us to conclude that species such as House Finch and California Towhee appear to be good indicators of intermediate disturbance. However, some urban adapters only reach significantly higher levels of relative abundance in dense housing areas, including Oak Titmouse, Western Scrub-Jay, Turkey Vulture, Northern Mockingbird, and American Crow. The Oak Titmouse is a common resident in oak woodlands, and researchers have noted them as urban adapters in other regions of California (Blair, 1996). Western Scrub-Jay (Blair, 1996; Stralberg and Williams, 2001), California Quail (Blair, 1996), House Finch (Blair, 1996; Bolger et al., 1997; Stralberg and Williams, 2001), Northern Mockingbird (Blair, 1996; Bolger et al., 1997), and California Towhee (Blair, 1996) have also been reported as urban adapters. We were not surprised to find that Western Scrub-Jay and American Crow were species more commonly found in Sonoma County's suburbs. Turkey Vultures were also more commonly found in suburbs, which could be related to increased detectability of this species in the open sky and roads associated with suburban environments. The magnitude of differences in the abundances of urban adapter species among land-use treatments far exceeded the magnitude of any suspected bias in detectability attributable to local woodland structure.

Northern Flickers, Orange-crowned Warblers, and Hutton's Vireos were all significantly more abundant in undeveloped sites as compared to exurban sites, and may make good indicators for the entire suite of urban avoiders. Our findings are consistent with prior studies which have identified Hutton's Vireo (Blair, 1996; Stralberg and Williams, 2001) and Orange-crowned Warblers (Stralberg and Williams, 2001) as urban avoiders or woodland associates. If any bias between detection rates among treatments did occur it did not hamper our ability to detect trends for species that were most abundant in the undeveloped sites, where tree density was highest, so we can be confident in the results for the urban avoider species noted above. Species other than those discussed here may be equally or more sensitive to development densities, but because of their low detection rates we were not able to establish a significant relationship between abundance and treatment.

5. Conclusions

We demonstrate that exurban development is differentially impacting certain bird species and assemblages. In some cases the impacts of exurban development can be as significant as that observed in suburban areas but this is not necessarily so for all taxa. The research presented here suggests that parcel size can be applied as a measure of disturbance that has consequences for bird communities, since the land-use types we compared relate back to overall parcel size classes and residential zoning classes.

The subdivision of rural parcels is generally under the jurisdiction of local counties in the United States (Theobald et al., 2000) and it can be difficult to reduce development densities on existing large private parcels through zoning regulations because of the loss in land value that can result and may require compensation (Richardson, 2003). More popular is an incentive-based approach generally implemented through conservation easements (Merenlender et al., 2004). Purchasing development rights before large parcels become fragmented by rural residential development can be an effective way to conserve sensitive species such as Hutton's Vireo, Orange-crowned Warbler, and Northern Flicker.

Unfortunately the drivers that create demand for rural residential development do not disappear when land is purchased for protection against development (Newburn et al., 2005). As a result, this type of development is pushed to other areas not currently protected. Therefore, it is important that we encourage local governments to invoke fees and taxes to pay for enacting nature-friendly policies (Brueckner, 2000) and promote high-density development within city service boundaries to minimize the continued subdivision of large, privately owned wildland parcels. Short of changing zoning regulations, one of the most common ways to prevent further subdivision of large, privately owned land parcels is through trading development rights; this process involves the sale of development rights, usually from designated "sending" areas and allows for more development than is currently zoned for in designated "receiving" areas (Johnston and Madison, 1997). More policy options and incentives are needed to curtail low-density residential expansion throughout the developed world where the demand for exurban development is high and existing land-use policies rarely provide the necessary controls.

Acknowledgements

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Attachment 3

Stralberg and Williams 2002

Effects of Residential Development and Landscape Composition on the Breeding Birds of Placer County's Foothill Oak Woodlands[1]

Diana Stralberg[2] and Brian Williams[3]

Abstract

This study examines the effect of rural residential development and landscape composition on breeding birds in Placer County's foothill oak woodlands. Point count survey data were used to construct generalized linear models for individual species' abundance or probability of occurrence, based on two sets of variables: GIS-derived landscape characteristics, including development density, oak woodland proportion, and habitat diversity; and field-collected local habitat parameters. We found that many species examined were sensitive to either development density or landscape composition at some distance between 250 and 4,000 m. Of the 48 breeding species common enough to analyze statistically, the occurrence of 24 species was significantly associated with landscape characteristics. Species shown to be associated with development density and/or urban edge proximity included the lark sparrow (-), Rufous-crowned sparrow (-), western meadowlark (-), black Phoebe (+), house finch (+) and western scrub-jay (+). Several other species were not development-sensitive but were positively associated with the proportion of oak woodland found in the surrounding landscape. For a subset of locations, some species also exhibited responses to local habitat variables, suggesting that further investigation of the importance of landscape vs. local factors is warranted. The diversity of responses observed across a range of species requires the recommendation of a multifaceted conservation strategy for oak woodland birds and their habitat.

Introduction

Placer County's human population is the fastest growing in California, with a growth rate of 3.5 percent in 2000 (California Department of Finance 2001). Much of this population growth is occurring in the county's foothill oak woodlands, 93 percent of which are privately owned and over 50 percent of which (30,000+ acres) have rural residential or urban land-use designations (Placer Legacy 2000). Concern about this rapid growth and the loss of open space and rural character led to the development of the Placer Legacy Open Space and Agricultural Conservation Program, which seeks to balance growth with the conservation of open space and wildlife resources. Because foothill oak woodlands are rapidly urbanizing and poorly protected, though treasured for their scenic and wildlife values, much of the program's early emphasis has focused on acquiring one or more large parcels to preserve oak woodlands. In addition, the County is interested in understanding how

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[1] An abbreviated version of this paper was presented at the Fifth Symposium on Oak Woodlands: Oaks in California's Changing Landscape, October 22-25, 2001, San Diego, California.

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the rural residential landscape can be better managed to preserve wildlife, sensitive resources and water quality. This project was initiated as a part of the Placer Legacy Program as an effort to assess the effects of rural residential development and habitat fragmentation on breeding birds as indicators for oak woodland habitat.

Habitat suitability for wildlife is an important consideration in reserve design, and local habitat relationships are relatively well studied in California's foothill oak woodlands (Avery and Van Riper 1990, Block 1989, Block and Morrison 1990, Block and others 1994, Tietje and others 1997, Verner and others 1997, Wilson and others 1991). Recently, much attention has also been focused on the potential effects of rural residential development, vineyard expansion and other human modifications to oak woodland landscapes. In Sonoma County, Merenlender and others (1998) found that the level of development of a parcel influences bird community composition and that neotropical migrants in particular demonstrate reduced abundances in suburban areas and, to a lesser extent, rural residential areas. Several recent studies of birds in other California habitats have suggested that characteristics of the surrounding landscape may influence habitat quality for many species and, in some cases, may even be better predictors of species occurrence than local habitat structure (e.g., Bolger and others 1997, Stralberg 1999). Currently, a need remains for a better understanding of landscape-scale processes that affect habitat suitability of oak woodlands beyond local habitat structure (Bell 1997, Garrison and Davis 1997, Thomas 1997). Such knowledge may be particularly valuable when candidates for reserves are structurally similar, as they are in foothill oak woodlands of Placer County.

We initiated this study to test the hypothesis that some birds will be affected by landscape-scale patterns of development irrespective of local habitat. One primary objective is to provide specific recommendations to the County of Placer regarding priorities for management, conservation and acquisition of foothill oak woodlands, as well as future zoning decisions and general plan revisions. We also hope to gain a better general understanding of the features of habitat and landscape patterns that determine species occupancy, in order to inform land-use planning and conservation, as well as wildlife management on private and public land. This may be accomplished in part through future revisions to the California Partners in Flight (CPIF) Oak Woodland Bird Conservation Plan (Zack and others 2000), an interagency effort to promote the conservation of migratory birds and their habitats throughout the Americas.

Methods

Study Area

Our study area in western Placer County ranged in elevation from 70 to 480 meters, and encompassed an area of approximately 550 km^2 (*fig. 1*). Dominant tree species included blue oak (*Quercus douglasii*), which occurs primarily on drier sites (especially ridges that were historically difficult to irrigate), and interior live oak (*Quercus wislizenii*), which tends to occur in more mesic areas such as drainage basins and north-facing slopes. A complex human history has altered the distribution and structure of many of these oak woodlands, including their understory structure and composition. Interspersed with oak woodlands is a combination of orchards, cropland, dry pasture rangeland, irrigated pasture, rural residential development (“ranchettes”), and urban and suburban development.

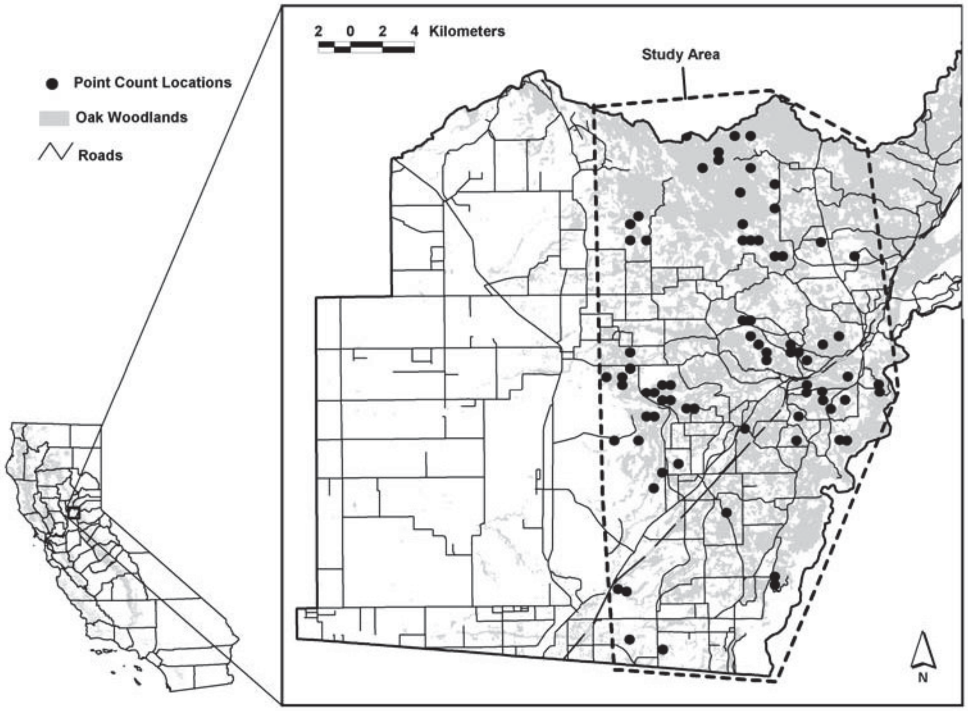


Figure 1—Study area and point count locations.

In Placer County, large intact blocks of oak woodland are rare, and habitat patches are not easily defined or necessarily isolated from other habitat patches. We therefore chose a point-based approach for sampling habitat, rather than surveying entire habitat patches. Our intent was to sample bird species at random throughout a representative cross-section of the County's development spectrum: from urban park to rural residential to largely undeveloped rangeland.

Study Design and Point Selection

A total of 75 points was surveyed. We began by selecting a stratified random sample of 80 potential survey points by generating a 500-m sampling grid of points superimposed over the county's oak woodlands within the study area. Suitable points (>2,600) were defined as meeting one of the following CWHR habitat classifications (Mayer and Laudenslayer 1988) according to GIS vegetation data (Forest Service 2000): blue oak woodland or blue oak foothill pine, but also montane hardwood, urban, annual grassland, valley-foothill riparian or agricultural cropland if our familiarity with the area suggested that the amount of oak woodland at or adjacent to the point was underestimated. Selected points were stratified by general plan land-use categories (Placer County General Plan 1994): (1) Low Density Residential (LDR) and Rural Residential (RR) 1-2.5 acres; (2) RR 2.5-5 and RR 5-10; (3) RR 10, Agricultural (Ag) 10, and Ag 20; and (4) Ag 40, Ag 80, and Open Space (OS). Actual land use varied considerably from the General Plan designation because many parcels were not yet "built out," but this method allowed representation of a range of land uses and parcel sizes, as well as geographic area, among sample points.

To improve our sampling effectiveness, we developed a random clustering technique that began by randomly choosing one of nine 7.5 ft topographic map quadrangles followed by the random selection of a legal section (1 mi^2 or 2.59 km^2) as a starting point. We then randomly chose points from the 500-m sampling grid within immediately adjoining sections, expanding the radius by 1 section as each layer of sections was exhausted. Constraints were that no more than 4 points could fall within one section and no more than 2 points of a given land-use category could occur in any one section. This process was repeated to produce two random sets of 40 semi-clustered points, each at least 500 m from the nearest sampling point.

Because the first 80 points included no parcels zoned for 80 acres and very few parcels smaller than 5 acres, we randomly selected an additional 22 points within these parcel size ranges (10 and 12 points, respectively). Each point was ground-truthed to meet the following minimum criteria: (1) oak woodland as the dominant habitat type, with at least two oaks within the 50-m radius and a canopy cover ≥ 10 percent; (2) no house or other large building within a 50-m radius; (3) not within 500 m of a major highway; (4) not excessively time-consuming to access; and (5) <5 percent paved two-lane public road within a 50-m radius (private single-lane dirt roads were fairly common and practically impossible to exclude). We did not exclude any points based on other habitat characteristics such as presence of water, understory composition, slope or aspect.

Of these original 122 locations, we were able to obtain access to 57 survey sites. The other 45 were either unsuitable (n = 16), or we were unable to contact the landowners (n = 15), or we were denied access (n = 8), or negotiating access was too time-consuming (n = 6). We repeated the selection process to find 6 stratified-random substitute points, identified 6 points semi-randomly (randomly chosen within a non-random area that was convenient to access), and added 6 points at widely separated urban parks for which we knew we could get immediate access. Within each park, the specific sample point was randomly determined in the field. The exact location of each site was later recorded with a Global Positioning System (to within approximately 5-15 m).

Bird Counts

Six-minute, unlimited-distance point counts (Ralph and others 1993) were done twice at each of the 75 sites, 7-28 days apart (mean = 16 days, SD = 4.4). Detections were recorded as within or beyond a 50-m radius. We assumed that 2 counts would be necessary to avoid problems with seasonal variation in vocalization frequency and hence detection probability. Point counts were done in the morning beginning at official sunrise to 4 hours after sunrise, during appropriate weather conditions (Verner 1985) between 17 May and 14 June 2001 by a single expert observer (B. Williams).

Habitat Parameters

We measured or estimated parameters describing the local habitat and physical conditions at 32 of the 75 point count locations *(appendix 1)*. The intent was to statistically control for habitat-specific variation to focus on landscape-scale effects.

Landscape Parameters Obtained from GIS Data

We calculated several urbanization and landscape composition metrics *(appendix 2)* for each point-count location using ArcView 3.2a and the Spatial Analyst Extension (ESRI 2000). The County's parcel base map and associated Assessor's database were used to determine the parcel size and overall property size of each site surveyed. In addition, the number of structures within various buffer distances (250 m, 500 m, 1000 m, 2000 m and 4000 m) of each point-count location was estimated based on the development status of each parcel centroid. Because structure locations were estimated based on parcel centroids, there is some uncertainty in the number of structures counted within point count radii. Furthermore, while the bird and vegetation data were collected in 2000, the parcel base map represents July 1998 parcels and the Assessor’s database contains 1999 ownership information (matching years were not available at the time of analysis). Thus, parcels that were subdivided and developed after 1998 are not correctly represented in this database. The parcel data are nevertheless a major improvement over any other available urbanization measure (i.e., Forest Service vegetation data), particularly in the rural residential zone, where the built footprint is not easily discernable even from aerial photos. As an index of housing density, we feel this measure is the best available, short of ground-based inventories.

Geographic information system (GIS) vegetation data (Forest Service 2000, 2.5 acre minimum mapping unit) were then used to coarsely determine the landcover composition of each point count location within circles of increasing radius: 250 m, 500 m, 1,000 m, 1,500 m, 2,000 m and 4,000 m. A proportion was obtained for each cover category within each radius. For analysis, the following CWHR categories were combined to calculate oak woodland coverage: blue oak woodland, blue oak-foothill pine, valley oak woodland, montane hardwood, and montane hardwood-conifer. Finer distinctions between oak woodland categories were not made due to the presumed low accuracy of the vegetation layer beyond cover class. The other category used for analysis was annual grassland, some of which was actually open oak savanna. The urban classification was not used in analysis due to the coarseness of this vegetation layer with respect to rural residential development patterns, particularly in comparison with the more accurate parcel base map and Assessor’s database (*fig. 2*). To evaluate the influence of landscape-level habitat diversity, we also calculated a Shannon-Wiener diversity index (Krebs 1989) for each of the above-listed radii ($H = - \Sigma_i \, p_i \ln(p_i)$, where p_i = area of i^{th} habitat type). For this metric, each CWHR category was treated separately to reflect diversity among oak woodland as well as other habitat types.

Finally, for each point we estimated the distance to the nearest structure or urban edge, using a combination of field notes, aerial photos and the GIS parcel basemap with associated Assessor’s ownership database (in that order, depending on availability). We also used 1:100,000 scale road and hydrography GIS datasets (Teale Data Center 1997, 1999) to calculate the distance from a point count to the nearest stream and nearest paved road.

A.

B.

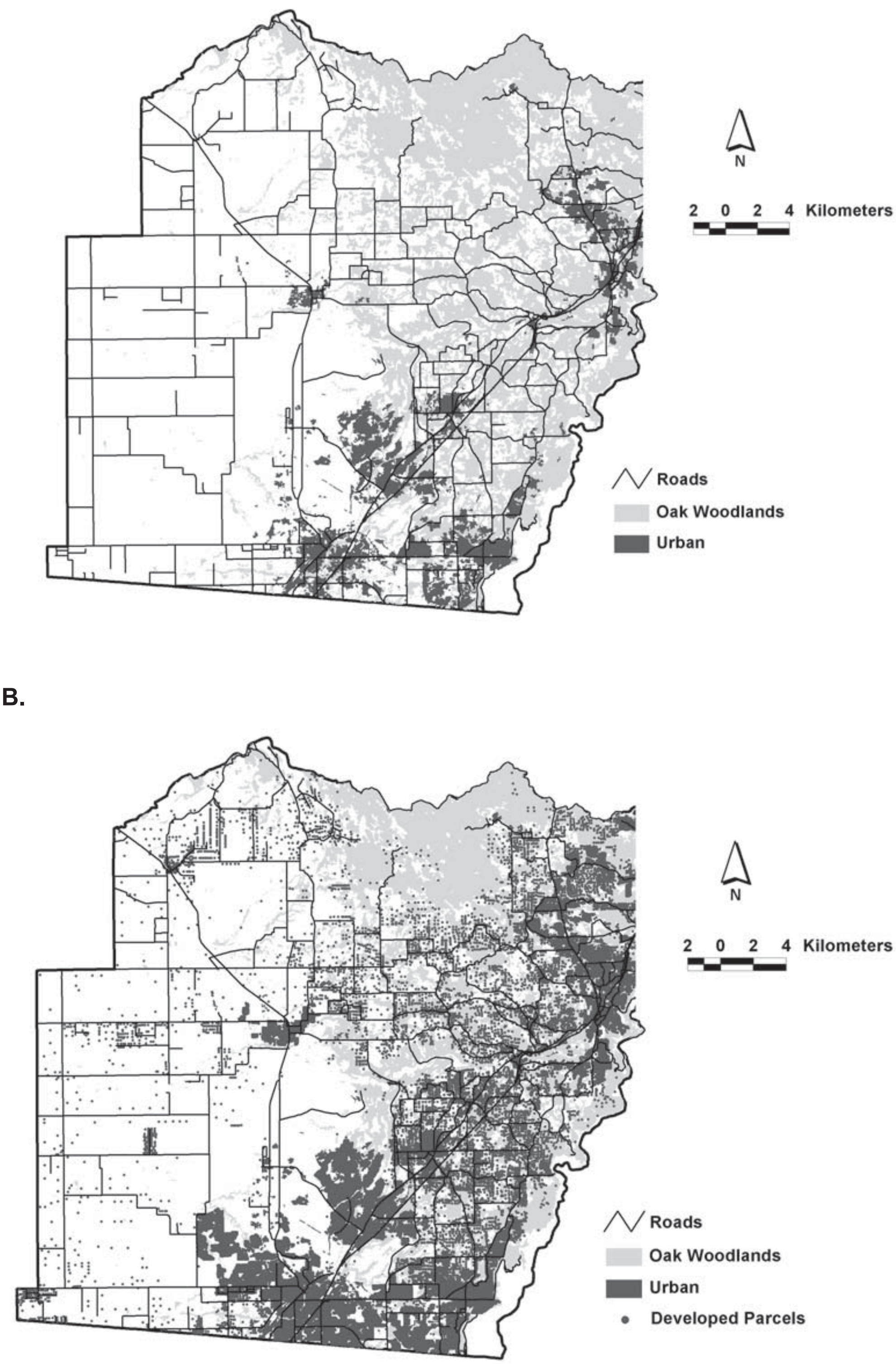


Figure 2—Differences in urban development identified by GIS vegetation data (Forest Service 2000) (a) and Placer County parcel base map and Assessor's database (Placer County 1999) (b).

Statistical Analysis

Species detected within 50 m at seven or more (10 percent) of the 75 sites throughout the sampling period were analyzed individually with respect to per point abundance or probability of occurrence. Because counts of most species had positively skewed distributions, we used generalized linear models with either a Poisson distribution and log link function or binomial distribution and logit link function (logistic regression). Poisson was the default model, but logistic regression was used for species that tended to exhibit low numbers or aggregated abundances (Hayek and Buzas 1997). Models were constructed and evaluated using Stata Version 7 (StataCorp 2000). Because many species had low detection rates within a 50-m radius *(appendix 3)* we also analyzed all detections with respect to probability of occurrence using logistic regression, statistically controlling for distance to the nearest urban edge, which at some point-count locations was within the range of bird detections (100 m or less for most species), potentially reducing the available habitat surveyed. We applied the same detection rate criterion (species occurring at 10 percent of sites or more) when analyzing all detections (unlimited distance).

To evaluate the influence of development density at various scales on bird abundance, we calculated Spearman rank correlation coefficients for each individual species and the number of structures within measurement radii of 250, 500, 1,000, 2,000 and 4,000 m. We selected landscape variables at the scales with the highest significant correlation ($P<0.05$) with bird abundance for inclusion in our initial model. Variables were included at more than one scale if graphing of correlation coefficients against measurement radius indicated more than one local maximum. We also included other landscape variables with significant Spearman correlations (distance to nearest road, distance to nearest creek or open water, elevation, parcel size and property size).

Using the subset of variables described above (pairwise correlations significant, $P<0.05$), we initially used a stepwise Poisson or logistic regression analysis (backward elimination, $P<0.15$) to select an appropriate model for each species. Variables with *P*-values greater than 0.05 were dropped or retained based on AIC (Akaiki's Information Criterion) comparisons with simpler models. Final models were considered significant at $P<0.01$ based on the likelihood ratio χ^2 statistic. To determine the robustness of our models, we calculated bootstrap estimates of coefficients and standard errors (200 repetitions, n=75) for each significant final model, scaling down models as necessary.

To translate results into terms meaningful to municipal planners and policymakers, we selected two development-sensitive species and calculated predicted bird abundances under existing general plan designations (as defined above).

To compare the effects of local and landscape-level variables, we constructed generalized linear models of habitat suitability for each species, using a subset of 32 sites for which local habitat variables were recorded. Again, Spearman rank correlations between species and habitat variables were used to determine significant ($P<0.05$) variables for inclusion in initial models. A stepwise regression analysis (backward elimination, $P<0.15$) using a subset of habitat variables (with models specifying the same distribution as in the analysis of landscape-level variables) was used to find the best-fitting (using AIC) significant model ($P<0.01$). Habitat models were constructed using only detections ≤ 50 m. For each significant final model, we also calculated bootstrap estimates of coefficients and standard errors (200 repetitions, n=75).

Results

Ninety-three species were detected in two visits to the 75 sites, approximately 76 of which are known or suspected to be local breeders. Limiting analysis to detections within 50 m resulted in 64 locally breeding native species. With respect to migratory status, 21 were neotropical migrants, 23 were short-distance migrants, and 22 were native residents. Nesting guilds were represented by 16 cavity nesters and 35 open cup nesters, 5 of which nest on the ground *(appendix 3)*.

Landscape-Level Associations

Using generalized linear models for detections within 50 m, landscape characteristics combined explained up to 41 percent of the variation in species abundance or probability of occurrence as measured by pseudo-R^2 values (*table 1*). Species best predicted by landscape characteristics (significant bootstrap model with pseudo-R^2 greater than 0.15) were: black Phoebe, Hutton's vireo, western scrub-jay, spotted towhee, Rufous-crowned sparrow, lark sparrow, black-headed grosbeak and house finch. Development density at some scale was a significant explanatory factor for black Phoebe (+), tree swallow (-), western scrub-jay (+), Rufous-crowned sparrow (-), lark sparrow (-) and house finch (+). For tree swallow and Rufous-crowned sparrow, however, development density did not remain a significant factor in models based on bootstrap resampling trials. The violet-green swallow was positively associated with property size, while the black Phoebe and western scrub-jay were negatively associated with parcel size, but these parameters did not remain significant in bootstrap models for any species.

Table 1—*Significant (*P *< 0.01) regression model results for landscape-level variables (detections limited to within 50 m).*[1, 2]

Species	Model type	Pseudo-R^2	LR Chi^2	*P*	AIC	Landscape variables	Coeff.	Std.Err	*P*
BCHU	Logistic	**0.13**	**9.28**	**0.0023**	**0.85**	**GRS500**	**-6.613**	**2.690**	**0.014**
								(2.679)	(0.014)
BLPH	Logistic	**0.25**	**18.04**	**<0.0001**	**0.78**	**DEV250**	**0.188**	**0.055**	**0.001**
		(0.41)	(28.01)		(0.63)		(0.159)	(0.055)	(0.004)
						Parcel size	(-0.078)	(0.043)	(0.072)
WEKI	Poisson	(0.22)	(17.53)	(<0.0001)	(0.89)	GRS4000	(9.614)	(2.396)	(<0.001)
HUVI	Logistic	**0.18**	**11.99**	**0.0025**	**0.80**	**OAK250**	**4.306**	**2.354**	**0.067**
								(2.104)	(0.041)
						H2000	**4.457**	**2.262**	**0.049**
								(1.905)	(0.019)
TRES	Poisson	(0.28)	(13.44)	(0.0012)	(0.55)	DEV4000	(-1.5E-03)	(6.9E-04)	(0.031)
						GRS4000	(7.252)	(3.413)	(0.034)
VGSW	Poisson	(0.18)	(14.19)	(0.0008)	(1.18)	OAK4000	(4.600)	(1.555)	(0.003)
						Property size	(0.005)	(0.002)	(0.025)
CLSW	Poisson	**0.09**	**5.30**	**0.0214**	**1.62**	**GRS250**	**3.500**	**1.267**	**0.006**
		(0.25)	(36.77)	(<0.0001)	(1.52)		(2.589)	(0.736)	(<0.001)
						OAK4000	(-3.9E-0)	(1.2E-0)	(0.002)
WESJ	Poisson	**0.19**	**36.55**	**<0.0001**	**2.08**	**DEV250**	**7.1E-02**	**1.5E-02**	**<0.001**
		(0.22)	(41.90)		(2.05)		(6.4E-02)	(1.1E-02)	
						Parcel size	(-0.005)	(0.003)	(0.050)
AMRO	Logistic	**0.13**	**6.71**	**0.0096**	**0.64**	**H250**	**2.856**	**1.241**	**0.021**
								(1.210)	(0.018)
OCWA	Logistic	**0.10**	**8.66**	**0.0033**	**1.04**	**OAK4000**	**4.999**	**1.696**	**0.003**
								(2.670)	(0.008)
SPTO	Logistic	**0.27**	**21.59**	**<0.0001**	**0.86**	**OAK4000**	**6.667**	**2.461**	**0.007**
								(2.404)	(0.006)
						H2000	**7.167**	**2.459**	**0.004**
								(2.179)	(0.001)
RCSP	Logistic	**0.20**	**12.23**	**0.0005**	**0.72**	**GRS1000**	**-8.818**	**4.169**	**0.034**
		(0.36)	(22.81)	(<0.0001)	(0.64)		(-7.073)	(3.280)	(0.031)
						H4000	(6.222)	(2.704)	(0.021)
						DEV250	(-0.277)	(0.161)	(0.086)
LASP	Poisson	**0.22**	**29.57**	**<0.0001**	**1.45**	**DEV1000**	**-0.018**	**0.007**	**0.012**
								(0.006)	(0.003)
						Stream distance	**9.2E-04**	**4.7E-04**	**0.049**
								(3.4E-04)	(0.006)
BHGR	Logistic	**0.19**	**11.14**	**0.0008**	**0.69**	**Elevation**	**0.004**	**0.001**	**0.001**
									(0.004)
LAZB	Poisson	**0.12**	**14.79**	**0.0001**	**1.46**	**OAK4000**	**4.364**	**1.245**	**<0.001**
								(1.154)	
RWBL	Logistic	(0.21)	(8.87)	(0.0029)	(0.49)	Stream distance	(2.3E-03)	(8.4E-04)	(0.008)
HOFI	Logistic	**0.26**	**26.66**	**<0.0001**	**1.11**	**DEV250**	**0.162**	**0.062**	**0.009**
								(0.070)	(0.021)
						DEV4000	**4.4E-04**	**1.6E-04**	**0.007**
								(1.9E-04)	(0.023)

[1] Bold parameter estimates and model diagnostics are based on bootstrap resampling trials. Numbers in parentheses represent parameter estimates and diagnostics from non-bootstrap models.
[2] See *appendix 2* for definitions of landscape variables and *appendix 3* for species names.

When all detections were analyzed, several additional species exhibited significant responses to landscape characteristics, with logistic regression models explaining up to 54 percent of the variation in probability of occurrence (*table 2*). In addition to the above-listed species, the presence of black-chinned hummingbird, Pacific-slope flycatcher, ash-throated flycatcher, cliff swallow, yellow-billed magpie, northern mockingbird, orange-crowned warbler and western meadowlark were reasonably well-predicted by landscape factors (pseudo-R^2 greater than 0.15 for bootstrap models). The model for chipping sparrow was strong (pseudo-R^2 = 0.39), but due to low detection rates for this species (8 of 75 sites), parameter estimates did not withstand bootstrap resampling validation. Controlling for urban edge distance, the species for which development density at some scale was a significant predictor of occurrence were black Phoebe (+), ash-throated flycatcher (-), western kingbird (-), tree swallow (-), cliff swallow (+), western scrub-jay (+), Rufous-crowned sparrow (-), chipping sparrow (-), lark sparrow (-), Lazuli bunting (-), western meadowlark (-) and house finch (+). For the three sparrow species, development density did not remain significant in bootstrap models, although the Rufous-crowned and lark sparrows did demonstrate an urban edge aversion (positive association with edge distance). Species demonstrating an affinity for urban edges (negative association with edge distance) were black Phoebe, house wren, and American robin, while the northern mockingbird was negatively associated with property size, a more local index of development density.

Species that were positively associated with oak woodland proportion or negatively associated with grassland proportion at one or more scales (validated by bootstrap resampling) were black-chinned hummingbird, Pacific-slope flycatcher, ash-throated flycatcher, Hutton's vireo, orange-crowned warbler, Rufous-crowned sparrow, Lazuli bunting and spotted towhee (*tables 1 and 2*). Negatively associated with oak woodland proportion or positively associated with grassland proportion (after bootstrap resampling) were western kingbird, yellow-billed magpie, cliff swallow, western scrub-jay and American crow (*tables 1 and 2*). Several species—the mourning dove, Pacific-slope flycatcher, Hutton's vireo, American robin, orange-crowned warbler, spotted towhee and Rufous-crowned sparrow—were all positively associated with habitat diversity (Shannon-Wiener H') in the surrounding landscape (after bootstrap resampling) (*tables 1 and 2*).

Finally, some species were associated with other landscape elements. Elevation was a significant predictor of yellow-billed magpie (-), house wren (-) and black-headed grosbeak (+) presence (after bootstrap resampling). Lark sparrows occurred more frequently at sites farther away from streams, while black-chinned hummingbirds and orange-crowned warblers were more likely to occur at sites closer to streams (*tables 1 and 2*).

Predicted abundances for two development-sensitive species (lark sparrow and western scrub-jay) were calculated under a range of development density scenarios (assuming constant development density) using the best model developed for each species' detections within 50m (other variables held constant at mean values). For the lark sparrow, predicted abundance (over two counts) dropped from 0.46 ± 0.23 at 40 acres per unit (Ag 40) to $7.02 \times 10^{-7} \pm 4.52$ at 1 unit per acre (RR 1.0). For the western scrub-jay, predicted abundance rose from 0.42 ± 0.20 at 40 acres per unit to 8.27 ± 0.43 at 1 unit per acre (*fig. 3*).

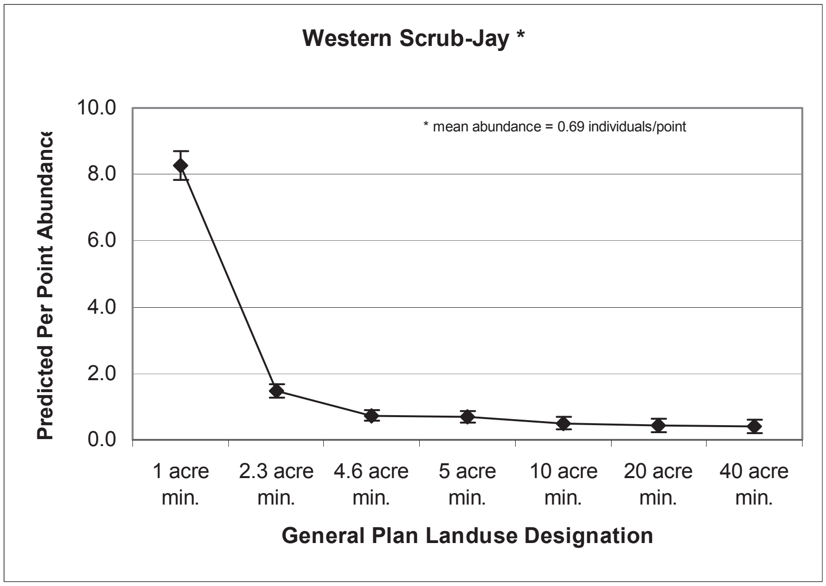
Table 2—*Significant (P<0.01) logistic regression model results for landscape-level variables (unlimited detections).* [1, 2]

Species	Pseudo-R^2	LR Chi^2	*P*	AIC	Landscape variables	Coeff.	Std.Err	*P*
MODO	0.13	12.71	0.0017	1.23	H250	-2.468	0.732 (0.793)	0.001 (0.002)
BCHU	0.23	15.97	0.0011	0.82	GRS500	-7.640	2.968 (3.688)	0.010 (0.009)
					Stream distance	-1.6E-03	8.4E-04 (8.2E-04)	0.066 (0.060)
PSFL	0.25	12.69	0.0018	0.59	H250	3.540	1.656 (1.346)	0.033 (0.009)
					OAK4000	5.665	3.13 (2.873)	0.070 (0.049)
BLPH	0.18	17.86	0.0001	1.18	DEV250	0.103	0.045 (0.055)	0.022 (0.063)
					Edge distance	-3.122	1.586 (1.954)	0.049 (0.110)
ATFL	0.27	24.73	0.0001	1.00	DEV500	-0.096	0.039 (0.031)	0.013 (0.002)
					OAK500	4.410	1.647 (1.603)	0.007 (0.006)
					DEV1000	0.012	0.007 (0.005)	0.062 (0.013)
WEKI	0.14	11.90	0.0026	0.99	DEV250	-0.118	0.067 (0.078)	0.077 (0.128)
					GRS250	3.306	1.590 (1.306)	0.037 (0.011)
HUVI	0.16	13.53	0.0012	1.03	OAK250	4.221	1.349 (1.696)	0.002 (0.013)
					H4000	3.458	2.297 (1.923)	0.132 (0.072)
TRES	0.14 (0.23)	9.47 (14.93)	0.0021 (0.0006)	0.81 (0.76)	DEV4000	-8.1E-04 (-1.3E-03)	4.2E-04 (4.5E-04)	0.043 (0.011)
					OAK4000	(-4.981)	(2.238)	(0.026)
CLSW	0.26	18.61	0.0001	0.79	DEV4000	3.7E-04	1.9E-04 (1.5E-04)	0.053 (0.011)
					GRS250	3.520	1.603 (1.400)	0.028 (0.012)
WESJ	0.21	19.67	0.0001	1.09	DEV500	0.059	0.030 (0.020)	0.049 (0.003)
					OAK500	-3.536	1.981 (1.469)	0.074 (0.016)
YBMA	0.20	15.38	0.0005	0.88	GRS500	3.570	1.907 (1.796)	0.061 (0.047)
					Elevation	-2.3E-03	1.2E-03	0.068 (0.060)
AMCR	0.16	14.71	0.0006	1.09	GRS1000	(4.209)	(1.940)	(0.030)
					Edge distance	(-6.572)	(2.639)	(0.013)

***Table 2** (cont.)*

Species	Pseudo-R^2	LR Chi^2	*P*	AIC	Landscape variables	Coeff.	Std.Err	*P*
HOWR	**0.13**	**13.63**	**0.0011**	**1.25**	**Elevation**	**-2.1E-03**	**8.9E-04** (8.3E-04)	**0.018** (0.012)
					Edge distance	**-3.363**	**1.684** (1.588)	**0.046** (0.034)
AMRO	**0.07**	**7.11**	**0.0077**	**1.31**	**Edge distance**	**-3.012**	**1.608** (1.388)	**0.061** (0.030)
NOMO	**0.27**	**24.20**	**<0.0001**	**1.07**	**Property size**	**-0.031**	**0.012** (0.011)	**0.008** (0.006)
OCWA	**0.33** (0.39)	**32.79** (38.60)	**<0.0001**	**0.98** (0.93)	**OAK4000**	**8.939** (13.364)	**3.124** (3.702)	**0.004** (<0.0001)
					H4000	**7.049** (6.964)	**2.773** (2.979)	**0.011** (0.019)
					Stream distance	**-1.6E-03** (-1.4E-03)	**8.8E-04** (6.8E-04)	**0.078** (0.033)
					Edge distance	(-3.273)	(1.462)	(0.025)
SPTO	**0.26**	**24.81**	**<0.0001**	**1.04**	**GRS500**	**-5.949**	**2.126** (2.149)	**0.005** (0.006)
					H2000	**4.965**	**1.980** (1.752)	**0.012** (0.005)
RCSP	**0.23** (0.28)	**17.88** (22.01)	**0.0001** (<0.0001)	**0.88** (0.85)	**H2000**	**4.499** (4.582)	**2.367** (1.709)	**0.057** (0.007)
					Edge distance	**4.108** (4.499)	**2.673** (1.707)	**0.124** (0.040)
					DEV250	(-0.222)	(0.149)	(0.136)
CHSP	(0.39)	(20.01)	(0.0002)	(0.54)	DEV250	(-0.926)	(0.543)	(0.088)
					H500	(-3.438)	(1.730)	(0.047)
					Elevation	(0.003)	(0.001)	(0.045)
LASP	**0.23** (0.28)	**22.74** (27.39)	**<0.0001**	**1.07**	**Stream distance**	**1.3E-03** (1.50E-03)	**6.2E-04** (5.8E-04)	**0.036** (0.010)
					Edge distance	**4.521** (2.839)	**2.280** (1.467)	**0.0547** (0.053)
					DEV250	(-0.178)	(0.099)	(0.072)
BHGR	**0.08** (0.12)	**7.63** (11.49)	**0.0058** (0.0032)	**1.24** (1.22)	**GRS1000**	**-4.185** (-5.790)	**1.824** (2.079)	**0.022** (0.005)
					Edge distance	(-2.002)	(1.080)	(0.064)
RWBL	(0.12)	(10.10)	(0.0064)	(1.11)	Stream distance	(1.4E-03)	(5.3E-03)	(0.008)
					Edge distance	(-2.388)	(1.413)	(0.091)
WEME	**0.26** (0.52)	**21.10** (42.01)	**<0.0001**	**0.84** (0.59)	**DEV2000**	**-0.007** (-0.015)	**0.002** (0.006)	**0.005** (0.017)
					GRS250	(9.017)	(2.946)	(0.002)
HOFI	**0.12**	**11.93**	**0.0026**	**1.19**	**DEV4000**	**5.5E-04**	**2.0E-04** (2.2E-04)	**0.007** (0.010)

[1] Bold parameter estimates and model diagnostics are based on bootstrap resampling trials. Numbers in parentheses represent parameter estimates and diagnostics from non-bootstrap models.
[2] See *appendix 2* for definitions of landscape variables and *appendix 3* for species names.



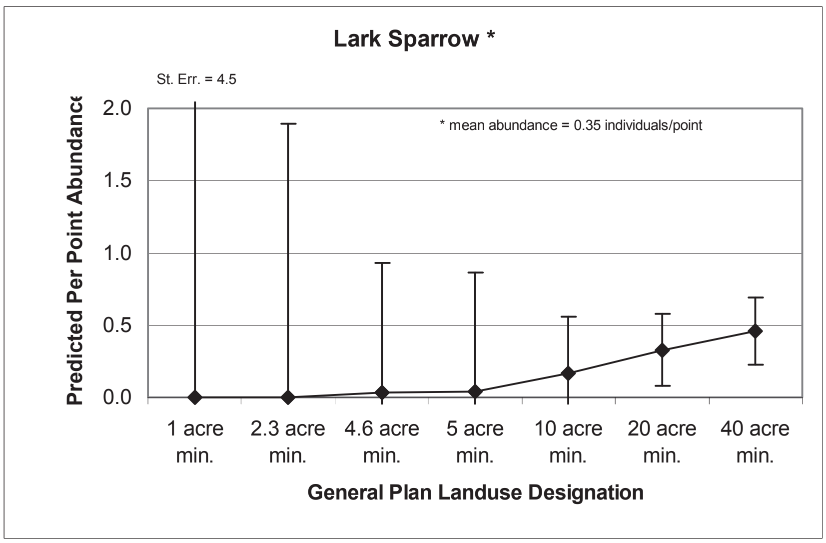


Figure 3—Predicted effects of housing density (by general plan land-use designation) on development-sensitive species.

Local Habitat Associations

Model results suggest that the occurrences of many species are significantly predicted by one or more habitat parameters (*table 3*). Due to low sample sizes, however, most of the final models were not sufficiently robust, as indicated by bootstrap resampling simulations. Species that were well-predicted by habitat variables (with bootstrap models significant at $P<0.01$) were, in order of model explanatory power (pseudo-R^2), western scrub-jay, orange-crowned warbler, Bewick's wren and brown-headed cowbird. Each of these species was predicted by different local habitat variables.

Table 3—*Significant (P < 0.01) regression model results for local habitat variables (detections limited to within 50 m).* [1, 2]

Species	Model type	Pseudo-R^2	LR Chi^2	P	AIC	Habitat variables	Coeff.	Std.Err	P
BCHU	Logistic	(0.34)	(13.03)	(0.0003)	(0.91)	# QW	(0.022)	(0.008)	(0.004)
ACWO	Poisson	(0.52)	(53.90)	(<0.0001)	(1.77)	Granary Tree	(3.581)	(0.578)	(<0.001)
						# QL	(0.202)	(0.057)	(<0.001)
NUWO	Poisson	(0.22)	(11.68)	(0.0029)	(1.50)	# QK	(-0.911)	(0.415)	(0.028)
						Grazing Level	(0.991)	(0.326)	(0.002)
HUVI	Logistic	(0.44)	(14.59)	(0.0007)	(0.79)	Percent Slope	(0.074)	(0.047)	(0.113)
						# QK	(1.113)	(0.498)	(0.025)
CLSW	Poisson	(0.49)	(26.65)	(<0.0001)	(1.06)	# QL	(0.182)	(0.061)	(0.003)
						Freq. Human Visits	(2.018)	(0.765)	(0.008)
WESJ	Poisson	**0.42** (0.52)	**41.03** (50.04)	**<0.0001** (<0.0001)	**1.93** (1.71)	**# QL**	**0.159** (0.139)	**0.053** (0.032)	**0.003** (<0.001)
						# Trees	**-0.011** (-0.014)	**0.004** (0.005)	**0.013** (0.009)
						Habitat Edge	(0.525)	(0.890)	(0.005)
BUSH	Logistic	(0.19)	(7.25)	(0.0071)	(1.09)	# QD	(0.059)	(0.033)	(0.071)
BEWR	Logistic	**0.14** (0.42)	**10.64** (15.88)	**0.0011** (0.0012)	**2.49** (1.09)	**Avg. Height**	**-0.293** (-0.599)	**0.097** (0.329)	**0.002** (0.069)
						# Snags	(1.020)	(0.576)	(0.069)
						Grazing Level	(-1.722)	(1.148)	(0.133)
HOWR	Logistic	(0.54)	(10.71)	(0.0011)	(0.41)	QW Canopy	(0.147)	(0.082)	(0.074)
WEBL	Poisson	(0.73)	(35.81)	(<0.0001)	(0.54)	Avg. dbh	(0.296)	(0.069)	(<0.001)
EUST	Logistic	(0.67)	(23.68)	(<0.0001)	(0.57)	# Trees	(-0.044)	(0.021)	(0.039)
						Max. dbh	(0.120)	(0.053)	(0.024)
OCWA	Logistic	**0.25** (0.34)	**10.91** (14.55)	**0.0010** (0.0007)	**1.14** (1.08)	**QW Canopy**	**0.058** (0.051)	**0.026** (0.022)	**0.024** (0.022)
						Avg. dbh	(-0.172)	(0.105)	(0.103)
SPTO	Logistic	(0.37)	(15.44)	(0.0004)	(0.99)	Avg. dbh	(-0.268)	(0.128)	(0.036)
						# Snags	(0.850)	(0.417)	(0.042)
CALT	Poisson	(0.48)	(6.96)	(0.0083)	(0.42)	Avg. Height	(-1.075)	(0.510)	(0.035)
BRBL	Poisson	(0.44)	(18.68)	(<0.0001)	(0.87)	# Trees	(-0.077)	(0.033)	(0.020)
BHCO	Poisson	**0.14** (0.32)	**8.12** (18.76)	**0.0044** (<0.0001)	**1.72** (1.45)	**# QK**	**0.514** (0.500)	**0.175** (0.177)	**0.003** (0.005)
						Rock Outcrop	(-1.055)	(0.380)	(0.006)
BUOR	Logistic	(0.49)	(9.74)	(0.0018)	(0.44)	Avg. dbh	(0.333)	(0.170)	(0.050)

[1] Bold parameter estimates and model diagnostics are based on bootstrap resampling trials. Numbers in parentheses represent parameter estimates and diagnostics from non-bootstrap models.
[2] See *appendix 1* for definitions of local habitat variables and *appendix 3* for species names.

Landscape and habitat associations are summarized in *table 4* for species with best-fitting landscape-level models (Pseudo-R^2 > 0.20) in addition to focal species included in the Oak Woodland Bird Conservation Plan (Zack and others 2000).

Table 4—*Summary of landscape and habitat associations for species with best-fitting landscape models and CPIF focal species.* [1 2]

Species	CPIF focal species status	Frequency (50 m / all)	Landscape model R^2 (50 m / all) (pct)	Development response[3]	Landscape oak woodland response[4]	Habitat model R^2 (50 m) (pct)	Positive habitat correlates	Negative habitat correlates
CAQU	2°	0.07 / 0.37						
BCHU		0.17 / 0.17	0 / 23		**positive**	34	# QW	
ACWO	1°	0.29 / 0.73				52	granary trees, # QL	
NUWO	2°	0.27 / 0.63				22	grazing level	# QK
PSFL		0.07 / 0.11	- / 25		**positive**			
BLPH		0.19 / 0.39	41 / 18	**positive**				
ATFL	2°	0.36 / 0.71	0 / 27	**negative**	**positive**			
WEKI		0.08 / 0.23	22 / 14	**negative**	**negative**			
HUVI	2°	0.16 / 0.25	18 / 16		**positive**	44	# QK, percent slope	
TRES		0.08 / 0.16	28 / 23	**negative**	positive			
CLSW		0.13 / 0.19	25 / 26	**positive**	**negative**	49	freq. human visits, No. QL	
WESJ	1°	0.39 / 0.67	22 / 21	**positive**	**negative**	52	**# QL*,** habitat edge	**# trees***
YBMA	1°	0.05 / 0.20	- / 20		**negative**			
OATI	1°	0.93 / 0.99						
WBNU	2°	0.48 / 0.73						
BEWR	2°	0.47 / 0.67				42	snags	**avg. height*,** grazing level
BGGN	1°	0.01 / 0.05				0		
WEBL	1°	0.11 / 0.20				73	avg. dbh	
NOMO		0.09 / 0.44	- / 27	**positive**				
EUST	2°	0.41 / 0.53				67	max. dbh	# trees
OCWA		0.24 / 0.36	10 / 39		**positive**	34	**QW canopy***	avg. dbh
SPTO		0.23 / 0.35	27 / 26		**positive**	37	snags	avg. dbh
CALT	2°	0.12 / 0.40				48	none	avg. height
RCSP		0.15 / 0.21	36 / 28	**negative**	**positive**			
LASP	1°	0.17 / 0.35	22 / 28	**negative**		0		
CHSP		0.04 / 0.11	- / 39	negative	positive			
WEME		0.01 / 0.23	- / 52	**negative**	negative			

[1] Refer to *tables 1-3* for model details. R^2 values are Pseudo-R^2 values from Poisson or logistic regression analysis (non-bootstrap). Bold type indicates variables and species with robust bootstrap resampling results.
[2] See *appendix 1* for definitions of local habitat variables and *appendix 3* for species names.
[3] As measured by development density, parcel size, property size or edge distance.
[4] As measured by oak woodland proportion within any measurement radius.

Discussion

Although the limited sampling of local habitat parameters reduced the robustness of our models, our data suggested fairly strong relationships between the occurrence and/or abundance of several bird species and local habitat variables. Clearly, local habitat characteristics directly influence a species' ability to feed, avoid predators and reproduce. Larger landscape characteristics may not be important for a songbird that meets all of its survival, feeding and reproduction goals within a small area, as long as the local habitat within its home range is suitable. This may especially be true in a landscape such as the Placer County foothills, where habitat fragmentation has generally not progressed to the stage of discrete, isolated oak woodland fragments (*sensu* Wiens 1994). Thus one would not predict that gradual extirpation of small populations from isolated habitat fragments (*sensu* MacArthur and Wilson 1967) would be an important process in this area.

Nevertheless, some of the species detected in our study did exhibit significant responses to characteristics of the surrounding landscape. Lark sparrow and Rufous-crowned sparrow abundances were negatively associated with development density, as was the occurrence of ash-throated flycatcher, western kingbird, tree swallow and western meadowlark. Conversely, the western scrub-jay, house finch and other species were positively associated with development density. This suggests that residential development in the oak woodland landscape may indirectly affect some bird species outside the area of immediate impact.

Urbanization-associated declines in bird abundance may be regulated by a variety of mechanisms, including increased urban-associated nest predators, anthropogenic habitat degradation, urban edge avoidance, increased dispersal mortality, and indirect responses to elimination of top-level predators (potentially resulting in the mesopredator release hypothesized by Soulé and others 1988). Ground-foraging birds such as lark, chipping and Rufous-crowned sparrows, may be particularly vulnerable to domestic cat *(Felis catus*) predation, as well as to ground-level disturbances such as mowing and grazing, which may limit seed availability.

With respect to nest predation, one might suspect that the higher presence of western scrub-jays, an important nest predator for many songbird species (Geupel and DeSante 1990), in more developed landscapes, could have detrimental effects on the reproductive success of other songbirds. Further demographic study would be needed to detect these effects.

Other species such as the Orange-crowned warbler, Hutton's vireo, Pacific-slope flycatcher and spotted towhee appear to respond to landscape composition and landscape-level habitat diversity but not necessarily to the presence of development *per se*. For these species, the amount, configuration and diversity of available oak woodland habitat in the surrounding landscape seems more important than the number of built structures. Although we were unable to control for local habitat conditions in our landscape models (due to small sample sizes), we did not find local habitat parameters to be strongly correlated with landscape composition. Thus we suspect that landscape-level fragmentation of oak woodland habitat, whether natural or human-induced, may affect populations of several bird species independent of local habitat conditions.

Variations in life history strategies probably make some species more susceptible than others to habitat fragmentation (Hansen and Urban 1992). Species with large foraging ranges, short dispersal distances, or widely-dispersed populations may depend on landscapes with higher proportions of suitable habitat (oak woodland in this case). In addition, some neotropical migrants may respond to larger landscape patterns (Hansen and Urban 1992), although several researchers have argued that traditional fragmentation paradigms based on eastern U.S. studies may not apply in the western U.S., where wooded habitats tend to be naturally fragmented (Verner and Larson 1989, Tewksbury and others 1998). Our results, though preliminary, support the notion that migratory species may be more susceptible to changes in the amount and configuration of oak woodland habitat configuration. Of the eight species that were positively associated with the proportion of oak woodland habitat in the surrounding landscape (after bootstrap validation), all but the Rufous-crowned sparrow and possibly spotted towhee are short-distance or neotropical migrants.

Comparisons with Other Studies

For many of the species detected, our results are consistent with previous similar studies. The negative association between Rufous-crowned sparrow abundance and development density, as well as urban edge distance, is consistent with the results of two southern California scrub studies (Bolger and others 1997 and Stralberg 1999), which also found negative landscape-level associations with urbanization for this species. Rufous-crowned sparrows tend to be patchily-distributed in our study area, as they are generally restricted to grassy slopes with scattered boulders and/or shrubs. While this species is capable of colonizing successional habitats (Shuford 1993, Williams, personal observation), its dispersal ability through unsuitable habitats may be limited.

Results for other resident species generally correspond with those of similar studies, which also found positive urbanization associations for northern mockingbird (Bolger and others 1997, Stralberg 1999), house finch (Bolger and others 1997, Merenlender and others 1998) and western scrub-jay (Merenlender and others 1998). Other resident species for which we found no significant development associations, including Bewick's wren, California quail, California towhee and bushtit, are more scrub- than woodland-associated and often occupy shrubby habitats within residential areas (Blair 1996). In scrub habitat, neither Bolger and others (1997) nor Stralberg (1999) found significant urbanization associations for any of these species.

Among short-distance migrants, the lark sparrow and western meadowlark responded to both development density and landscape-level habitat composition (with lark sparrow preferring oak woodland and western meadowlark preferring grassland/oak savanna-dominated landscapes). These species were also found by Bolger and others (1997) to be edge/fragmentation sensitive. For the lark sparrow, Breeding Bird Atlases in Sonoma and Monterey Counties provide anecdotal evidence that the species is no longer found in apparently suitable habitat near urban areas where it was formerly present (Humple 1999).

Caveats

With respect to GIS data sources, the vegetation layer (Forest Service 2000) used to calculate landscape composition and habitat diversity was fairly coarse (2.5 acre minimum). It was thought to overestimate oak woodland types, misidentifying non-native ornamental trees as oaks or classifying open oak savanna as grassland. Furthermore, landscape metrics calculated at large scales, particularly at the 4000 m radius, may reflect physical gradients unrelated to urbanization or landscape composition *per se.*

We are also cautious about interpreting local habitat relationships as they were based on a small subset of sites that was not randomly selected. Although they do represent the extreme ends of the development spectrum (urban parks and large undeveloped parcels), some portions of our study area are underrepresented, primarily those that contain smaller rural residential parcels. Habitat models for most of the species examined were not robust enough to withstand bootstrap resampling simulations. Thus some of the habitat relationships we found may have been spurious, and deserve further examination with a more complete dataset.

Furthermore, the results presented here are based on a single year of data. High levels of background variability in point count surveys found by other researchers in similar habitat (Verner and others 1996) suggest that additional years of data are needed to validate our models. Additional data would also increase detection rates, allowing more robust analyses of seemingly development-sensitive species with low detection rates (e.g., chipping sparrow).

Finally, as with any study that attempts to relate point count survey results with habitat or landscape characteristics, we must caution that adult abundance (or presence) is not necessarily an indication of habitat quality. Many areas may function as population sinks, drawing in birds from healthy populations elsewhere, yet failing to replace the population with new recruits (Brawn and Robinson 1996, Donovan and others 1995). To fully assess the relationship of rural residential development and habitat fragmentation on breeding birds, data on reproductive success and adult survival are needed.

Implications for Conservation Planning

Our results highlight the fact that the importance of local habitat and landscape characteristics may vary greatly by species. On one end of the response spectrum, several sparrow species appear to experience negative consequences of human development. Our models predict that lark sparrow densities would be reduced (below the mean detected in this study) at development densities greater than 5 acres per parcel, and would be virtually non-existent (albeit with large error bounds) at a one acre per parcel density (*fig. 5*). Although we lack information on sustainable densities for these species (but see Zack and others 2000), low densities predicted by our models are of concern. Further study over multiple years would be necessary to identify population trends.

For other woodland species, including orange-crowned warbler and Hutton's vireo, the quality, the amount and configuration of available habitat in the surrounding landscape seem more important than the number of built structures. This suggests that development that retains oak woodlands (including a significant interior live oak component within the blue oak matrix) may still provide adequate habitat for these species. Other species such as Bewick's Wren appear insensitive to development and landscape characteristics but are well-predicted by the presence of certain local habitat features.

Conserving habitat for birds across this development-sensitivity spectrum is no easy task, and may hinge upon several complementary strategies:

- Preserving the remaining large, undeveloped parcels of oak woodland (>40 acres) should help ensure the local persistence of landscape-sensitive species.
- Limiting the subdivision of rural residential parcels into small (1-5 acre) ranchettes may help sustain development-sensitive species in more marginal areas.
- Managing oak woodlands on small parcels to retain a variety of habitat components including large trees, snags and interior live oaks can provide habitat for a host of human-tolerant avian species.
- Oak woodland species have varying habitat needs, so maintaining a mosaic of habitat types is important for preserving a suite of oak woodland species.

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Appendix 1—*Descriptions of local habitat variables measured (or estimated) at each survey location for the area within a 50 m radius.*

Variable	Description	Variable	Description
Percent slope	Percent slope of point	Avg. height	Average height of canopy (m)
Aspect	Slope aspect of point	Max. height	Height of tallest tree (m)
# QD	Number of blue oaks >2" dbh	Shrub cover	Shrub cover category (0-5)
# QW	Number of live oaks >2" dbh	Bare soil	Amount of exposed soil (0-3)
# QL	Number of valley oaks >2" dbh	Grass height	Herbaceous layer height category (1-4)
# QK	Number of black oaks >2" dbh	Grass density	Herbaceous layer density category (0-3)
# PS	Number of gray pines >2" dbh	Grazing intensity	Grazing intensity (0-3)
# PP	Number of ponderosa pines >2" dbh	Rock outcrops	Rock outcrop amount (0-4)
Trees	Number of total trees >2" dbh	Granary tree	Number of Acorn Woodpecker granary trees
Snags	Number of snags >5" dbh	Down wood	Estimated number of pieces of downed wood >10cm in diameter and ≥1m in length
Canopy cover	Percent tree canopy cover	Freq. human visits	Estimated level of human visitation during breeding season (0-4)
QW canopy	Percent live oak canopy cover	Habitat edge	Presence of obvious ecotone
Avg. dbh	Average dbh of all trees	Grazing level	Estimated level of grazing intensity (0-3)
Max. dbh	Diameter of largest tree		

Appendix 2—*Descriptions of landscape-level variables measured for each survey location.*

Variable	Abbreviations	Description
Development density	DEV250, DEV500, DEV1000, DEV2000, DEV4000	Number of human-built structures within 250 m-4000 m radius circle, as estimated by development status of parcel centroids
Oak woodland proportion	OAK250, OAK500, OAK1000, OAK2000, OAK4000	Percent of 250 m-4000 m radius circle containing oak woodland habitat, including blue oak woodland, blue oak-foothill pine, valley oak, montane hardwood and montane hardwood-conifer
Grassland proportion	GRS250, GRS500, GRS1000, GRS2000, GRS4000	Percent of 250 m-4000 m radius circle containing annual grassland, including some oak savanna
Habitat diversity	H250, H500, H1000, H2000, H4000	Shannon-Wiener diversity index ($H = - \Sigma_i p_i \ln(p_i)$, where p_i = area of i^{th} habitat type) within 250 m-4000 m radius circle
Elevation		Elevation (m) of point count location based on 30 m digital elevation model (USGS)
Stream distance		Distance (m) to nearest stream based on 1:100K hydrography GIS layer (Teale Data Center)
Road distance		Distance (m) to nearest road based on 1:100K road GIS layer (Teale Data Center)
Edge distance		Distance (m) to nearest human structure based on a combination of field notes, parcel base map and digital aerial photos

Appendix 3—*Summary of bird species detected at 75 sites visited twice during the breeding season (excluding waterfowl, shorebirds and raptors).*[1]

Common name	Latin name	AOU Code	No. of sites detected (≤50 m)	No. of sites detected (unlimited)	Breeding status	Migratory status
Ring-neck pheasant	*Phasianus colchicus*	RPHE	4	30	B	R
Wild turkey	*Meleagris gallopavo*	WITU	4	11	B	R
California quail	*Callipepla californica*	CAQU	5	28	B	R
Mourning dove	*Zenaida macroura*	MODO	20	46	B	R
Black swift	*Cypseloides niger*	BLSW	1	2	?	NTM
Black-chinned hummingbird	*Archilochus alexandri*	BCHU	13	13	B	NTM
Anna's hummingbird	*Calypte anna*	ANHU	32	34	B	SDM
Calliope hummingbird	*Stellula calliope*	CAHU	1	1	?	NTM
Acorn woodpecker	*Melanerpes formicivorus*	ACWO	22	55	B	R
Nuttall's woodpecker	*Picoides nuttallii*	NUWO	20	47	B	R
Downy woodpecker	*Picoides pubescens*	DOWO	4	4	B	R
Hairy woodpecker	*Picoides villosus*	HAWO	1	2	B	R
Western wood-pewee	*Contopus sordidulus*	WEWP	3	12	B	NTM
Willow flycatcher	*Empidonax traillii*	WIFL	3	3	NB	N/A
Hammond's flycatcher	*Empidonax hammondii*	HAFL	1	1	NB	N/A
Dusky flycatcher	*Empidonax oberholseri*	DUFL	1	1	NB	N/A
Pacific slope flycatcher	*Empidonax difficilis*	PSFL	5	8	B	NTM
Black Phoebe	*Sayornis nigricans*	BLPH	14	29	B	R-SDM
Ash-throated flycatcher	*Myiarchus cinerascens*	ATFL	27	53	B	NTM
Western kingbird	*Tyrannus verticalis*	WEKI	6	16	B	NTM
Hutton's vireo	*Vireo huttoni*	HUVI	12	19	B	NTM
Warbling vireo	*Vireo gilvus*	WAVI	5	8	NB	NTM
Tree swallow	*Tachycineta bicolor*	TRES	6	12	B	NTM
Violet-green swallow	*Tachycineta thalassina*	VGSW	10	13	B	NTM

Appendix 3 (cont.)

Common name	Latin name	AOU code	No. of sites detected (≤50 m)	No. of sites detected (unlimited)	Breeding status	Migratory status
Cliff swallow	*Petrochelidon pyrrhonota*	CLSW	10	14	B	NTM
Barn swallow	*Hirundo rustica*	BASW	2	3	B	NTM
Western scrub-jay	*Aphelocoma californica*	WESJ	29	50	B	R
Yellow-billed magpie	*Pica nuttalli*	YBMA	4	15	B	R
American crow	*Corvus brachyrhynchos*	AMCR	4	22	B	R-SDM
Oak titmouse	*Baeolophus inornatus*	OATI	70	74	B	R
Bushtit	*Psaltriparus minimus*	BUSH	48	57	B	R
White-breasted nuthatch	*Sitta carolinensis*	WBNU	36	55	B	R
Bewick's wren	*Thryomanes bewickii*	BEWR	35	50	B	R
House wren	*Troglodytes aedon*	HOWR	6	31	B	SDM-NTM
Blue-gray gnatcatcher	*Polioptila caerulea*	BGGN	1	4	B	SDM-NTM
Western bluebird	*Sialia mexicana*	WEBL	8	14	B	R-SDM
Swainson's thrush	*Catharus ustulatus*	SWTH	1	2	NB	N/A
American robin	*Turdus migratorius*	AMRO	8	31	B	SDM
Wrentit	*Chamaea fasciata*	WREN	4	11	B	R
Northern mockingbird	*Mimus polyglottos*	NOMO	7	33	B	R
European starling	*Sturnus vulgaris*	EUST	31	40	B	R
Cedar waxwing	*Bombycilla cedrorum*	CEWA	1	3	NB	N/A
Orange-crowned warbler	*Vermivora celata*	OCWA	18	27	B	SDM-NTM
Yellow warbler	*Dendroica petechia*	YWAR	5	7	?	NTM
Yellow-rumped warbler	*Dendroica coronata*	AUWA	1	2	NB	N/A
Black-throated Gray warbler	*Dendroica nigrescens*	BTYW	1	1	NB	N/A
Townsend's warbler	*Dendroica townsendi*	TOWA	2	4	NB	N/A
Wilson's warbler	*Wilsonia pusilla*	WIWA	7	9	NB	N/A
Yellow-breasted chat	*Icteria virens*	YBCH	1	7	B	NTM
Western tanager	*Piranga ludoviciana*	WETA	4	8	NB	N/A

Appendix 3 (cont.)

Common name	Latin name	AOU code	No. of sites detected (≤50 m)	No. of sites detected (unlimited)	Breeding status	Migratory status
Spotted towhee	*Pipilo maculates*	SPTO	17	26	B	R-SDM
California towhee	*Pipilo crissalis*	CALT	9	30	B	R
Rufous-crowned sparrow	*Aimophila ruficeps*	RCSP	11	15	B	R
Chipping sparrow	*Spizella passerina*	CHSP	3	8	B	SDM-NTM
Lark sparrow	*Chondestes grammacus*	LASP	13	26	B	SDM
Song sparrow	*Melospiza melodia*	SOSP	3	8	B	SDM
Black-headed grosbeak	*Pheucticus melanocephalus*	BHGR	10	25	B	NTM
Lazuli bunting	*Passerina amoena*	LAZB	18	29	B	NTM
Western meadowlark	*Sturnella neglecta*	WEME	1	17	B	SDM
Red-winged blackbird	*Agelaius phoeniceus*	RWBL	6	20	B	R-SDM
Brewer's blackbird	*Euphagus cyanocephalus*	BRBL	7	15	B	SDM
Brown-headed cowbird	*Molothrus ater*	BHCO	25	36	B	SDM-NTM
Bullock's oriole	*Icterus bullockii*	BUOR	9	17	B	NTM
Hooded oriole	*Icterus cucullatus*	HOOR	1	2	B	NTM
House finch	*Carpodacus mexicanus*	HOFI	35	49	B	SDM
Lesser goldfinch	*Carduelis psaltria*	LEGO	52	61	B	SDM
Lawrence's goldfinch	*Carduelis lawrencei*	LAGO	3	2	B	SDM
American goldfinch	*Carduelis tristis*	AMGO	15	21	B	SDM
House sparrow	*Passer domesticus*	HOSP	3	10	B	R

[1] B = Breeding, NB = Not Breeding, NTM = Neotropical Migrant, SDM = Short-distance Migrant, R=Resident

Attachment 4

Tietje et al. 1997

Relative Abundance and Habitat Associations of Vertebrates in Oak Woodlands in Coastal-Central California[1]

William D. Tietje[2] Justin K. Vreeland[3] Nancy R. Siepel[3] JoAnn L. Dockter[3]

Abstract: *We estimated relative abundance and assessed habitat associations of small mammals, birds, amphibians, and reptiles in oak (*Quercus *spp.) woodlands from 1993 to 1995 at Camp Roberts in California's central coast. Within taxa, relative abundance was highest for dusky-footed woodrats (*Neotoma fuscipes*) (9.7 percent trap success), plain titmice (*Parus inornatus*) (49.4 territories per 40 ha), slender salamanders (*Batrachoseps *spp.) (2.2 percent detection rate) and skinks (*Eumeces *spp.) (3.1 percent detection rate). Percent cover of shrubs, grass, and downed wood were the three strongest correlated habitat components (mean of the absolute value of all correlation coefficients* [$|r_s|$] *= 0.64, 0.62, and 0.59, respectively) for abundant species of small mammals. Percent shrub cover and litter weight were correlated with abundant birds, and herpetofauna, respectively (mean* $|r_s|$ *= 0.57 and 0.49, respectively). Within taxa, woodrats, dark-eyed juncos (*Junco hyemalis*), and slender salamanders exhibited the strongest habitat associations across all habitat components (mean* $|r_s|$ *= 0.74, 0.73, and 0.44, respectively). Dense oak woodlands with shrubby understory and downed woody material supported the greatest numbers of vertebrate fauna.*

Only limited information is available about the characteristics that make oak (*Quercus* spp.) woodland valuable wildlife habitat. Previous research has developed some fundamental information on wildlife-habitat relationships in oak woodlands (Block 1989; Block and Morrison 1987, 1990; Block and others 1988; Morrison and others 1991; Verner and Ritter 1985, 1988). This paper attempts to add to the existing body of information by summarizing 2.5 years of wildlife habitat-relationships data collected before conducting an experimental treatment to assess the effects of fire on oak woodland biodiversity. This study also identifies habitat components of particular importance to several common species of terrestrial vertebrates in blue oak woodlands of the California central coast, where wildlife-habitat relationships are little studied.

Landowners, land-use planners, and other land managers can use information from this study to develop management strategies for California's oak woodlands. In addition, the information generated may serve as input to the model validation needs of the California Wildlife Habitat Relationships (CWHR) System (Airola 1988), which frequently is used to predict the effects of environmental and anthropogenic perturbations on wildlife.

Study Area

Camp Roberts, a military facility of the California Army National Guard, is located in northern San Luis Obispo County 18 km north of Paso Robles, California. The northern portion of Camp Roberts is in Monterey County. The facility comprises 17,800 ha, of which approximately 7,200 ha are classified as oak woodland (Camp Roberts 1989). The dominant tree species in the overstory is blue oak (*Quercus douglasii*) with a variable contribution of coast live oak (*Q. agrifolia*). Where it occurs, understory is comprised of toyon (*Heteromeles*

[1]An abbreviated version of this paper was presented at the Symposium on Oak Woodlands: Ecology, Management, and Urban-Interface Issues, March 19-22, 1996, San Luis Obispo, Calif.

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arbutifolia), redberry (*Rhamnus crocea*), bigberry manzanita (*Arctostaphylos glauca*), ceanothus (*Ceanothus* spp.), poison oak (*Toxicodendron diversilobum*), and, infrequently, chamise (*Adenostoma fasciculatum*). On the woodland floor, wild oats (*Avena* spp.), bromes (*Bromus* spp.), and fescues (*Festuca* spp.) predominate. Common forbs include deerweed (*Lotus scoparius*), filaree (*Erodium* spp), and hummingbird sage (*Salvia spathacea*).

Methods

Experimental Design

Using topographic maps and ground reconnaissance, we selected oak stands within the southern half of Camp Roberts where there is the least potential for interference with military activities and where most of the dense oak woodlands at Camp Roberts occur. To accommodate a treatment, we selected blue oak stands with varying contributions of coast live oak that were >16 ha in size and had an estimated canopy cover of >50 percent. Within these stands, we established nine, square 5.8-ha plots in the summer of 1993. We used a compass and meter tape to lay out a 17 × 17 sampling grid (289 intersections every 15 m in two directions).

Vegetation Sampling

Vegetation surveys were conducted in the spring and summer of 1995. Densities of living and dead trees were determined by the point-centered quarter method (Cottam and Curtis 1956). Distance (≤10 m) to the nearest living and dead trees ≥5.1 cm dbh (diameter at breast height [1.4 m above ground level]) and their species were recorded. On trees that bifurcated at or below breast height, the distance to the nearest stem ≥5.1 cm dbh was measured. We also recorded the number of saplings ≥1.4 m in height and <5.1 cm dbh that occurred within 5 m of the center point. Forty-five sapling and tree samples were taken per plot.

At alternate intersections on all plot grid lines (145 intersections per plot), percent cover of tree canopy, shrub foliage, ground vegetation, and downed woody material were derived from vertical interceptions ("hits") at six points spaced 1.7 m along each of the ropes (12 points per intersection × 145 intersections per plot × nine plots = 15,660 points); occurrence of downed wood >5.1 cm diameter was recorded when within 30 cm of points. We collected all herbaceous material within a 30-cm by 30-cm frame centered on one randomly selected point along one of the ropes. Litter (i.e., organic material lying on the ground before the previous season's production) was separated from the current season's production of herbaceous material, air dried, and weighed to the nearest 1 g.

Animal Sampling

Small Mammal Trapping

Small mammal trapping was conducted in the fall (3 October to 18 November) of 1993, the spring (8 May to 3 June) and fall (10 October to 11 November) of 1994, and the spring (9 May to 10 June) and fall (9 October to 10 November) of 1995 by placing a single Sherman live trap (trap size: 7.6 cm by 9.5 cm by 30.5 cm) at each of the 289 intersections on each plot. Traps were baited with a mixture of corn, oats, and barley laced with molasses and checked for 5 consecutive days. Captured animals were ear-tagged and released. Species, capture location, sex, age (juvenile or adult), and tag number were recorded. After the fall 1993 trapping bout, two study plots were shifted four lines (i.e., line E became line A), resulting in the loss of 680 trap-nights (17 traps per line × four lines × five nights × two plots). These 680 points were not used for summaries or analyses. Total trapping effort on the nine study plots was 64,345 trap nights (1,445 trap nights per bout × five trapping bouts per study plot × nine study plots - 680 trap nights).

Bird Census

Two or three field biologists, trained to identify birds by sight and sound, recorded pairs of breeding birds during 1994 (6 April to 4 May) and 1995 (27 March to 26 April) by spot mapping. To facilitate consistent sampling effort within each plot, we mapped territories along four evenly-spaced grid lines. The initial line and direction walked was alternated clockwise around the plot for each visit. Two to three plots per person were visited each day. The first visit began within 30 minutes of sunrise. We recorded the grid location and activity of each detected bird. Ten to 12 separate visits per plot were conducted each year. Following guidelines from Bibby and others (1992:58), we updated and interpreted individual species maps after each visit. Bird territories by species and plot were delineated each year after the field season.

Amphibian and Reptile Monitoring

In January and February 1994, we placed a single 1.3-cm by 61.0-cm by 61.0-cm plywood coverboard (Grant and others 1992) flush with the ground within 2 m of each intersection on alternate lines on each plot (136 coverboards per plot). Once weekly, during 24 January to 26 April 1995, we recorded species and number of amphibians and reptiles observed under the coverboards.

Data Analyses

We pooled habitat data and animal data by taxa within plots. Data were assessed for normality using Shapiro-Wilks tests (Conover 1980:363) and visual inspection of normal-probability plots and histograms in PROC UNIVARIATE of PC-SAS (SAS Institute Inc. 1988:627-628, Schlotzhauer and Littell 1987:117-119). Although all habitat variables and most response variables were normally distributed, nonparametric analyses were used because sample sizes were small (n = 9) after pooling. Consequently, we used Spearman rank correlation (r_s) (Zar 1984:318) in PROC CORR of PC-SAS (SAS Institute Inc., 1988:209-235) to assess habitat associations for the six most abundant (≥100 individuals captured per five bouts) small mammal species, four most abundant (≥10 territories occurring on ≥8 plots) bird species, and four most abundant (≥60 observations) amphibian and reptile species. To determine which habitat components were most important for each taxa, we averaged absolute values (| |) of correlation coefficients (therefore, mean $|r_s|$) for each habitat component across species within taxa). To determine the average strength of each species' habitat associations, we averaged absolute values of correlation coefficients for each species across habitat components. Differences were considered significant when $P \leq 0.05$. Power (1 - β) is reported for significant coefficients (Zar 1984:312).

Results

Habitat

Across all nine plots, density of live stems (including saplings) ranged from 130.4 to 461.1 stems per ha, and density of snags ranged from 9.4 to 35.7 per ha (*table 1*). Live tree canopy and shrub cover ranged from 40.2 to 70.1 and 0 to 35.4 percent of plots, respectively. Grass, forbs, downed wood, and unvegetated ground comprised 38.1 to 71.6 percent, 1.4 to 6.3 percent, 1.1 to 6.5 percent, and 8.4 to 14.8 percent of ground cover, respectively. Stem density, snag density, tree canopy cover, shrub cover, and percent ground cover of downed wood were proportionally related. Grass cover was approximately inverse to live tree canopy cover and shrub cover. Litter weight varied from 8.5 g per 900 cm^2 to 27.8 g per 900 cm^2 (*table 1*).

Table 1—Habitat characteristics of nine vegetation variables used to assess habitat associations of small mammals, birds, reptiles, and amphibians on nine 5.8-ha plots in oak woodlands, Camp Roberts, California, spring and summer 1995.

	Plot range[1]								
Habitat characteristic	Mean (SE)	Mean (SE)	Mean (SE)	Mean (SE)	Mean (SE)	Mean (SE)	Mean (SE)	Mean (SE)	Mean (SE)
Live tree density (stems/ha)[2,3]	130.4	181.8	224.8	233.4	241.9	274.2	330.5	423.6	461.1
Snag density (stems/ha)[2]	9.4	15.2	16.6	22.5	22.8	24.4	28.6	34.8	35.7
Tree canopy cover (pct)	40.2 (2.1)	45.3 (2.5)	53.2 (2.8)	53.7 (2.7)	55.9 (2.6)	56.3 (2.6)	61.7 (2.4)	67.8 (2.5)	70.1 (2.6)
Shrub cover (pct)	0 (0)	2.4 (0.8)	3.8 (0.9)	8.3 (1.3)	9.9 (1.5)	13.2 (1.7)	20.8 (2.5)	24.3 (2.6)	35.4 (2.7)
Grass cover (pct)	38.1 (2.2)	43.9 (2.3)	46.7 (1.9)	48.7 (2.2)	50.0 (2.5)	56.9 (1.8)	58.3 (1.6)	67.1 (1.8)	71.6 (1.5)
Forb cover (pct)	1.4 (0.3)	2.1 (0.6)	2.2 (0.5)	2.7 (0.4)	3.2 (0.5)	3.2 (0.6)	3.2 (0.6)	3.9 (0.7)	6.3 (0.8)
Downed wood cover (pct)	1.1 (0.4)	2.2 (0.5)	2.6 (0.5)	3.4 (0.6)	3.6 (0.6)	3.6 (0.7)	3.7 (0.6)	3.8 (0.6)	6.5 (0.8)
Unvegetated ground (pct)	8.4 (0.7)	8.9 (0.7)	9.6 (0.9)	10.2 (0.9)	10.7 (0.9)	12.4 (1.1)	12.9 (0.9)	13.3 (0.9)	14.8 (1.1)
Litter weight (g)	8.5 (0.9)	13.4 (1.5)	13.7 (1.5)	14.6 (1.9)	14.9 (1.5)	21.6 (1.9)	23.0 (2.4)	27.8 (2.2)	27.8 (3.1)

[1] Means from the nine plots are ranked from least to greatest, left to right, within rows.
[2] Live tree density and snag density were determined using the point-centered quarter method (Cottam and Curtis 1956). Standard errors are not associated with either density estimate because a formula for calculating standard error was not presented in the paper.
[3] Includes saplings, which were measured using fixed-radius plots and therefore have an associated standard error. Mean saplings/ha ranged from 0 ± 0 stems/ha to 121.7 ± 26.2 stems/ha. Maximum standard error (on a mean of 99.0 stems/ha) was 30.5 stems/ha.

Small Mammals

Richness and Numbers

During 64,345 trap-nights of effort, we recorded 14,076 captures of 5,767 individuals of 10 species of small mammals (*table 2*). Dusky-footed woodrats (*Neotoma fuscipes*), piñon mice (*Peromyscus truei*), California pocket mice (*Perognathus californicus*), brush mice (*Peromyscus boylii*), deer mice (*Peromyscus maniculatus*), and California mice (*Peromyscus californicus*) were the six most abundant species captured with 32, 19, 18, 16, 10, and 2 percent of total individual captures, respectively (*table 2*). Among these species, trap success was greatest for woodrats (9.7 percent of total captures) and least for California mice (0.5 percent of total captures); average captures per animal were greatest for woodrats (3.3) and least for deer mice (1.6). Four species had <100 individual captures per five bouts (*table 2*). We also captured ground squirrels (*Spermophilus beecheyi*) on three study plots and pocket gophers (*Thomomys bottae*) on two plots; we did not record these captures.

Habitat Relationships

Percent shrub cover was the strongest correlated habitat component for California mice (r_s = 0.97), woodrats (r_s = 0.95), piñon mice (r_s = 0.83), and California pocket mice (r_s = 0.51) (*table 3*). Percent tree canopy cover and percent unvegetated ground cover were the strongest correlates for brush mice and deer mice, respectively (r_s = 0.68 and 0.82, respectively). All species were negatively correlated with percent grass cover (r_s = -0.12 [deer mice] to -0.88 [woodrats]) and positively correlated with percent shrub cover (r_s = 0.08 [deer mice] to 0.97 [California mice]) and percent unvegetated ground cover (r_s = 0.05 [brush mice] to 0.82 [deer mice]). Across all habitat components, woodrats exhibited the

Table 2—Capture statistics of 10 species of small mammals captured in Sherman live traps on nine 5.8-ha plots (64,345 trap-nights) in oak woodlands, Camp Roberts, California, spring and fall, fall 1993 to fall 1995.

Species	Total captures	Individual captures	Total trap success[1]	Percent of individuals captured[2]	Average captures per animal[3]
Dusky-footed woodrat (*Neotoma fuscipes*)	6,207	1,871	9.65	32.44	3.32
Piñon mouse (*Peromyscus truei*)	2,798	1,119	4.35	19.40	2.50
California pocket mouse (*Perognathus californicus*)	1,799	1,014	2.80	17.58	1.77
Brush mouse (*Peromyscus boylii*)	1,762	916	2.74	15.88	1.92
Deer mouse (*Peromyscus maniculatus*)	929	597	1.44	10.35	1.56
California mouse (*Peromyscus californicus*)	341	108	0.53	1.87	3.16
California vole (*Microtus californicus*)	105	81	0.16	1.40	1.30
Merriam's chipmunk (*Tamias merriami*)	73	27	0.11	0.47	2.70
Heermann's kangaroo rat (*Dipodomys heermanni*)	46	18	0.07	0.31	2.56
W. harvest mouse (*Reithrodontomys megalotis*)	16	16	0.02	0.28	1.00
Total	14,076	5,767	21.88	100.00	2.44

1 Total captures expressed as a percent of total trap-nights (64,345).
2 Individual captures expressed as a percent of total number of individuals captured (5,767).
3 Total captures ÷ individual captures.

*Table 3—Spearman rank correlations (**r_s**) between total individual captures of six relatively abundant species of small mammals and six habitat characteristics on nine 5.8-ha plots in oak woodlands, Camp Roberts, California, spring and fall, fall 1993 to fall 1995.*

Habitat characteristic	Dusky-footed woodrat	Pinon mouse	California pocket mouse	Brush mouse	Deer mouse	California mouse
Tree canopy cover (pct)	0.62	0.72*	0.13	0.68*	-0.17	0.72*
P[1]	0.08	0.03	0.73	0.04	0.67	0.03
Shrub cover (pct)	0.95*	0.83*	0.51	0.47	0.08	0.97*
P	<0.01	0.01	0.16	0.21	0.83	<0.01
Grass cover (pct)	-0.88*	-0.80*	-0.36	-0.67*	-0.12	-0.86*
P	<0.01	0.01	0.34	0.05	0.77	0.01
Forb cover (pct)	0.61	0.54	-0.12	0.41	0.44	0.44
P	0.08	0.13	0.76	0.28	0.24	0.23
Unvegetated groundcover (pct)	0.47	0.47	0.30	0.05	0.82*	0.14
P	0.21	0.21	0.43	0.90	0.01	0.71
Downed wood cover (pct)	0.90*	0.73*	0.37	0.55	-0.02	0.96*
P	<0.01	0.03	0.32	0.12	0.97	<0.01

1 *P*-value of correlation coefficients. Power of significant coefficients ranged from 0.5080 ($r_s = 0.67$) to 0.9992 ($r_s = 0.97$). All $n = 9$. Asterisks denote significance at $P \leq 0.05$.

strongest habitat correlations (mean $|r_s| = 0.74$, range = -0.88 to 0.95), whereas deer mice were least strongly correlated (mean $|r_s| = 0.28$, range = -0.17 to 0.82) (*table 3*). Only California pocket mice were not significantly correlated with at least one habitat component (all correlation $P > 0.05$).

Birds

Richness and Numbers

We delineated territories of 24 bird species during 212 visits in spring 1994 and 1995. Territories were not delineated for 50 other species because fewer than three detections were recorded or the species' behavior precluded such delineation (e.g., western scrub-jays [*Aphelocoma californica*]). Plain titmice (*Parus inornatus*), dark-eyed juncos (*Junco hyemalis*), house finches (*Carpodacus mexicanus*), and white-breasted nuthatches (*Sitta carolinensis*) were the most frequently observed species with an annual average of 49.4, 21.5, 13.0, and 10.2 territories, respectively (*table 4*).

Table 4—Average (annual) number and density of breeding-bird territories (derived from spot-mapping observations) of 24 bird species on nine 5.8-ha study plots in oak woodland, Camp Roberts, California, spring 1994 and spring 1995.

Species	Mean no. territories	SE	No. territories/40 ha
Plain titmouse (*Parus inoratus*)	64.5	6.5	49.4
Dark-eyed junco (*Junco hyemalis*)	28.0	0.5	21.5
House finch (*Carpodacus mexicanus*)	17.0	0.5	13.0
White-breasted nuthatch (*Sitta carolinensis*)	13.3	1.8	10.2
Lesser goldfinch (*Carduelis psaltira*)	8.5	1.5	6.5
Anna's hummingbird (*Calypte anna*)	6.5	0.5	5.0
Blue-gray gnatcatcher (*Polioptila caerulea*)	5.3	1.8	4.1
Lawrence's goldfinch (*Carduelis lawrencei*)	5.3	1.3	4.1
California towhee (*Pipilo crissalis*)	4.5	2.0	3.5
Common bushtit (*Psaltriparus minimus*)	4.5	4.5	3.5
Hutton's vireo (*Vireo huttoni*)	4.3	1.8	3.3
Western bluebird (*Sialia mexicana*)	3.8	1.3	2.9
Bewick's wren (*Thryomanes bewickii*)	3.0	0.5	2.3
Lark sparrow (*Chondestes grammacus*)	3.0	0	2.3
Nuttall's woodpecker (*Picoides nuttallii*)	3.0	0.5	2.3
Spotted towhee[1] (*Pipilo maculatus*)	2.8	0.3	2.2
House wren (*Troglodytes aedon*)	1.8	0.3	1.4
Orange-crowned warbler (*Vermivora celata*)	1.8	0.8	1.4
Northern flicker (*Colaptes auratus*)	1.0	0	0.8
Bullock's Oriole (*Icterus bullockii*)	1.0	0.5	0.8
California quail (*Callipepla californica*)	0.5	0.5	0.5
Acorn woodpecker (*Melanerpes formicivorus*)	0.3	0.3	0.2
Brown-headed cowbird (*Molothrus ater*)	0.3	0.3	0.2
Cooper's hawk (*Accipiter cooperii*)	0.3	0.3	0.2
Total	183.8	24.3	140.8

[1]Formerly rufous-sided towhee.

Habitat Relationships

Percent shrub cover was the strongest correlated habitat component for dark-eyed juncos (r_s = 0.79), white-breasted nuthatches (r_s= -0.64), and house finches (r_s= 0.46) (*table 5*). Tree canopy cover was the strongest correlated habitat component for plain titmice (r_s = 0.40). Juncos exhibited the strongest habitat correlations across all habitat components (mean $|r_s|$ = 0.73, range = 0.65 to 0.79); titmice exhibited the weakest habitat correlations across all habitat components (mean $|r_s|$ = 0.28; range = -0.16 to 0.40). Only dark-eyed juncos were significantly ($P \leq 0.05$) correlated with any habitat component.

***Table 5**—Spearman rank correlations (r_s) between average number of territories (derived from spot-mapping observations) of four relatively abundant songbird species and four habitat characteristics on nine 5.8-ha plots in oak woodlands, Camp Roberts, California, spring 1994 and spring 1995.*

Habitat characteristic	Plain titmouse	Dark-eyed junco	House finch	White-breasted nuthatch
Live stem density (trees/ha)	0.15	0.71*	0.14	-0.38
P[1]	0.70	0.03	0.73	0.31
Standing snag density (stems/ha)	-0.16	0.65	0.07	-0.29
P	0.68	0.06	0.86	0.44
Tree canopy cover (pct)	0.40	0.78*	0.44	-0.50
P	0.28	0.01	0.24	0.17
Shrub cover (pct)	0.39	0.79*	0.46	-0.64
P	0.29	0.01	0.21	0.06

[1] *P*-value of correlation coefficients. Power of significant coefficients ranged from 0.5793 (r_s = 0.71) to 0.7454 (r_s = 0.79). All n = 9. Asterisks denote significance at $P \leq 0.05$.

Amphibians and Reptiles

Richness and Numbers

We recorded 1,516 observations of 15 to 17 species of amphibians and reptiles during 17,136 coverboard checks in 1995: five or six species of lizards, two or three salamanders, six snakes, one toad, and one frog species (*table 6*). Skinks (*Eumeces* spp.), western fence lizards (*Sceloporus occidentalis*), Slender salamanders (*Baltrachoseps* spp.), and gopher snakes (*Pituophis melanoleucus*) were the four most relatively abundant species with 35, 26, 25, and 4 percent of total observations, respectively, and 3.1, 2.3, 2.2, and 0.4 percent of total possible observations, respectively (*table 6*). Eleven species had <60 total observations.

Habitat Relationships

Percent tree canopy cover, percent shrub cover, percent forb cover, and litter weight were the strongest correlated habitat components for slender salamanders, gopher snakes, skinks, western fence lizards, respectively (r_s = 0.82, 0.59, 0.46, and 0.59, respectively) (*table 7*). All species were positively correlated with percent shrub cover (r_s = 0.10 [fence lizards] to 0.59 [gopher snakes]), percent forb cover (r_s = 0.06 [gopher snakes] to 0.46 [skinks]), percent downed wood cover (r_s = 0.15 [fence lizards] to 0.58 [gopher snakes]), and litter weight (r_s = 0.28 [skinks] to 0.62 [slender salamanders]), and negatively correlated with percent grass cover (r_s = -0.05 [fence lizards] to -0.53 [slender salamanders]). Slender salamanders exhibited the strongest habitat correlations across all habitat components (mean $|r_s|$ = 0.44, range = -0.53 to 0.82); western fence lizards exhibited the weakest habitat correlations across all habitat components (mean $|r_s|$ = 0.20, range = -0.05 to 0.59). Only slender salamanders were significantly ($P \leq 0.05$) correlated with any habitat component.

Table 6—Amphibians and reptiles observed under 136 coverboards during 14 consecutive weeks on each of nine 5.8-ha plots (17,136 board checks), Camp Roberts, California, 24 January to 26 April, 1995.

Species	Total observations	Percent success[1]	Percent of total observations[2]
Reptiles—Lizards			
Skink (*Eumeces* spp.)	535	3.12	35.29
Western fence lizard (*Sceloporus occidentalis*)	388	2.26	25.59
California legless lizard (*Anniella pulchra*)	33	0.19	2.26
Southern alligator lizard (*Gerrhonotus coeruleus*)	15	0.09	0.99
Side-blotched lizard (*Uta stanburiana*)	13	0.08	0.86
Reptiles—Snakes			
Gopher snake (*Pituophis melanoluecus*)	60	0.35	3.96
Striped racer (*Coluber constrictor*)	33	0.19	2.18
Common king snake (*Lampropeltis getulus*)	28	0.16	1.85
Ring-necked snake (*Diadophis punctatus*)	18	0.11	1.19
Garter snake (*Thamnophis sirtalis*)	1	0.01	0.07
Nightsnake (*Hypsiglena torquata*)	1	0.01	0.07
Amphibians—Salamanders			
Slender salamander (*Batrachoseps* spp.)	383	2.24	25.26
Ensatina (*Ensatina eschscholtzii*)	1	0.01	0.07
Amphibians—Frogs and toads			
Western toad (*Bufo boreas*)	6	0.04	0.40
Unidentified frog	1	0.01	0.07
Total	1,516	8.85	100.00

[1]Total observations expressed as a percent of total coverboard checks (17,136).
[2]Total species observations expressed as a percent of total observations (1,516).

Table 7—Spearman rank correlations (r_s) between total observations of four relatively abundant amphibian and reptile species and seven habitat characteristics on nine 5.8-ha plots in oak woodlands, Camp Roberts, California, 24 January to 26 April, 1995.

Habitat characteristic	Slender salamander	Gopher snake	Skink	Western fence lizard
Litter weight (g)	0.62	0.47	0.28	0.59
P[1]	0.08	0.20	0.47	0.10
Tree canopy cover (pct)	0.82*	0.34	-0.15	0.22
P	0.01	0.37	0.70	0.58
Shrub cover (pct)	0.32	0.59	0.23	0.10
P	0.41	0.10	0.55	0.80
Grass cover (pct)	-0.53	-0.40	-0.08	-0.05
P	0.14	0.28	0.83	0.90
Forb cover (pct)	0.44	0.06	0.46	0.27
P	0.24	0.88	0.22	0.48
Unvegetated ground cover (pct)	0.02	-0.12	0.42	-0.03
P	0.97	0.76	0.26	0.93
Downed wood cover (pct)	0.35	0.58	0.31	0.15
P	0.35	0.10	0.42	0.70

[1]*P*-value of correlation coefficients. Power of the one significant coefficient was 0.8051. All $n = 9$. Asterisks denote significance at $P \leq 0.05$.

Discussion

Small mammal, reptile, and amphibian species richness was similar to that described in other published studies in oak woodlands in California. Compared to Block and Morrison (1991), small mammal species richness and composition at Camp Roberts was similar (12 species from Camp Roberts, including ground squirrels and pocket gophers, for which we did not specifically survey, versus 15 species from their study). We cannot compare our bird species richness data with those in other studies (Block 1989; Block and Morrison 1987, 1991; Verner 1987) because we spot mapped only selected species with at least three detections of a singing male. We found two fewer species of lizards and four fewer species of amphibians than Block and Morrison (1991). Differences in species composition between studies within the small mammal, amphibian, and reptile taxa likely can be attributed to different geographic areas and census methods.

When comparing relative abundance of small mammal species common to both studies, the list from Camp Roberts is similar to live-trapping capture rates of Block and Morrison (1991) with the notable exception of woodrats. Woodrats ranked fifth in the Block and Morrison (1991) study and first at Camp Roberts. Little is published on the density of breeding bird territories estimated from spot mapping. However, numbers are available for the plain titmouse, an abundant species at Camp Roberts, where density was one-and-a-half times the April estimate for an ungrazed oak woodland at the San Joaquin Experimental Range, Madera County (49.4 per 40 ha at Camp Roberts versus 31.2 per 40 ha in Madera County [Verner and Lyman 1988]). The ranked list of relative abundances in oak woodland of amphibian and reptile species collected with pitfall traps by Block and Morrison (1991) is similar to the list from coverboards used at Camp Roberts.

At Camp Roberts, many species of terrestrial vertebrates were associated with shrubby areas of dense oak woodland with downed wood: seven species were significantly ($|r_s| \geq 0.67$ [critical correlation coefficient when n = 9 and $\alpha = 0.05$ (two-tailed)], $P \leq 0.05$) associated with one or more of these habitat components. Although small mammals were strongly associated with dense woodlands, habitat relationships were less pronounced for birds, reptiles, and amphibians. A larger sample size may be needed to detect strong habitat associations, given the relatively low number of individuals present in these groups.

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Attachment 5

Donnelly and Marzluff 2004

Importance of Reserve Size and Landscape Context to Urban Bird Conservation

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Abstract: *We tested whether reserve size, landscape surrounding the reserve, and their interaction affect forest songbirds in the metropolitan area of Seattle, Washington (U.S.A.), by studying 29 reserves of varying size (small, medium, large) and surrounding urbanization intensity (urban, suburban, exurban). Larger reserves contained richer and less even bird communities than smaller reserves. These size effects disappeared when we removed the positive correlation of shrub diversity with reserve size, suggesting that greater habitat diversity in large reserves supported additional species, some of which were rare. Standardizing the number of individuals detected among all reserve size classes reversed the effect of size on richness in exurban landscapes and reduced the magnitude of the effect in suburban or urban landscapes. The latter change suggested that richness increased with reserve size in most landscapes because larger areas also supported larger samples from the regional bird species pool. Most bird species associated with native forest habitat (native forest species) and with human activity (synanthropic species) were present in reserves larger than 42 ha and surrounded by >40% urban land cover, respectively. Thus, we recommend these thresholds as means for conserving the composition of native bird communities in this mostly forested region. Native forest species were least abundant and synanthropic species most abundant in urban landscapes, where exotic ground and shrub vegetation was most common. Therefore, control of exotic vegetation may benefit native songbird populations. Bird nests in shrubs were most dense in medium (suburban) and large reserves (urban) and tended to be most successful in medium (suburban) and large reserves (exurban), potentially supplying another mechanism by which reserve size increased retention of native forest species.*

Key Words: exotic vegetation, forest songbird, nest predation, reserve size, urban conservation, urban landscape

Importancia del Tamaño de la Reserva y el Contexto del Paisaje para la Conservación de Aves Urbanas

Resumen: *Evaluamos si el tamaño de la reserva, el paisaje que rodea a la reserva y su interacción afecta a aves canoras de bosque en el área metropolitana de Seattle, Washington (E.U.A) estudiando 29 reservas de tamaño variable (pequeño, mediano y grande) y la intensidad urbana circundante (urbano, suburbano y exurbano). Las reservas más grandes contenían comunidades de aves más ricas y menos homogéneas que reservas más pequeñas. Estos efectos de tamaño desaparecieron cuando removimos la correlación positiva de la diversidad de arbustos con el tamaño de reserva, sugiriendo que la mayor diversidad de hábitat en las reservas grandes soportaba especies adicionales, algunas de las cuales eran raras. La estandarización del número de individuos detectados entre todas las clases de tamaño de reserva revirtió el efecto del tamaño sobre la riqueza en paisajes exurbanos y redujo la magnitud del efecto en paisajes suburbanos o urbanos. Este cambio sugirió que la riqueza incrementó con el tamaño de la reserva en la mayoría de los paisajes porque áreas mayores también soportaron muestras mayores del conjunto regional de especies de aves. La mayoría de las especies de aves asociadas con el hábitat de bosque nativo (especies nativas de bosque) y con la actividad humana (especies sinantrópicas) estuvieron presentes en reservas mayores a 42 ha y rodeadas por >40% de cobertura urbana, respectivamente. Así, recomendamos estos umbrales como medio para conservar*

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la composición de comunidades de aves nativas en esta región mayormente boscosa. Las especies nativas de bosque fueron menos abundantes y especies sinantrópicas fueron más abundantes en paisajes urbanos, donde fue más común la vegetación herbácea y arbustiva exótica. Por lo tanto, el control de la vegetación exótica puede beneficiar a las poblaciones de aves canoras. Los nidos de aves en arbustos fueron más densos en reservas medianas (suburbanas) y grandes (urbanas) y tendieron a ser más exitosas en reservas medianas (suburbanas) y grandes (exurbanas), potencialmente proporcionando otro mecanismo por el cual el tamaño de la reserva incrementó la retención de especies nativas de bosque.

Palabras Clave: ave canora de bosque, conservación urbana, depredación de nidos, paisaje urbano, tamaño de reserva, vegetación exótica

Introduction

Each year the Earth's human population grows and appropriates more natural resources for its use, including land for residential development (Vitousek et al. 1997). Much of this land use and associated land-cover conversion occurs in existing suburbs and at the suburban-exurban interface (for standard definitions of urbanization levels, see Marzluff et al. 2001). These changes to the landscape have fairly consistent effects on communities of birds and other wildlife. As landscapes become more developed and fragments of native habitat shrink, demographic and behavioral mechanisms cause bird species richness and evenness to decrease and total bird density to increase (Marzluff 2001). Richness and evenness decrease because species associated with native habitat decline in abundance and eventually go extinct as a result of decreased nest success, direct human disturbance (e.g., flushing), or area sensitivity (Whitcomb et al. 1981) and are replaced by fewer, synanthropic species (associated with humans) that proliferate (Beissinger & Osborne 1982). Colonists often increase in abundance by exploiting food and nest sites provided by humans (Marzluff 2001). These responses by bird communities to urbanization challenge bird conservation, an endeavor made more urgent by increasing per capita rates of land development (Ewing 1994) and lagging protection of native habitat (McKinney 2002).

Effective wildlife conservation in urbanizing areas requires that we know if and how native habitat patch size and surrounding development interact to determine bird community structure and underlying population function. We tested whether reserve size, urbanization intensity, and their interaction affect forest songbirds in the Seattle, Washington, metropolitan area. To elucidate mechanisms that might drive observed patterns, we relate breeding bird community composition, bird species relative abundance, and bird reproductive success to urbanization intensity, reserve size, and local vegetation. We relate bird responses to habitat composition at a large scale (urbanization intensity) and a small scale (local vegetation) because birds select habitat at multiple scales (Hilden 1965).

Methods

Study Area

The Seattle metropolitan area (47°40′N, 122°20′W) is within the Western Hemlock (*Tsuga heterophylla* [Raf.]) Zone of the Pacific Northwest (U.S.A.) (Franklin & Dyrness 1988). Because of logging, the subclimax tree Douglas-fir (*Pseudotsuga menziesii* [Mirb.]) dominates the area. The metropolitan area is composed of a large business district that is surrounded by residential developments and satellite business districts (Fig. 1). Despite its urban character, the Seattle area retains a substantial amount of relatively undisturbed native vegetation in the form of privately owned, undeveloped parcels and parks. These habitat reserves range from 1 to 1500 ha.

Site Selection

We used a stratified random-selection process to choose 29 reserves representing all possible combinations of three sizes—small (mean ± SE = 2.1 ± 0.6 ha, $n = 3$ exurban + 6 suburban + 2 urban), medium (34.7 ± 6.0 ha, $n = 2$ exurban + 6 suburban + 2 urban), and large (1471.1 ± 559.8 ha, $n = 2$ exurban + 4 suburban + 2 urban)—within three landscapes or levels of residential development intensity (exurban, suburban, and urban) below 1000 m in elevation. We quantified size and landscape with digital orthophotos and Landsat satellite images, respectively. Orthophotos indicated that all reserves had been isolated from other forest fragments for at least 5 years prior to the study and that exurban reserves were usually isolated by clearcuts, roadways, and utility corridors rather than residential development. To quantify landscape, we converted Landsat images to a three-class land cover based on impervious surface (e.g., pavement) and vegetation (following Botsford 2000; forest = 59% of 356,377 ha classified; urban forest = 19%; urban land cover = 11%; other land cover = 11%). Forest was ≥70% trees and <20% impervious surface. Urban forest was ≥25% trees and 20–60% impervious surface. Urban land cover was ≥60% impervious surface. Other land cover was ≥75% open water or bare soil.

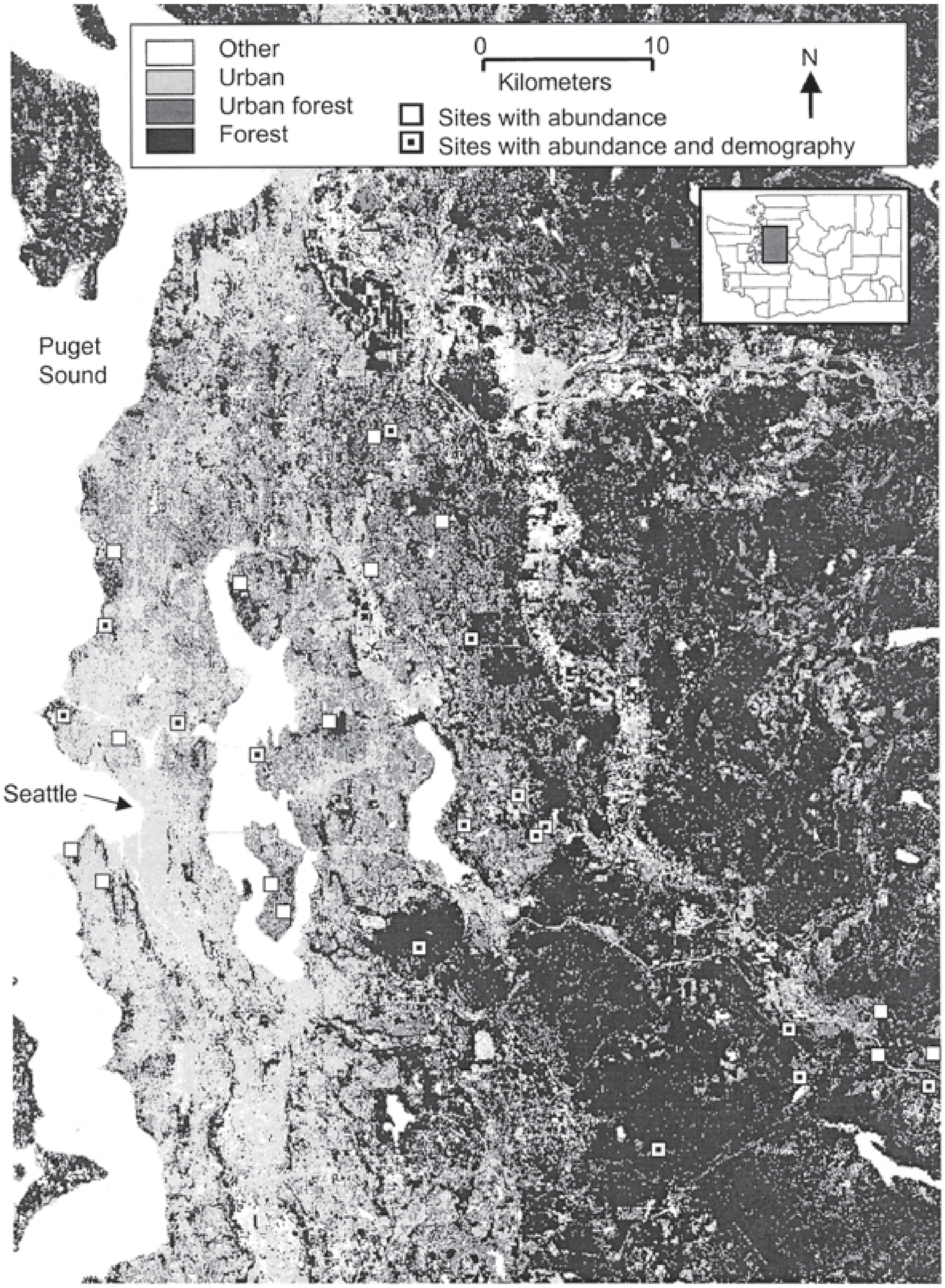

Figure 1. Classified Landsat image from 1998 showing habitat reserves where we studied bird community composition, species abundance, and bird demography.

We classified a reserve's landscape based on the dominant land cover within a 1-km buffer surrounding the reserve. We used Geographic Resource Analysis Support System and the r.le add-on programs (Baker 1997; Alberti et al. 2001) to calculate land cover representation within buffers. The buffer size was selected to reflect the size of a typical residential development and the approximate distance over which subsidized nest predators travel. Reserves with buffers dominated by forest (mean %: forest = 77, urban forest = 17, urban land cover = 5, $n = 7$), urban forest (mean%: forest = 36, urban forest = 44, urban land cover = 20, $n = 16$), and urban land cover (mean %: forest = 9, urban forest = 19, urban land cover = 72, $n = 6$) were classified as exurban, suburban, and urban, respectively. These classifications were distinct according to a discriminant analysis based on urban land cover, urban forest, mean urban patch size, and contagion ($\chi^2_8 = 111.4$, $p < 0.001$).

Once we identified a park or undeveloped lot as a potential study site based on size and landscape, we walked within the reserve to inspect canopy composition and drove around the reserve to determine type of urbanization. We rejected reserves with canopies dominated by younger trees (<70 yrs), canopies dominated by red alder (*Alnus rubra* [Bong.]) and big-leaf maple (*Acer macrophyllum* [Pursh]), and adjacent areas dominated by land uses other than single-family residential. The final criterion was relaxed in exurban landscapes, where single-family residential was rare by definition. We applied the aforementioned criteria because the dominant land cover before European settlement was relatively mature mixed conifer and deciduous forest (Booth 1991) and because multiple land-cover and land-use types may have confounded our design.

Bird Surveys

In 1998 we completed a pilot study at 14 reserves (5 small, 3 medium, and 6 large). We conducted five fixed-radius (50-m) point-count surveys at all reserves between 26 April and 20 July. We (R.D. and one assistant that he trained) recorded all birds that we detected in or just above the canopy by sight or sound during 10 minutes at each point. We set points within the medium and large reserves using two parallel transects with 150 m between all successive points. All points within large and medium reserves were >80 m from forest edges. In each small site, we centered points within the reserve. Extreme variation in site size necessitated varying the number of survey points per site. We established and surveyed as many points as possible up to a maximum of eight points per reserve (small, one point; medium, three to four points; large, five to eight points). In so doing we surveyed the entire area of all small and medium reserves. We did not survey more than eight points in large reserves because richness did not increase after six points (Donnelly 2002). We maintained the same survey protocol in subsequent years but reduced the number of annual visits per site to four. This reduction in survey effort was justified because the pilot study detected a mean of only 1.8 ± 0.58, 0.33 ± 0.33, and 1.33 ± 0.42 new species during the fifth visits to small ($n = 5$), medium ($n = 3$), and large reserves ($n = 6$), respectively.

We analyzed the bird survey data at the community and population levels using data from four surveys conducted in 26 reserves in 1999 (including the reserves from the 1998 pilot study) and 2 reserves in 2000. The benefit of increasing sample size with the two sites from 2000 outweighed the potential for confounding year effects because richness was consistent at sites among years ($r = 0.85$, $p < 0.001$, $n = 20$) and evenness tended to be similar at sites among years ($r = 0.31$, $p = 0.19$, $n = 20$). Greater variation in evenness among years could be explained by greater sensitivity to relative abundance.

We investigated patterns of total bird relative abundance (including all species except those noted below), species richness, Shannon evenness (Magurran 1988), and species relative abundance based on a subset of observed birds. For all analyses we deleted birds that bred primarily in riparian corridors, migrant birds that did not breed in our study area, and birds that ranged over large areas, because our survey technique was unable to assess how they were using the field sites. For further analysis of richness we controlled the increase in total number of birds with area surveyed by rarefying the data (James & Rathbun 1981) with Ecosim 7.0 (Gotelli & Entsminger 2002; options: 1000 iterations, $n = 17$). To index relative abundance at each study site, we averaged the mean number of individuals per species per point across surveys from a single year. We expressed total bird relative abundance as the sum of all species abundances within a site. Abundances of species and all birds were based on seasonal means across surveys within a breeding season rather than seasonal maximums to avoid inflating abundance estimates with young of the year and migrating individuals.

Vegetation Surveys

We quantified the vegetation in plots centered on each bird survey point. In small plots (0.02 ha) we visually estimated (1) the percent cover (vertical, unless stated otherwise) of all ground and shrub species and (2) the horizontal cover and canopy closure from 1.5 m above ground at the cardinal and subcardinal directions with a Moosehorn Coverscope (Garrison 1949). In large plots (0.08 ha) we counted the number of snags and live trees. From these data we calculated 11 vegetation indices: (1 and 2) percent cover for ground and shrub strata; (3 and 4) total percent horizontal and total canopy closure by adding all respective covers (canopy closure, $n = 8$; horizontal, $n = 4$); (5 and 6) preponderance of exotic species in the ground and shrub strata by dividing the percent cover of all species introduced to the Western Hemlock Zone or typically not found below 1000 m in elevation by the percent cover of all species; (7 and 8) diversity (Shannon-Wiener Diversity Index [Magurran 1988]) of shrubs and trees based on percent cover and number of individuals, respectively; (9, 10, and 11) relative snag density, tree density, and red alder domination. We expressed the last as the number of alders divided by all trees. We summarized the indices by site by averaging values across survey points.

Estimation of Bird Productivity

We measured two aspects of reproductive success for 1–3 years per reserve at 15 reserves (Fig. 1): the production of nestlings within a few days of fledging and the ratio of juveniles to adults caught passively in a standardized mist-net survey.

Standard nest-searching techniques were used to locate breeding attempts by birds nesting in shrubs (Martin & Geupel 1993). We searched for nests of the American Robin (avian scientific names are provided in Fig. 4 if not at first mention in text) and Swainson's Thrush within a 8-ha subsection of medium and large reserves and the entire area within small reserves.

We described nest locations based on landmarks and bearings so that we could monitor attempts without leaving cues for predators. We visited each nest every 4–5 days and on the expected day of fledging to categorize the fate of the nest. Nests were "successful" if we observed compacted nest lining, fresh feces on the nest cup or nearby vegetation, or fledglings close to the nest. Nests were "depredated" if the nest cup was disturbed or the clutch or brood was damaged or removed before nestlings were capable of temperature regulation and significant locomotion. Nests were classified as "disturbed" or "abandoned" based on signs of disturbance near the nest, the behavior of incubating or brooding adults (e.g., flushing from nest), and proximity to a likely source of disturbance (e.g., hiking trails). Nests were "substrate-collapsed" if eggs or young nestlings fell to the ground because the supporting substrate collapsed under the weight of the nest. We took care to approach nests when corvids were absent and from a variety of directions to avoid making the nest conspicuous.

Because we found nests at all stages of the nesting cycle, we calculated daily survivorship rates and their variances (Mayfield 1961; Johnson 1979). We assumed that the risk of failure was greater during the brooding stage than the incubation stage as a result of more frequent trips by birds to the nest and nestling vocalizations. Therefore, we calculated daily rates for brooding and incubation. We extrapolated these values to the nest cycle—13 days of incubation and 12 days of brooding—and multiplied the resulting nest-cycle success rate by an estimate of nest density, the number of nests found per search hour. The product indexed the probability of a successful nest. To alleviate problems caused by small sample sizes, we pooled shrub nests by site classification (i.e., size and landscape combination).

We estimated the number of juveniles produced per adult for a subset of shrub-nesting bird species by capturing birds with a modified technique for monitoring avian productivity and survivorship (Desante 1992). At each site we set and operated 10 mist nets (7 30-mm mesh and 3 38-mm mesh measuring 2.6 × 6 m) for 5.5 hours beginning at dawn between 15 May and 10 August. Each site was sampled five times annually. We aged birds according to the procedure of Pyle (1997) and banded each individual to avoid recounting. We assumed that all juveniles were produced in the immediate area and included all of them in the analysis. Our trapping method was effective at capturing the American Robin and Swainson's Thrush, but sample sizes were not large for either species. We therefore pooled nests for these species to compare nest-cycle success among design factors.

Statistics

We set α at 0.05 and completed all statistical analyses other than quantification of community nestedness with the Statistical Package for Social Sciences (SPSS 2001). To meet the assumptions of parametric tests, we transformed many vegetation parameters (all percent covers with arcsine square root; tree diversity with exponential), community metrics (evenness with arcsine square root), and bird species relative abundance (all species with log [abundance + 1]).

We tested the effects of reserve size and landscape context on bird communities and populations with full-factorial general linear models. We included vegetation parameters as covariates in models of total bird relative abundance, richness, and evenness and species relative abundance if these parameters varied with size or landscape and correlated with the response variable (Table 1). If the parameter's inclusion in a model increased the p value associated with a significant main effect or interaction by ≥ 0.15, we concluded that it was a potential mechanism or that it correlated with one.

We estimated where bird species switched from present to absent, or thresholds of occurrence, along continuous ranges of reserve size and landscape context (percent urban land cover) by adapting techniques for quantifying community nestedness. Communities were nested if species in smaller communities—those with fewer species—tended to be included in larger communities. We tested for community nestedness with respect to size and landscape by entering species presence-absence matrices for all 29 reserves into the program Nest (Lomolino 1996). For nested communities, we defined the threshold of occurrence for a species (for method, see Atmar & Patterson 1993) as the size or landscape value at the intersection of the occurrence threshold curve with the row representing that species in the matrix. To obtain a general threshold for the community, we averaged thresholds across species.

We tested the effects of reserve size and landscape context on individual nesting parameters with two techniques. First, we modeled nests found per search hour with three general linear models: a test for an effect of landscape based on small reserves, a test for an effect of landscape based on large reserves, and a test for an effect of size based on suburban reserves. We could not use full-factorial models because we did not monitor nests in medium reserves in exurban and urban landscapes. Second, we tested for differences in nests found per search hour, the mean nest-cycle success of shrub nests, and their combination by comparing overlap in 95% confidence intervals.

To determine which levels of significant main effects and interactions differed in general linear models, we completed post hoc tests. For main effects we used Hochberg's GT2 method (test statistic = H) because this method is robust to differences in sample sizes among treatments (Sokal & Rohlf 1995). Hochberg's test indicates which levels of a main effect differ but does not distinguish among combinations of size and landscape (e.g., small exurban from small suburban). Because this test does not apply to interactions, we computed Scheffe's

Table 1. Influence of reserve size, landscape context, and vegetation on bird communities, populations, and individuals based on full factorial general linear models.

Metric or species	*Factor showing association without covariate in model*[a]	F	p	*Vegetative covariate and sign of correlation*[b]	p *increase with model covariate*[c]
Community					
total bird density	landscape	5.2	0.01	% exotic ground cover +	0.11
				% horizontal shrub cover +	0.05
	size	2.7	0.09		
richness	size	19.1	<0.001	shrub diversity +	0.00
	landscape	4.3	0.03	shrub diversity +	0.06
rarefied richness	interaction	4.9	0.01		
evenness	size	4.0	0.04	shrub diversity −	0.17*
Population					
American Crow	interaction	3.9	0.01	% exotic ground cover +	0.09
				% exotic shrub cover +	0.01
				number snags −	0.01
American Robin	landscape	4.2	0.03	% exotic ground cover +	0.45*
				% exotic shrub cover +	0.20*
				number snags −	0.07
Bewick's Wren	landscape	7.0	0.01	% exotic ground cover +	0.37*
				% exotic shrub cover +	0.28*
				number snags −	0.07
Black-headed Grosbeak	landscape	4.4	0.02		
Brown Creeper	landscape	4.6	0.03	number snags +	0.03
Black-throated Gray Warbler	landscape	3.9	0.04		
Bushtit	interaction	4.5	0.01	% exotic ground cover +	0.10
				% exotic shrub cover +	0.43*
				number snags −	0.00
Chestnut-backed Chickadee	landscape	3.5	0.04		
Hammond's Flycatcher	landscape	3.6	0.04	number snags +	0.03
Hutton's Vireo	size	4.8	0.02		
	landscape	4.7	0.03		
Pine Siskin	landscape	3.6	<0.05	% exotic shrub cover +	0.85*
Spotted Towhee	landscape	5.4	0.02		
Varied Thrush	interaction	7.1	0.01		
Wilson's Warbler	landscape	3.9	0.03	% horizontal shrub cover +	0.13
				number snags −	0.40*
Winter Wren	landscape	3.8	0.04	% exotic ground cover −	0.32*
				% exotic shrub cover −	0.45*
				number snags +	0.86*
Yellow-rumped Warbler	interaction	3.4	0.02	number snags +	0.00
Individual shrub nests found per search hour	landscape	8.2	0.04		

[a] *Main effects on indices of individual breeding success were tested separately. Landscape was tested with large sites (df = 2,3). Size was tested with suburban sites (df = 2,6).*
[b] *Vegetation variables were included as covariates only if they varied with the design factor (all df = 2,26) and correlated with the response metric. Signs for covariate relationships with metrics were based on Pearson's coefficients for analyses at the community and population levels (all* n *= 29).*
[c] *Asterisk indicates inclusion of the vegetative covariate in the model led to a large change in* p *(>0.15).*

post hoc test (test statistic = S) for significant interactions following the method of Zar (1996).

Results

Communities

All bird community metrics responded to landscape and/or size. Total relative abundance of birds in exurban reserves was lower than in suburban reserves (Table 1; Fig. 2; $H = 1.9$, $p = 0.04$) and tended to be lower than in urban reserves ($H = 2.1$, $p = 0.06$). It also tended to decrease with reserve size (Table 1). Bird species richness increased with reserve size (Table 1; Fig. 3a; small to medium $H = 5.0$, $p < 0.01$; small to large $H = 9.3$, $p < 0.001$; medium to large $H = 4.3$, $p = 0.02$) and was greater in suburban reserves than in exurban reserves (Table 1; Fig. 3a; $H = 3.8$, $p = 0.04$), perhaps with the exception of the small size class. The landscape effect held

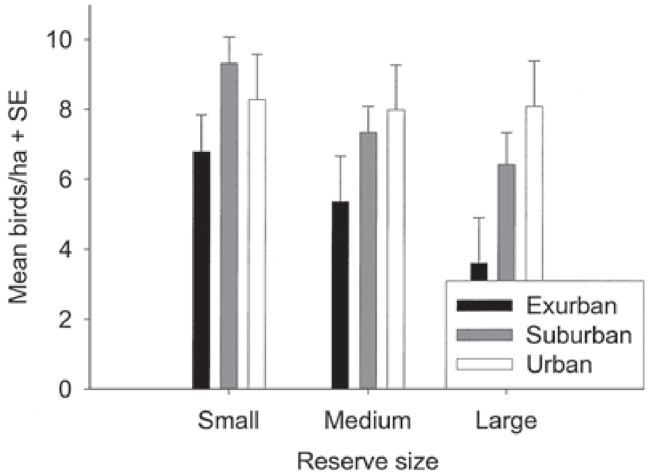

Figure 2. Total bird relative abundance as a function of habitat reserve size and urbanization intensity.

with fewer than four surveys per site (Donnelly 2002) but changed with rarefaction; rarefied richness increased with urbanization intensity in medium and large reserves but showed the opposite trend in small reserves (Table 1; Fig. 3b). Evenness was greater in small reserves than large reserves (Table 1; Fig. 3c; $H = 4.8$, $p = 0.03$). This relationship disappeared when shrub diversity was included as a covariate in the model (Table 1).

Populations

Species-specific thresholds in reserve size and surrounding urbanization intensity ordered (created nested communities; sensu Atmar & Patterson 1993) the retention of native forest species (percent of perfect nesting by size: 19.2, $p < 0.01$; Fig. 4a) and gain of synanthropic species (percent of perfect nesting by landscape: 13.5, $p = 0.01$; Fig. 4b). Retention was more ordered than gain. Native forest species tended to switch from present to absent when reserves fell below 42.2 ± 15.0 ha (mean threshold of occurrence, $n = 17$). Synanthropic species were almost completely absent from the eight reserves with the least urban land cover (<6% urban land cover) and tended to switch from absent to present when urban land cover exceeded $40 \pm 9.9\%$ (mean threshold of occurrence, based on 12 species present in at least four reserves). The increases in retention of native forest species with reserve size and in gain of synanthropic species with urbanization intensity are also visible in Fig. 3a.

The relative abundance of many bird species varied with landscape (Table 1). Of those species responding to landscape, three were most abundant in exurban reserves (Black-throated Gray Warbler, Hammond's Flycatcher, Winter Wren; exurban to suburban $H = 0.04$–0.1, all $p < 0.05$; exurban to urban $H = 0.04$–0.2, all $p < 0.05$), four were most abundant in suburban reserves (Black-headed

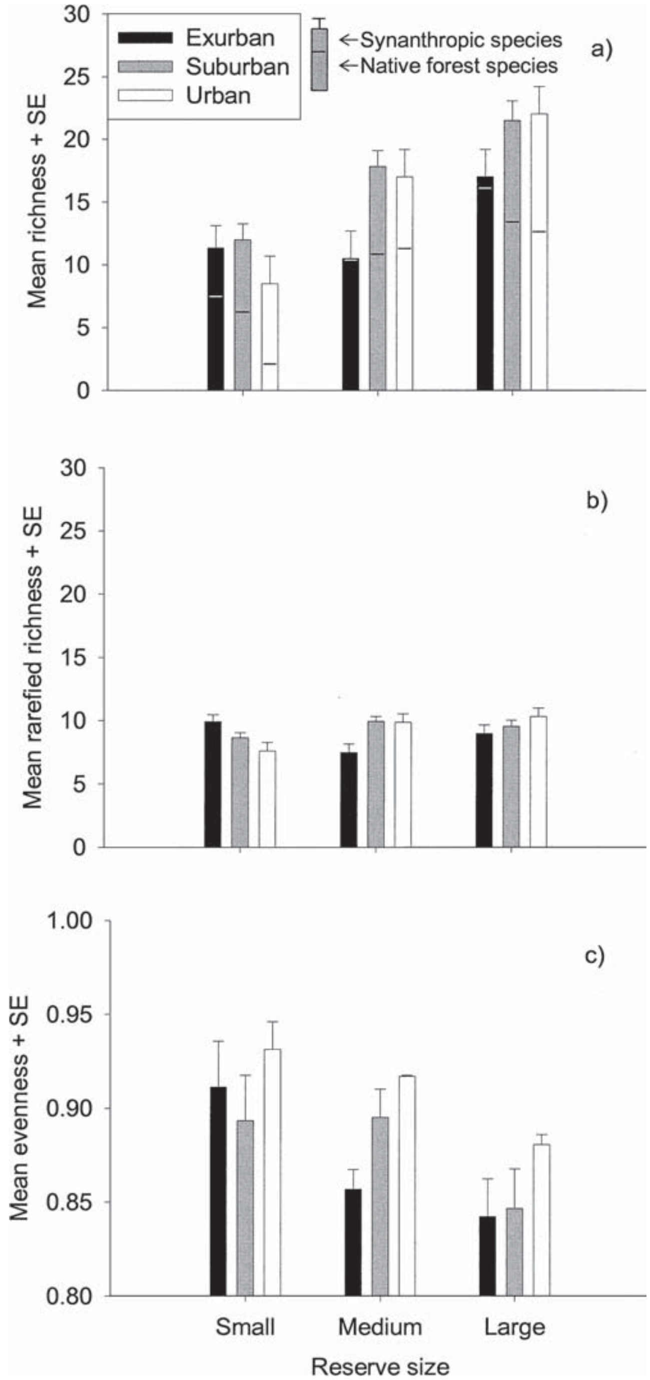

Figure 3. (a) Bird species richness, (b) rarefied bird species richness, and (c) bird community evenness as a function of habitat reserve size and urbanization intensity. In (a), horizontal lines separate native forest species (bottom) from synanthropic species (top).

Grosbeak, Brown Creeper, Chestnut-backed Chickadee, Spotted Towhee; suburban to exurban $H = 0.03$–0.12, all $p < 0.05$; suburban to urban $H = 0.06$–0.12, all $p < 0.05$), and four were most abundant in urban reserves (American Robin, Bewick's Wren, Hutton's Vireo, Pine Siskin;

Figure 4. Ordered retention of (a) native forest and (b) synanthropic bird species in habitat reserves. Columns represent communities ranked by (a) reserve size and (b) urban land cover. Rows represent species ordered to maximize presences in the upper right and absences in the lower left. Filled and unfilled squares indicate presence and absence, respectively. The intersection of the superimposed occurrence threshold curve (shape dependent on matrix dimensions and percent fill) with a row indicates a species-specific occurrence threshold or the size or land cover value where a species tended to switch from present to absent or vice versa. We calculated mean thresholds of occurrence based on all species present in more than three reserves (marked with asterisks).

urban to suburban $H = 0.02–0.12$, all $p < 0.05$; urban to exurban $H = 0.02–0.2$, all $p < 0.05$). Only three of the species responding to landscape were not found within all three landscape levels (Bewick's Wren, Black-headed Grosbeak, Pine Siskin). In each case, they were absent from exurban reserves. Many of the associations between relative abundance and landscape dissipated when one or more vegetation variables were included in the models as covariates. Two correlated variables ($r = 0.63$, $p < 0.001$, $n = 29$) caused most of these effects (Table 1): exotic ground cover ($n = 3$ species; mean % cover: exurban = 2.7 ± 2.3, suburban = 17.2 ± 4.9, urban = 35.1 ± 16.2) and exotic shrub cover ($n = 4$ species; mean % cover: exurban = 0 ± 0, suburban = 4.2 ± 2.0, urban = 27.3 ± 11.6).

Five species varied in abundance with reserve size and with combinations of size and landscape (Table 1). Hutton's Vireo was more common in medium than small reserves ($H = 0.018$, $p = 0.01$). The American Crow and Bushtit were absent from exurban reserves and more common in small urban reserves than all other combinations of size and landscape (American Crow, $S = 4.4–7.3$; all $p < 0.05$; Bushtit, $S = 4.5–7.5$; all $p < 0.05$). The Varied Thrush was more abundant in medium exurban reserves than all other reserve types except medium urban reserves ($S = 4.5–6.8$, all $p < 0.05$). The Yellow-rumped Warbler was rare and was found only in small exurban reserves. Replication limited our ability to distinguish its abundance in small exurban reserves from its abundance in other combinations of size and landscape (to small suburban $S = 4.6$, $p = 0.04$; to medium suburban $S = 4.6$, $p < 0.05$).

Nest Success and Causes of Nest Failure

Nest predation was the most common cause of failure at shrub nests. Fifty-one percent (95 of 188) of monitored nests failed. Seventy-seven percent (59 of 76) of nests with a known cause of failure were depredated. Other causes of failure were disturbance (8%), abandonment (8%), and substrate collapse (4%).

The relative abundance of shrub nests and nest-cycle success was related to reserve size and landscape context. Nests were three to four times more abundant in medium suburban and large urban reserves than all other combinations of reserve and size (Fig. 5a). Within suburbs they appeared to be more abundant in medium reserves than small and large reserves. Within urban areas they appeared to be more abundant in large reserves than small reserves. Large urban reserves also had more nests than large reserves in other landscapes (Table 1; Fig. 5a; urban to suburban $H = 0.085$, $p = 0.04$; urban to exurban $H = 0.094$, $p = 0.01$). If landscape had an effect on the relative abundance of nests in small sites, the pattern it produced opposed the pattern observed in large sites. Nests were conspicuously absent in small urban reserves, where the search effort per unit area was high (approximately75 hours/ha/year). Nest-cycle success (combination of incubation and brooding stages) appeared to be nearly two times greater in medium sites than in sites of other sizes within suburbs and in large sites than in smaller sites within exurban areas (Fig. 5b). Similar to the pattern of nest abundance, the number of successful shrub nests found per unit search effort appeared to peak in medium sites within suburbs and within large sites in urban landscapes (Fig. 5c). These sites were three to four times more successful by this measure than other combinations of size and landscape.

The juvenile-to-adult ratio for shrub-nesting birds appeared to correlate with nest productivity only in urban landscapes. There, juveniles were more common per adult in large than small reserves (ratios: small, 0; medium, no data; large, 0.12). The opposite pattern occurred in exurban reserves (ratios: small, 0.39; medium, no data; large, 0), despite nearly equal nest abundance and nest-cycle success in small and large exurban reserves. The juvenile-to-adult ratio was lowest in medium reserves in suburbs (ratios: small, 0.27; medium, 0.13; large, 0.17), a trend that was also not apparent from monitoring nests.

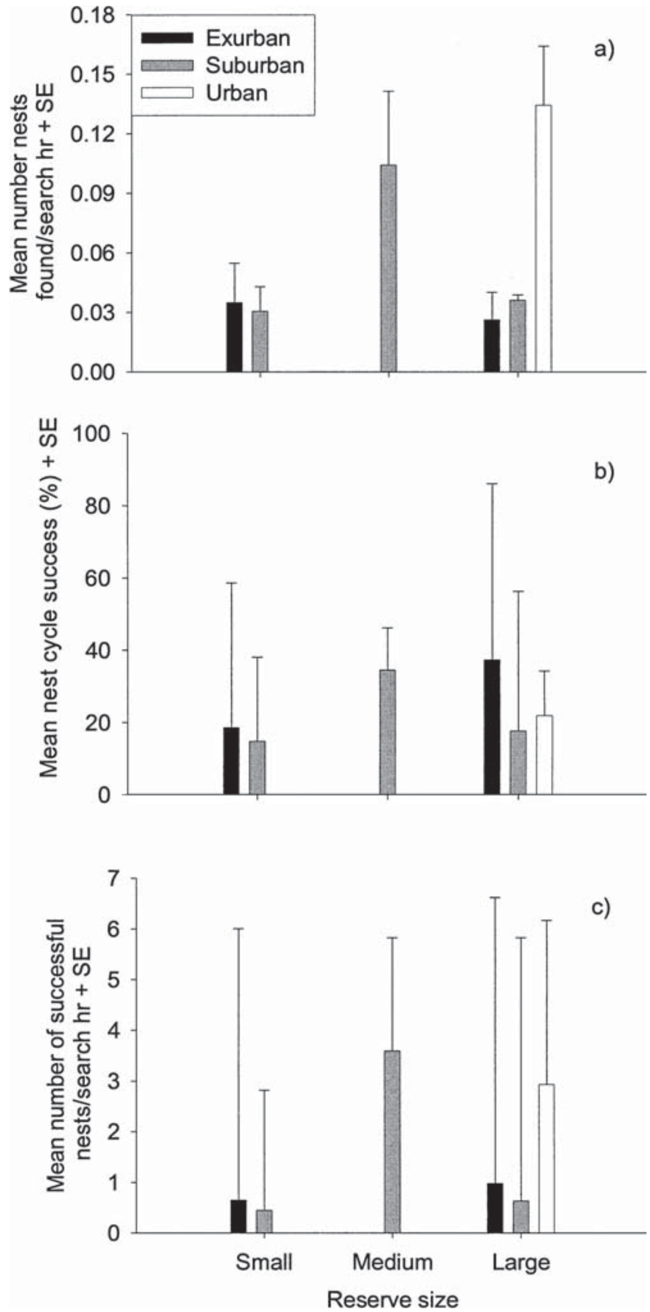

Figure 5. Shrub nest success in habitat reserves expressed as (a) nests found per search hour, (b) nest cycle success, and (c) a combination of these factors. We did not find any nests in the small urban reserve or search for nests in medium exurban and medium urban reserves.

Discussion

Communities

Bird communities generally changed with size and landscape, as predicted by the literature. As reserve size increased, richness increased (Fig. 3a) but individuals became less evenly distributed among those species (Fig. 3c). Theory argues that richness should increase with reserve size because, relative to smaller areas, larger areas (1) support larger populations that are more resistant to demographic stochasticity (MacArthur & Wilson 1967); (2) support more individual birds representing a larger proportion of species from the regional pool (passive sampling; Wiens 1989); and (3) contain greater habitat heterogeneity and more niches (β diversity). We found evidence for the second and third mechanisms. Rarefaction reduced the magnitude of the size effect on richness in suburban and urban reserves (Fig. 4b), implicating passive sampling. A biological effect of reserve size on species richness was also likely, however, because rarefaction dampened but did not remove the size effect in most landscapes. We hypothesize that greater shrub diversity in larger reserves than in smaller reserves may explain at least some of the remaining size effect because shrub diversity and richness were positively correlated (Table 1). Moreover, this hypothesis was consistent with the negative correlation of evenness with size (Fig. 3c) and its apparent explanation by shrub diversity (Table 1). Bird species responding to greater habitat diversity were rare. Thus, they lowered evenness and contributed little to rarefied richness, a sample derived from species surveys. Regardless of the mechanism driving greater richness in larger reserves, this benefit of larger reserve size appeared to hold only in suburban and urban landscapes.

Landscape had both expected and unexpected relationships with avian community composition. As expected, total bird relative abundance was greater in urban and suburban reserves than in exurban reserves. However, supplemental food and human-made nest sites could not have explained the entire effect because synanthropic species were not common within reserves. This suggests that density increased because native birds packed into forest patches when forest was rare on the landscape (Hannon & Schmiegelow 2002). The degree of packing tended to be negatively correlated with reserve size, perhaps because similar numbers of birds dispersed over more forest habitat when it was available. Unlike the pattern of total bird relative abundance, the increase in rarefied richness with urbanization intensity in medium and large sites was unexpected. The unexpected increase in species number may have resulted from our truncation of the urbanization-intensity gradient at approximately 70% impervious surface. Had we extended the gradient to the core business district (90–100% impervious surface), richness probably would have declined to a subset of the six most synanthropic bird species in this region (House Sparrow, American Crow, European Starling, Glaucous-winged Gull [*Larus glaucescens*], Herring Gull [*Larus argentatus*], Rock Dove [*Columba livia*]). We hypothesize that the dramatic reduction in species richness would have caused richness to peak at intermediate values of urbanization intensity, as documented by others (Blair 1996) and predicted by the intermediate-disturbance hypothesis (Huston 1979).

Populations

As expected, reserve size and surrounding urbanization intensity were related to the presence or absence of individual species. The number of native forest species present within bird communities decreased with reserve area as species reached individual thresholds of occurrence; most species were present at sites larger than 42 ha. This pattern could have been caused by either differential susceptibility to area-related local extinction (Bolger et al. 1991), differential dispersal ability (Darlington 1957), or an underlying arrangement of habitats in which those in smaller sites were included within larger sites, thus increasing habitat diversity (Cody 1983). We believe that local extinction was the best hypothesis because all strong dispersers—such as the long-distance migrants Black-throated Gray Warbler and Western Tanager—were not present in the smallest sites and there was no evidence of hierarchical arrangement of habitats. The gain of synanthropic species was similarly ordered, with most species being gained in reserves surrounded by >40% urban land cover. Some of these species, such as the Black-headed Grosbeak and Cedar Waxwing, were native species that probably relied more on the juxtaposition of habitats produced by urbanization than supplemental food or human-made nest sites.

The relative abundance of many native forest and synanthropic species varied with landscape or the combination of landscape with size but not with size alone. Again, this pattern agreed with the literature: area-sensitive native forest species were generally present at constant abundance or absent (Whitcomb et al. 1981), and synanthropic species generally increased in abundance with urbanization and the resources that it provided (Marzluff 2001). Most of the relationships between relative abundance and landscape appeared to be explained by exotic ground and shrub cover. Native forest species decreased and synanthropic species increased with these attributes of the local vegetation. Because exotic ground and shrub cover were positively associated with urbanization intensity, it was difficult to tell whether their explanatory power was due to the indirect effects of urbanization or the direct impacts of these variables on individual fitness. Because the species in question represent many foraging and nesting guilds, we believe that both types of effects probably occur in these communities.

Individual Nest Success

The American Robin and Swainson Thrush, two shrub-nesting thrushes, appeared to be more productive in larger (medium and large) reserves only in suburban and urban landscapes. In urban landscapes there appeared to be roughly the same number of successful nests in large reserves than in small reserves as a result of nest density rather than nest success. Nest density appeared as important as nest success in exurban landscapes. In large exurban reserves there were three times fewer successful nests than in same-sized urban reserves because of low nest density and despite relatively high nest success. Nest density and success were two to three times higher in medium suburban sites than most combinations of reserve size and landscape, resulting in the highest apparent density of successful nests. The effect of size on the productivity of shrub-nesting birds in urban and suburban reserves was consistent with greater richness in larger reserves because populations of shrub-nesting birds are likely to persist and contribute to richness where they are more productive.

The relationship of reserve size and landscape to the relative risk of predation at artificial shrub nests was very similar to that for nest success (Donnelly 2002). Risk was least in large urban, medium suburban, and small exurban reserves, suggesting that it decreased with size in urban landscapes but increased with size in exurban landscapes. The similarity of patterns of nest success and predation risk implicated nest predation as a driver of nest success. This finding was supported by the fact that most nests failed as a result of predation, and the effect of urbanization intensity on the risk of nest predation was explained by horizontal and exotic shrub cover (Donnelly 2002). Where shrub nests were more concealed, they survived longer. Despite this pattern, the abundance of diurnal, visual predators that we sampled did not positively correlate with predation risk. Instead it appeared that rats may have increased the risk of nest predation (Donnelly 2002). Recently, estimates of population productivity based on per-nest success have been questioned because re-nesting can compensate for low rates of nest success (Thompson et al. 2001) if predation rates are not very high (<65%; Schmidt & Whelan 1999). Because the overall percentage of nest failure at our sites was below this threshold, we assessed whether re-nesting compensated for nest predation and reduced annual nest success by estimating the juvenile-to-adult ratio for each site. The pattern of these ratios for shrub-nesting birds relative to reserve size and landscape context was more similar to that for risk of nest predation than for nest abundance or nest cycle success (Donnelly 2002). As a result, we hypothesize that re-nesting did not compensate for nest predation and that large reserve size was beneficial in urban and suburban reserves but may have had little effect in exurban reserves. We state the last interpretation more cautiously because it was possible that low bird density in large exurban reserves made netting less effective. Limited correlation of juvenile-to-adult ratios with nest abundance and nest-cycle success suggested that the mechanism(s) dictating risk of nest predation (e.g., rat abundance) differed from those dictating juvenile survivorship.

Conservation and Planning Implications

Reserve size was important to bird community composition in all landscapes and to breeding success in some landscapes. These relationships suggest strategies for conserving native forest birds in the Seattle metropolitan region. Richness increased with reserve size in all landscapes because larger reserves had larger samples of individuals from the regional pool of species and provided habitat for more species than small reserves. As reserves decreased in size, native forest species disappeared at predictable sizes. For example the Golden-crowned Kinglet was almost always present in reserves of >21 ha but tended to be absent from smaller reserves. Because species exhibited these thresholds of occurrence, a collection of medium and small reserves will not conserve species such as the Golden-crowned Kinglet or regional bird diversity (Patterson 1987). Policy makers can encourage retention of larger reserves within landscapes by limiting development and requiring planners in growing counties and incorporated areas to plan for large, contiguous blocks of forest (some >42 ha), especially in areas of high forest habitat diversity. Large reserves in more urban landscapes (>40% urban land cover) will support richer communities than large exurban reserves, but the difference will be due to greater colonization by synanthropic species (some of which are native).

Population abundance within reserves was influenced by landscape and rarely by the combination of landscape and reserve size. Different groups of bird species peaked in abundance in exurban, suburban, and urban reserves. The effect of landscape was explained by exotic ground and shrub cover. These covers increased in more urban landscapes and were associated with increases in synanthropic species and decreases in native forest species. It is not clear whether these plants have a direct influence on the birds or whether they correlate with other aspects of urbanization. Nonetheless, we recommend that land managers and homeowners minimize exotic ground and shrub cover in forest fragments.

The combination of reserve size and landscape setting appeared to influence breeding success and potentially determine whether populations were self-sustaining. Reserve size was beneficial to breeding birds in suburban and urban landscapes. The density of nests in shrubs was greatest in medium suburban and large urban reserves and appeared to be at least as important as nest success to overall reserve productivity. In contrast, large exurban reserves and small reserves in all landscapes had very low densities of successful nests (0 in a small urban reserve). These relationships lead us to two conclusions. First, small urban reserves have no value as breeding habitat for at least two native forest species that nest in shrubs. Second, larger reserves in more urbanized (suburban and urban) landscapes have exceptional conservation value for most native forest species, but it will often be necessary to manage human disturbances that negatively affect birds, including free-ranging domestic cats, dog walking, hiking, and refuse. Land managers can educate recreationists and homeowners adjacent to parks and route trails to steer away from some habitat set aside for wildlife conservation. Homeowners can minimize the access of potential nest predators to refuse, keep pets inside or on a leash, stay on designated hiking trails, and trap rats.

We do not recommend that the guidelines encouraging larger reserves in suburban and urban landscapes be applied to all landscapes. Although we are most concerned about the retention of native forest species, a number of synanthropic species are also native but require some level of disturbance or habitat interspersion. For example, the native Song Sparrow and Black-headed Grosbeak are present only in habitat with some fragmentation. Rohila (2002) made similar recommendations for the retention of some native cavity-nesting bird species in this region. She recommended that some landscapes contain 27–60% forest interspersed with settlement. Providing some heterogeneity of landscape will help preserve native forest species, native synanthropic species, and regional bird diversity (Pyle 1980).

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Attachment 6

Lenth et al. 2006

Conservation Value of Clustered Housing Developments

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Abstract: *Traditionally, exurban lands in Colorado have been subdivided into a grid of parcels ranging from 2 to 16 ha. From an ecological perspective, this dispersed pattern of development effectively maximizes the individual influence of each home on the land. Clustered housing developments, designed to maximize open space, are assumed to benefit plant and wildlife communities of conservation interest. They have become a popular alternative for rural development despite the lack of empirical evidence demonstrating their conservation benefits. To better inform rural land-use planning, we evaluated clustered housing developments by comparing their spatial pattern with that of dispersed housing developments and by comparing their conservation value with that of both dispersed housing developments and undeveloped areas in Boulder County, Colorado. We used four indicators to assess conservation value: (1) densities of songbirds, (2) nest density and survival of ground-nesting birds, (3) presence of mammals, and (4) percent cover and proportion of native and non-native plant species. Clustered and dispersed housing developments did not differ on the majority of variables we examined. Both types of housing development had significantly higher densities of non-native and human-commensal species and significantly lower densities of native and human-sensitive species than undeveloped areas. More rigorous ecological guidelines and planning on a regional scale may help create clustered developments with higher conservation value.*

Keywords: exurban development, grassland birds, mammals, plant communities, rural residential development

Valor de Conservación de Desarrollos de Vivienda Agrupados

Resumen: *Tradicionalmente, los terrenos exurbanos en Colorado han sido subdivididos en una red de parcelas que varían entre 2 y 16 ha. Desde una perspectiva ecológica, este patrón disperso de desarrollo maximiza efectivamente la influencia individual de cada hogar en el terreno. Se asume que los desarrollos de vivienda agrupados, diseñados para maximizar el espacio abierto, benefician a las comunidades de plantas y vida silvestre de interés para la conservación. Los desarrollos de vivienda agrupados se han vuelto una alternativa popular para el desarrollo rural a pesar de la ausencia de evidencia empírica que demuestre sus beneficios para la conservación. Para aportar mejor información a la planificación del uso de suelo rural, evaluamos los desarrollos de vivienda agrupados comparando su patrón espacial con el de desarrollos de vivienda dispersos y comparando su valor de conservación con el de desarrollos de vivienda dispersos y de áreas sin desarrollo en el Condado Boulder, Colorado. Utilizamos cuatro indicadores para evaluar el valor de conservación: (1) densidades de aves canoras, (2) densidad y supervivencia aves que anidan sobre el suelo, (3) presencia de mamíferos y (4) cobertura porcentual y proporción de especies de plantas nativas y no nativas. Los desarrollos de vivienda agrupados y dispersos no difirieron en la mayoría de las variables que examinamos. Ambos tipos de desarrollo de vivienda tuvieron densidades de plantas no nativas y de especies comensales con humanos significativamente mayores y densidades de especies nativas y especies sensibles a humanos significativamente*

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menores que en las áreas sin desarrollo. Directrices ecológica más rigorosas y la planificación en una escala regional puede ayudar a crear desarrollos agrupados con mayor valor de conservación.

Palabras Clave: aves de praderas, comunidades de plantas, desarrollo exurbano, desarrollo residencial rural, mamíferos

Introduction

The American West is growing more rapidly than any other region of the United States and is the only region where rural areas are growing faster than metropolitan areas (U.S. Census Bureau 2000). There is little argument that human development has serious implications for biodiversity (Wilcove et al. 1998; Czech et al. 2000; Marzluff 2001) and that ecological research needs to encompass the private lands where we live (Knight 1999; Miller & Hobbs 2002; Hilty & Merenlender 2003).

Private lands are far more productive and well watered than protected lands, and therefore may be disproportionately important habitat for wildlife (Scott et al. 2001). In some cases, wildlife populations in protected areas may be sustained only by source populations on adjacent privately owned lands (Hansen & Rotella 2002). Thus the fate of ranch and farmlands currently being subdivided for housing developments deserves careful consideration. Growth trends in the American West are not likely to diminish. It is therefore crucial that the impacts of current growth patterns be understood so that future developments can accommodate natural communities.

Several researchers have successfully identified species or guilds that serve as good indicators of ecological conditions (e.g., O'Connell et al. 2000; Reynaud & Thioulouse 2000). The effects of development gradients on species communities have also been examined (e.g., Friesen et al. 1995; Germaine et al. 1998; Blair 1999; Parsons et al. 2003). Although species richness and diversity may peak at intermediate levels of development (Blair 1996), many studies differentiate between species that decrease in abundance and eventually disappear with increasing urbanization and species that thrive in urban habitats (e.g., Bolger et al. 1997; Fernandez-Juricic 2001; Stralberg & Williams 2002). In rural areas, land-use planners should strive for development guidelines that protect species that are sensitive to development.

We focused on growth beyond incorporated city limits, termed *exurban development* (Theobald 2004). Characterized by widely dispersed, large-lot development, exurban growth is highly consumptive of land. In the United States exurban development currently takes up five times more land than all urban and suburban development combined (Theobald 2004) and is the fastest-growing type of development (Crump 2003). Dispersed exurban developments increase non-native and human-commensal plant and animal species (Maestas et al. 2003) and can alter the composition of plant and wildlife communities up to 180 m away from houses (Odell & Knight 2001). These effects may increase for several decades (Hansen et al. 2005).

Clustered housing developments offer an alternative to traditional exurban development. In clustered housing developments roughly the same number of houses that would be constructed under a conventional dispersed development plan are grouped more closely together on smaller lots (usually <1 ha), and the remaining area is protected as open space under a conservation easement. Clustered housing developments are assumed to benefit wildlife (e.g., Arendt 1996; Theobald et al. 1997; Odell et al. 2003); yet to date, no one has examined their conservation values.

We set out to test the intuitive assumption that clustered housing developments have greater conservation value than more conventional, dispersed housing developments, relative to undeveloped areas. Land-use policy is a strong driver of landscape pattern, and we wanted our results to be useful to land-use planners. We therefore worked with local land-use planners and land managers to choose dispersed housing developments, clustered housing developments, and undeveloped areas, based on the planning processes that created them. We then characterized the spatial patterns resulting from both the clustered housing development and dispersed housing development planning processes to see how these patterns differed. Finally we evaluated the conservation value of clustered housing developments, dispersed housing developments, and undeveloped areas based on four indicators: (1) densities of songbirds, (2) nest density and survivorship of ground-nesting birds, (3) presence of mammals, and (4) percent cover and composition of native and non-native plant species.

Methods

Boulder County, Colorado, lies at the interface between the Great Plains and the Rocky Mountains (40°00′54″N, 105°16′12″W). The city of Boulder is surrounded by an extensive belt of open space, farms, ranches, and exurban development. We chose this region because Boulder County planners began implementing clustered development nearly 30 years ago.

Colorado state law gives landowners the right to subdivide their land into 14-ha parcels without county land-use review. But in 1972, the Colorado General Assembly adopted the Planned Unit Development Act (CRS 24-67-101 et seq), which gives local governments more flexibility and decision-making power in return for a higher level of forethought and concern for development design on behalf of the landowner. This enabled Boulder County to develop its Non-Urban Planned Unit Development process in 1978, which provides an alternative to the typical 14-ha division of land. If house lots are restricted to 25% of the land to be developed, and a conservation easement is placed on the remaining 75% of the property, the developer is allowed a higher housing density. This process was designed to concentrate urban development, and protect lands with high agricultural or natural resource value.

Although we focused our study at the scale of the individual housing development, we chose our study sites to control for strong gradients of contrast within the study area. We restricted all study sites to one general soil type, a Nederland-Valmont association (USDA 1975). We chose this soil type because it is very cobbly, and therefore most of it has not been plowed and is still characterized primarily by natural vegetation. Restricting all study sites to one soil type avoided inherent differences in plant and wildlife communities related to habitat. We also controlled for strong contrasts in housing density in the surrounding matrix. Using a moving window with an 800-m radius (ArcGIS, ESRI 2003), we computed the average housing density from parcel data for the entire county. We then identified locations that were at an exurban housing density of 1 housing unit per 16 ha and selected study sites within this exurban density matrix. Thus, our study sites were not located near high-density development nor surrounded entirely by open space.

Within this soil type and exurban density, six clustered housing developments were located in areas that had not been used for row-crop agriculture or as irrigated hay meadows. These developments ranged from 35.5 ha to 292 ha (including both the housing development and the protected outlot). Average size was 92 ha. The overall housing density across the six clustered developments with their outlots was 9.75 ha/house. The outlots, protected from development through a conservation easement, allowed traditional uses such as horse and cattle grazing.

We selected six contiguous areas of dispersed development, or development that had not undergone the clustering process. These sites were made up of parcels ranging from 2 ha to 16 ha and differed in pattern of development but not in housing density. These dispersed housing developments had total areas ranging from 32 ha to 121 ha, an average size of 65 ha, and the same overall housing density of 9.75 ha per house. Many of the dispersed developments included horse properties, and some had cattle grazing.

We chose six undeveloped areas made up of properties managed by the City of Boulder Open Space and Mountain Parks Department, Boulder County Parks and Open Space, and the U.S. Department of Commerce. The area of these sites ranged from 216 ha to 1379 ha (average 480 ha). Most of the undeveloped sites allowed public access along trails, dogs on leash or under voice command, and some seasonal grazing of cattle or horses. All 18 study sites were similar in elevation, ranging from 1550 m to 1900 m, and were in a mixed-grass prairie ecosystem.

Characterizing Spatial Pattern

To characterize the spatial pattern of dispersed and clustered housing developments, we analyzed each developed site following the methods of Theobald et al. (1997). In ArcGIS (ESRI 2003) we digitized a point marking each house in the study area. We buffered each house with a 200-m hypothetical zone of influence based on Bock et al.'s (1999) findings in the same grassland system that suburban edge effects extend up to 200 m. We calculated the proportion of each development remaining outside of this zone of influence (within which plant and wildlife communities may be affected) (see Fig. 1c & 1d for an example). We extended this analysis with a more refined method that treats each study site as a continuous surface (GIS frag, Ripple et al. 1991; Theobald 2003). Again in ArcGIS (ESRI 2003), we created a unique layer for each of the 12 developed study sites and digitized a point marking each house in the study area. For each location inside the study area (each 30 × 30 m cell), we calculated the Euclidian distance to the nearest house (Fig. 1e & 1f). We then averaged these distances for each site to quantify the spatial configuration of all the houses. Our analyses did not account for houses in adjacent parcels outside our study sites.

Bird Sampling

For each field season (summers of 2003 and 2004), we established a systematic random sample of six evenly distributed transects in each of the 18 study sites. Transects were 200-m long, at least 200-m apart, and at a 45° angle from roads and property lines. All transects were located at least 50 m from houses, roads, trails, riparian areas, and development boundaries. In this way transects were almost exclusively located in the open grasslands of dispersed developments and in the protected outlots of clustered housing developments.

We surveyed birds along each transect once during each of two breeding seasons (mid-May to the end of June in 2003 and 2004). We used distance sampling (Buckland et al. 1993), which provides estimates of bird densities without assuming that all birds have an equal probability of detection or that every bird present during the survey is detected. We recorded all bird species seen or heard along the transect and estimated their distance to the nearest meter, calibrated with a laser rangefinder (Bushnell Corporation, Overland Park, Kansas City). We also measured the sighting angle from the transect line with a large

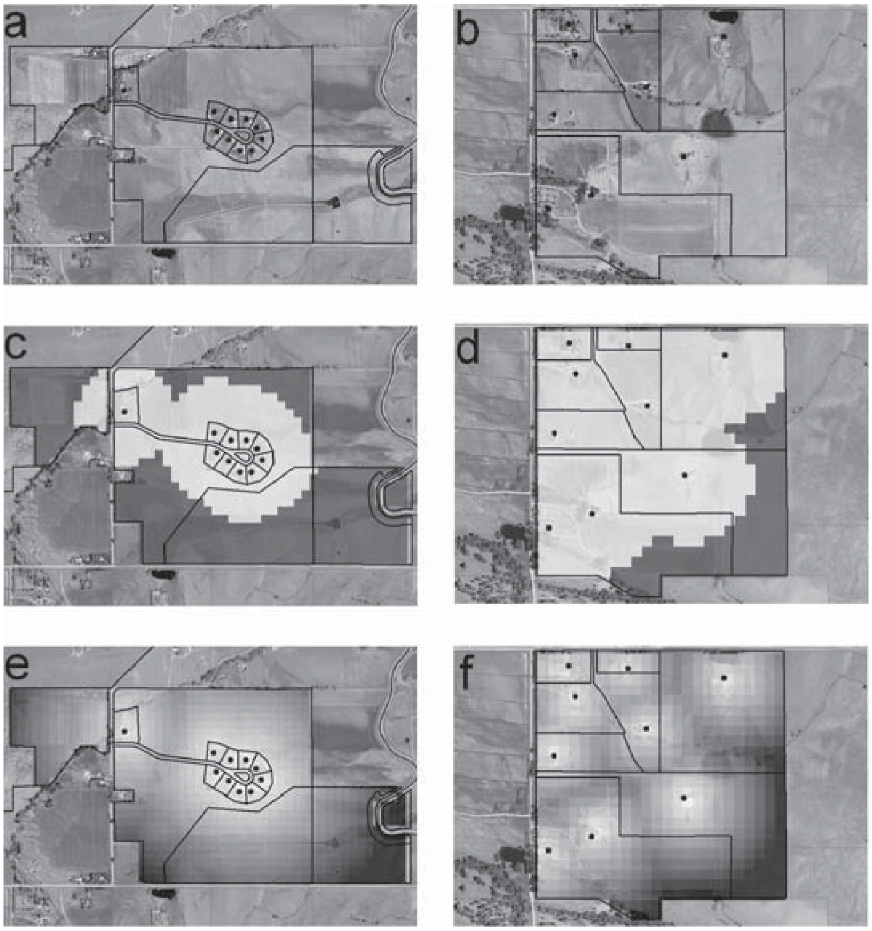

Figure 1. Discreet distance analysis of (a) clustered development with a total area of 85 ha, 10 houses, and 80 ha of protected outlots and (b) dispersed development with a total area of 60 ha and 9 houses. When each house in the development is buffered by a hypothetical 200-m zone of influence the (c) clustered development retains 49 ha (58% of the total area) outside the zone of influence, whereas the (d) dispersed development retains only 13 ha (22% of the total area) outside the zone of influence. In (e) and (f) distance from the nearest house is reflected as a continuous surface.

protractor. These detectability based density estimates are more reliable than traditional index counts (Rosenstock et al. 2002). Sampling occurred between sunrise and 3 hours after sunrise and was not conducted in inclement weather.

Nest Survival

Because density can be a misleading indicator of habitat quality (Van Horne 1983), we also examined nest density and survival. We located nests by dragging a 2.4-cm-diameter rope, between two observers spaced 30-m apart, over the grasslands. This method flushed adult birds off of their nests, which we then located (Miller et al. 1998). We marked nests with a flag placed about 20 m away in one of the four cardinal directions, which was randomly selected to minimize cueing predators to nest locations. We visited each nest every 2–5 days until fledging or nest failure and recorded the fate of each nest. Searches were centered on our sampling transects and performed on a rotation of sites until an equal area was searched in each of the three land-use types.

Mammal Surveys

Detection frequencies of mammals were determined using scent stations established at random points along the transects in each site. Stations were operated during both field seasons (July of 2003 and May–July of 2004). A total of 108 track nights were evenly distributed among sites for an equal sampling effort in all three land uses. At each station we sprayed a 1-m^2 metal plate with a solution of ethanol and talc. As the ethanol evaporated only a thin film of powder was left on the plate, which registered clear prints (Zielinski 1995). We secured a sponge to the center of the plate and poured a liquid lure (Carmen Pro's Choice, Sterling Trap and Fur, Sterling, Ohio) over the sponge to attract carnivores. Although this method was designed to attract medium-sized carnivores, many other mammals visited our stations, and we identified and recorded all tracks on a daily basis (Halfpenny 2001). We replenished the lure each day. Nights when precipitation obscured the tracking surface were not included as a track night, and the station was resprayed with the talc solution and left out for an additional night. We placed scent stations at least 200-m apart and considered them independent sampling points. However, multiple nights at one station were not considered independent samples and were pooled together for the analysis.

Vegetation Surveys

We conducted plant surveys during the peak growing season of July 2003. We randomly located a 1-m^2 plot along three transects in each site and identified and recorded all species within the plot. We also estimated percent cover of individual plant species and identified all species as native or non-native to Colorado (Weber 1976).

Statistical Analyses

To determine whether spatial pattern significantly differed between the dispersed and clustered housing developments, we compared both of our metrics (the average proportion of each housing development outside a hypothetical 200-m zone of influence surrounding houses and the average distance from all locations to the nearest house) within each of the six clustered developments to that of each of the six dispersed developments. We compared both sets of means with a Wilcoxon rank-sum test (PROC NPAR1WAY, SAS Institute 1999), a nonparametric *t* test that does not assume normality.

We used the program DISTANCE (Thomas et al. 1998) to generate estimates of bird densities (birds per hectare) in each land-use category. For each species with sufficient sample size (>30 detections), we modeled the species' detection function, based on exact distance values, with the robust models suggested by Buckland et al. (2001). We selected the best model based on Akaike's information criterion corrected for small sample sizes (AIC_c) (Burnham & Anderson 2002) and by inspecting probability density functions and chi-square goodness-of-fit statistics (Buckland et al. 1993). For each bird species analyzed, we obtained density estimates in each land use by rerunning the best model and stratifying by land-use type. We performed pairwise comparisons of density estimates across the three land-use categories with a *z* test (Ott & Longnecker 2001). In the absence of an overall *F* test to control experimental error, densities were considered significantly different at $\alpha' = 0.03$. (We divided 0.1 by 3 according to Bonferroni's adjustment for three pairwise comparisons.) We established an α of 0.1 a priori for all analyses to minimize Type II error.

We calculated nest density for each land use based on the mean number of nests located per hectare searched in each of the six sites included in that land-use category. To test whether the density of nests varied by land use, we conducted an analysis of variance (PROC GLM, SAS Institute 1999). Only when the overall *F* test was significant ($p < 0.1$) were pairwise comparisons made with the least-significant-difference method (Ott & Longnecker 2001).

We used Stanley's (2004) model to estimate stage-specific (i.e., egg laying, incubation, nestling) daily survival probabilities for all nests. The Stanley model, like the Mayfield (1975) method, avoids the positive bias of apparent nest success by estimating daily survival rates based on the number of exposure days. The Stanley method goes a step further by allowing for calculation of stage-specific daily survival rates when transition and failure dates are unknown. We used AIC_c to evaluate competing models of nest survivorship, comparing the models' weights, which represent the strength of evidence in support of each model.

We used data collected from scent stations to estimate the proportion of stations visited by each mammal within each land use. We used Fisher's exact test (PROC FREQ, SAS Institute 1999) to test for significant differences in detection frequencies among land-use types. If the overall test was statistically significant ($p < 0.1$), we also used Fisher's exact test to conduct pairwise comparisons to test whether proportions differed among individual land uses. We calculated standard errors for the proportions based on the normal approximation to the binomial (Ott & Longnecker 2001).

We compared species richness and percent cover for both native and non-native plant species across land use. We tested to see whether native and non-native plant cover varied by land use with an analysis of variance (PROC GLM, SAS Institute 1999), based on an *n* of six sites per land use. When the overall *F* test was significant ($p < 0.1$), we conducted a least-significant-difference means comparison to test for differences among land uses. Non-native cover was transformed to the arc-sin square root to stabilize variance; the variance of native cover was more homogeneous without transformation. Both sets of means and errors are presented in the original scale.

Results

Analysis of Spatial Pattern

Both landscape metrics showed that clustered housing developments differed spatially from dispersed housing developments. The proportion of land area in clustered developments outside the hypothetical 200-m zone of influence around each house was nearly twice that of dispersed housing developments ($z = 2.32$, $p = 0.0076$). The proportion of land in each clustered development outside of the zone of influence around each house ranged from 0.339 to 0.726 (average 0.517). The average proportion of land in dispersed developments outside of the same hypothetical zone of influence ranged from 0.156 to 0.512 (average 0.266). Open space in clustered housing developments was significantly farther away from houses than the open space in dispersed housing developments ($z = 2.16$, $p = 0.01$). Whereas the average distance from each location (30 × 30 m cell) to the nearest house in clustered developments ranged among sites from 189 m to 361 m (average 254 m), the average distance from each location within dispersed developments to the nearest house ranged among sites from 164 m to 213 m (average 166 m).

Bird Communities

We detected 1960 birds of 63 different species over two field seasons. We detected 39 species in dispersed developments, 44 in clustered developments, and 22 in undeveloped areas. We were able to generate reliable density estimates for 13 of the 15 most common bird species detected during our surveys. Although common, Cliff Swallows (*Hirundo pyrrhonota*) and Barn Swallows (*Hirundo rustica*) were almost exclusively detected in flight, which program DISTANCE is not designed to analyze. Common Grackles (*Quiscalus quiscula*), European Starlings (*Sturnus vulgaris*), American Robins (*Turdus migratorius*), Red-winged Blackbirds (*Agelaius phoeniceus*), Mourning Doves (*Zenaida macroura*), Rock Doves (*Columba livia*), and Killdeer (*Charadrius vociferus*) reached significantly higher densities in either dispersed or clustered housing developments when compared with undeveloped areas ($z \geq 2.17$, $p \leq 0.03$ for all comparisons) (Fig. 2). Black-billed Magpies (*Pica hudsonia*) were also detected more frequently in dispersed and clustered housing developments, but this difference was not significant ($z \geq 1.61$, $p \leq 0.11$).

Western Meadowlarks (*Sturnella neglecta*), Vesper Sparrows (*Pooecetes gramineus*), Grasshopper Sparrows (*Ammodramus savannarum*), and Horned Larks

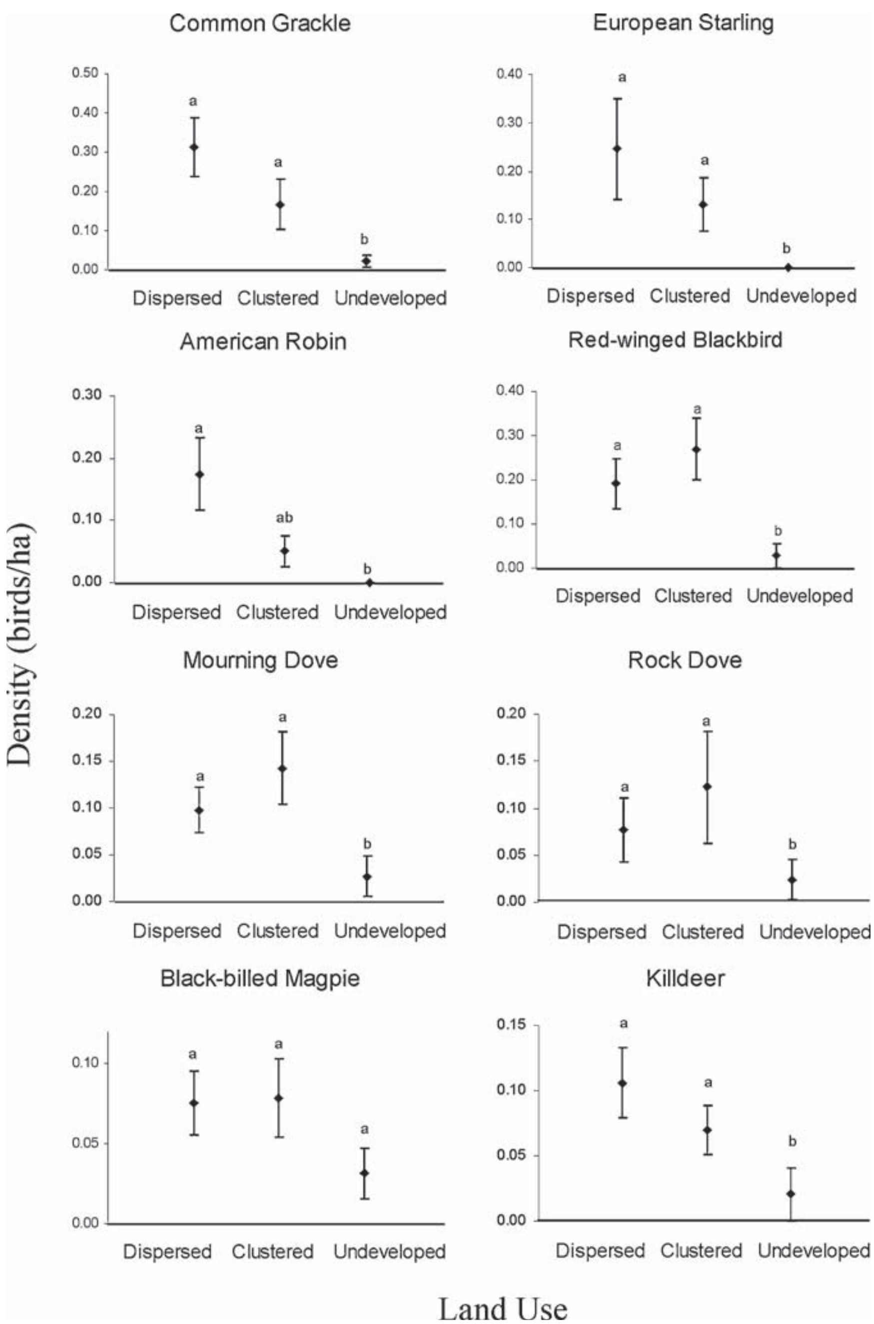

Figure 2. Densities (±1 SE of the mean) of bird species that reached their highest densities in either dispersed or clustered housing developments. Different letters above error bars indicate a statistically significant difference at $\alpha' = 0.03$ (Bonferroni adjusted for multiple comparisons).

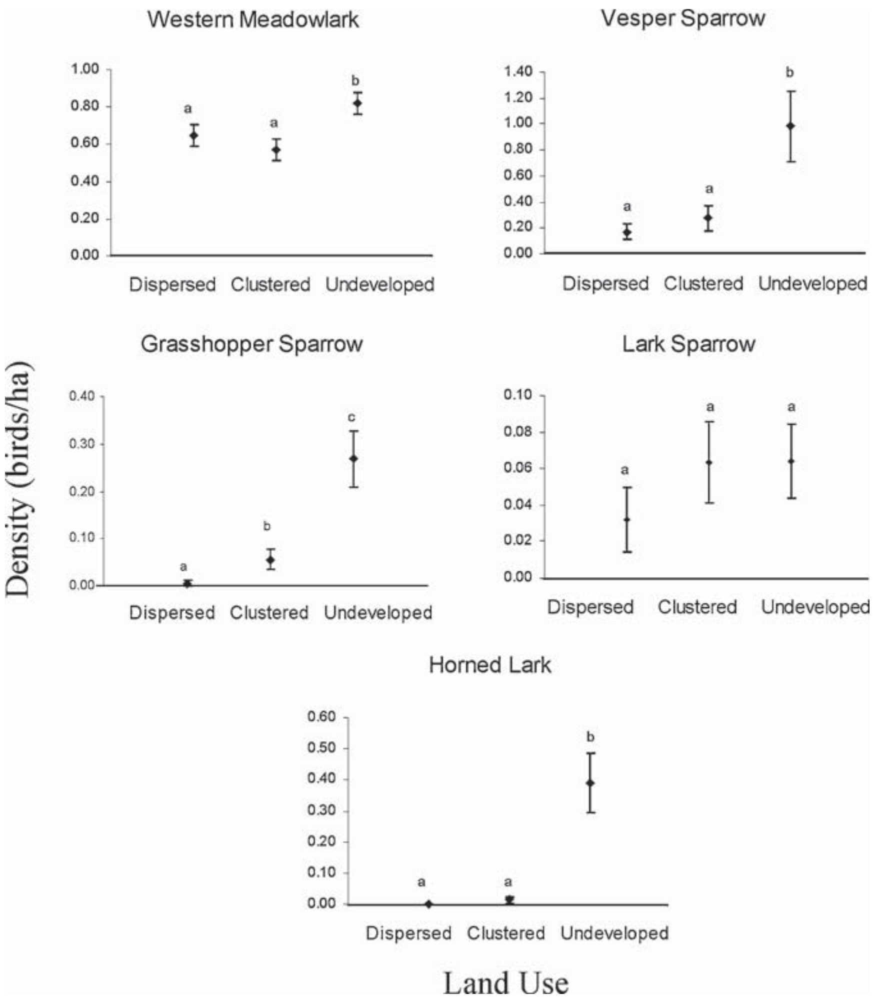

Figure 3. Densities (±1 SE of the mean) of bird species that reached their highest densities in undeveloped areas. Different letters above error bars indicate a statistically significant difference at $\alpha' = 0.03$ (Bonferroni adjusted for multiple comparisons).

(*Eremophilia alpestris*) reached significantly higher densities in undeveloped areas than in dispersed or clustered housing developments ($z \geq 2.47$, $p \leq 0.02$ for all comparisons) (Fig. 3). Lark Sparrows (*Chondestes grammacus*) occurred more frequently in clustered developments and undeveloped areas than in dispersed developments, but this difference was not significant ($z \geq 1.14$, $p \leq 0.25$).

We monitored 126 nests over two field seasons. Twenty nests were in dispersed housing developments, 18 in clustered housing developments, and 88 in undeveloped areas. The majority of the nests we found were of Vesper Sparrows, Western Meadowlarks, and Grasshopper Sparrows. We occasionally found nests of Mourning Doves, Common Nighthawks, Horned Larks, and Red-winged Blackbirds and rarely found nests of Lark Sparrows, Killdeer, and Brewer's Blackbirds. We searched 142 ha in each land use. Roughly equal numbers of hectares were searched in each site, depending on its size. The density of nests in undeveloped areas was significantly higher than the density of nests in dispersed housing developments ($p < 0.0001$) or clustered developments ($p < 0.0001$) (Fig. 4).

We used AIC_c to evaluate competing models of nest survival. Because we were more interested in differences between land uses than differences between species and because the relative numbers of nests contributed by different bird species were similar across land uses, we pooled all bird species together for the analysis. The best overall model treated daily survival probabilities as equal for all nesting stages. This model carried 53% of the AIC_c weight, whereas the second-best model carried only 22% of the weight. Once the best overall model was determined, we compared this model, which pooled land use, to a set of models treating land use separately. The AIC_c selected the overall model that pooled all three land uses. This model carried 98% of the weight, whereas the set of models treating land use separately carried only 2% of the weight. We therefore considered nest survival statistically similar across dispersed developments, clustered developments, and undeveloped areas. We estimated mean daily survival probability for all stages and all land uses to be 0.9559 (SE = 0.006). For a hypothetical bird species with a 4-day egg-laying period, a 13-day incubation period, and a 12-day nestling period, this daily survival probability would result in an overall survival rate of 0.27.

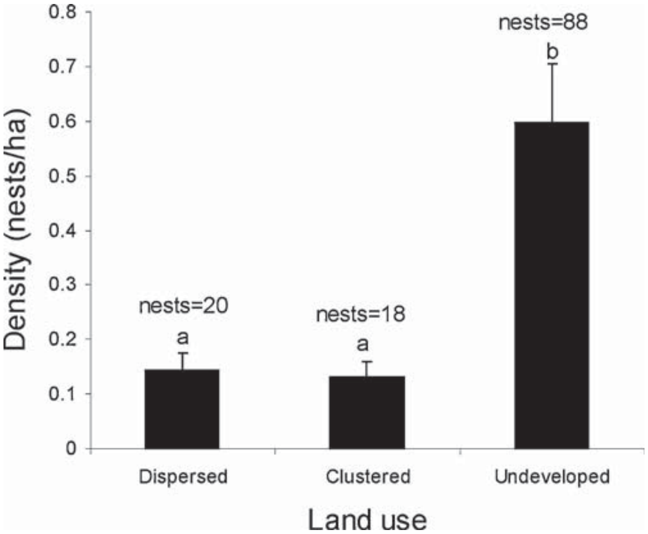

Figure 4. Density (±1 SE of the mean) of nests located per hectare searched in each land use. Different letters above error bars indicate a statistically significant difference determined with an F*-protected least-significant-difference (0.10) method in analysis of variance based on a square-root transformation of the data to stabilize variance. The means and standard errors are presented in the original scale.*

Mammal Communities

We detected domestic dogs (*Canis familiaris*) and cats (*Felis domesticus*), coyotes (*Canis latrans*), red foxes (*Vulpes vulpes*), striped skunks (*Mephitis mephitis*), cows (*Bovidae* spp.), horses (*Equidae* spp.), prairie dogs (*Cynomys ludovicianus*), rabbits (*Sylviagus* spp.), deer (*Odocoileus hemionus*), and field mice (*Peromyscus* spp.) at scent stations over the two seasons of sampling (Fig. 5). Cats, rabbits, and deer were not detected enough to conduct statistical analyses. We detected dogs more frequently on dispersed ($p = 0.006$) and clustered ($p = 0.01$) housing developments than undeveloped areas. Detections of red fox, skunk, cow, and prairie dog were higher in dispersed and clustered housing developments than in undeveloped areas, but not significantly so. Field mice were detected more frequently in undeveloped areas than in either dispersed ($p = 0.093$) or clustered ($p = 0.093$) developments. Although not statistically significant, detection of coyotes was higher in clustered housing developments and undeveloped areas than in dispersed developments.

Plant Communities

We identified 112 plant species among the three land uses, 39 of which were non-native. Undeveloped areas had 12 native species that were not found on either dispersed or clustered housing developments, whereas dispersed and clustered housing developments each had a few non-native species not found in undeveloped areas (Fig. 6). Mean native species percent cover in undeveloped areas was nearly twice that of dispersed ($p = 0.001$) or clustered ($p = 0.008$) developments, and mean non-native species cover was significantly higher in dispersed ($p = 0.004$) and clustered ($p = 0.01$) housing developments than in undeveloped areas (Fig. 7).

Discussion

Our results indicated that the plant and wildlife species composition of clustered housing developments in Boulder County, Colorado, is more similar to that of dispersed housing developments than to that of undeveloped areas. Clustered and dispersed housing developments were characterized by high densities of human-commensal species (e.g., Bolger et al. 1997; Fernandez-Juricic 2001; Stralberg and Williams 2002) and low densities of species that are sensitive to development (e.g., Bolger et al. 1997; Bock et al. 2002; Maestas et al. 2003). Nest survival did not vary by land use, but due to the large discrepancy in nest densities, dispersed and clustered housing developments combined contributed only 30% of all successful nests, whereas undeveloped areas alone contributed 70% of the successful nests.

Two factors contributed to the low conservation value of clustered housing developments. The first was their scale, and the second was the composition of their plant communities. The protected outlots of these clustered housing developments averaged <80 ha, whereas undeveloped areas averaged 480 ha. The clustered developments, and dispersed developments, were dominated by non-native vegetation, whereas undeveloped areas were characterized by native vegetation.

The scale of clustered housing developments mediated the effects of the houses on the landscape in several ways. Competition with and predation by generalist species is a problem for bird communities of conservation concern located near housing developments (e.g., Blair 1996; McKinney 2002; Hansen et al. 2005). House lots contain bird feeders, fruiting trees, flowering shrubs, non-native vegetation, human garbage, noise, pets, water, and built structures that offer enhanced vertical structure, food resources, and nesting sites otherwise unavailable in grasslands. Many of the human-commensal species that reached their highest densities in either dispersed or clustered housing developments are edge-adapted generalists (McKinney 2002) or species that are able to exploit the wider variety of habitat configurations and resources available near housing developments. When present, these larger human-commensal species can outcompete native birds for nest sites and food resources (Blair 1996; Marzluff 2001; McKinney 2002).

The distribution of these generalist species in clustered housing developments was influenced by the size

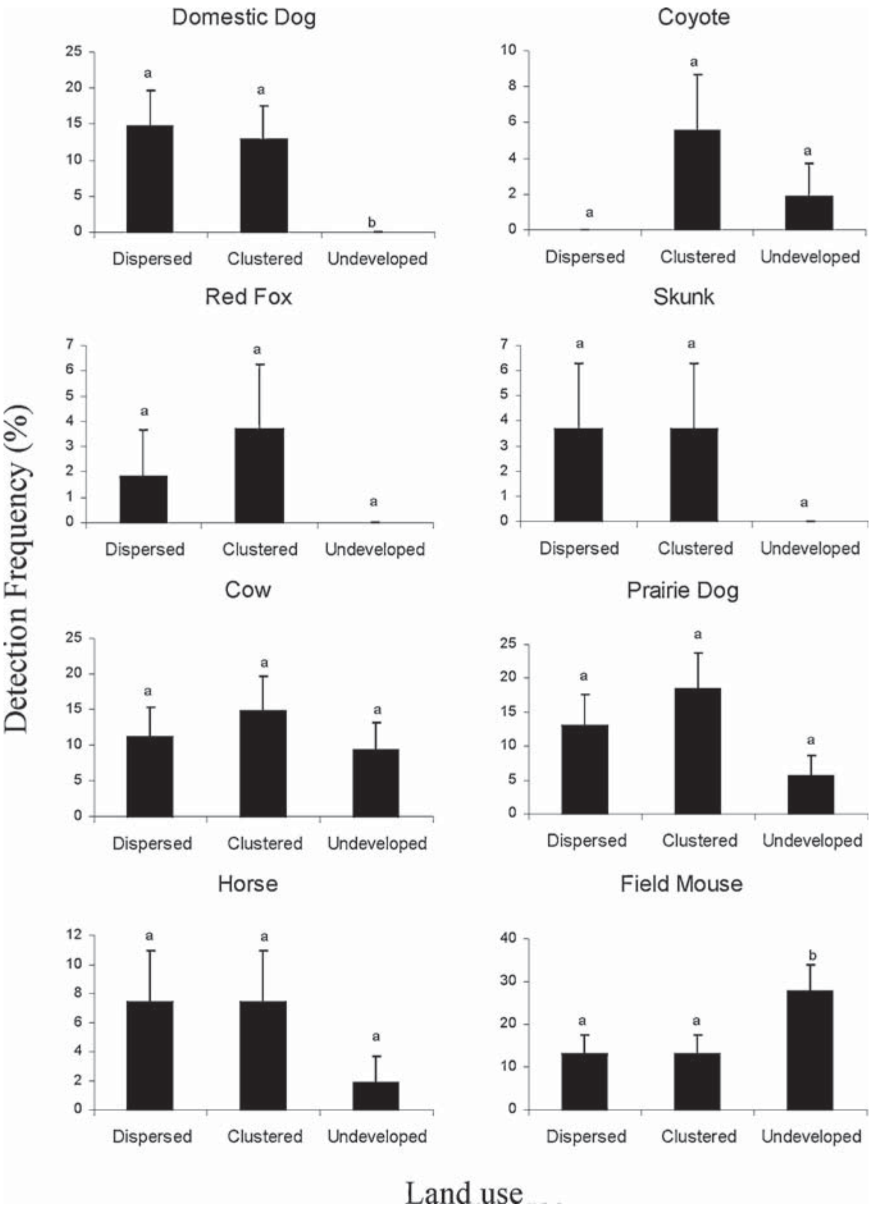

Figure 5. Frequencies (±1 SE of the mean) of mammal detections at scent stations in each land use. Different letters above error bars indicate a statistically significant difference at $\alpha = 0.10$.

of the outlots and the configuration of the house lots, which in most cases did not minimize their footprint. Two of the clustered developments were linear clusters that stretched across the protected outlot, and in one of the clustered developments the houses were clustered in the very center of the outlot, obviously not maximizing contiguous open space. Bock et al. (1999) studied grassland bird communities in Boulder County and found that suburban edge effects extend up to 200 m into the grasslands. In a mountain shrubland of Colorado, Odell and Knight (2001) determined that the zone of influence around each house (the area within which generalist species dominate) is 180 m. In the clustered developments we studied, the average distance from the nearest house was 254 m. Thus on average nearly half the area of protected outlots could have been exposed to the edge effects surrounding housing developments. The size of these protected outlots may simply be insufficient to protect grassland species of conservation concern.

The presence of humans and their pets, also mediated by the scale of the clustered housing developments, can directly influence biodiversity by displacing wildlife (Hansen et al. 2005). A single pedestrian moving through a bird's territory is enough to make the bird stop singing (Gutzwiller et al. 1994). The frequent presence of humans in an area could result in fewer birds establishing nesting territories (Gutzwiller et al. 1997). Although we did not detect reduced nest survival in dispersed and clustered housing developments, they supported far fewer nests than undeveloped areas. Subsidized predators, such as domestic cats and dogs, extend the realm of human influence and have a negative impact on wildlife communities (e.g., Coleman & Temple 1996; Crooks & Soulé 1999; Odell & Knight 2001). Dogs were detected frequently in

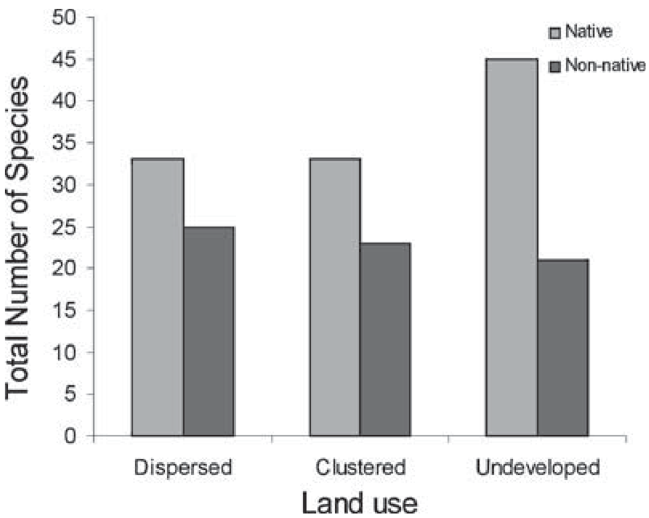

Figure 6. Total number of native and non-native plant species by land use.

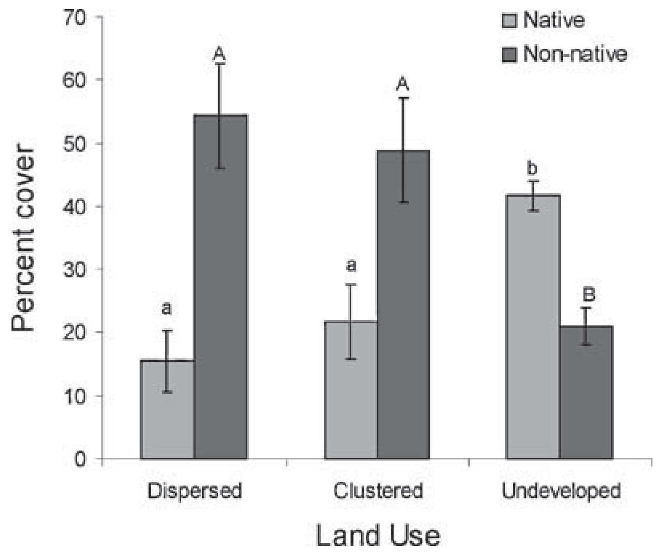

Figure 7. Percent cover (±1 SE of the mean) of native and non-native plant species in each land use. Different letters above error bars represent a statistically significant difference determined with an F*-protected least-significant-difference (0.10) method in analysis of variance. Non-native cover was transformed to the arc-sin square root to stabilize variance. The variance of native cover was more homogeneous without transformation. Both sets of means and errors are presented in the original scale.*

dispersed and clustered housing developments. In addition, we observed landowners in clustered housing development walking their dogs off leash through the protected outlots. Whereas in the undeveloped areas human and dog recreation is limited to established trails, the outlots associated with clustered housing developments may experience user impacts throughout.

Although the size and configuration of clustered developments was an important factor, the plant community may have played an even more significant role in shaping the species communities we observed. Winter and Faaborg (1999) studied high-quality prairie fragments ranging from 31 ha to 1084 ha and found that fragment size has little influence on the densities of grassland bird species; in all cases variation in their densities was better explained by vegetation variables than by fragment size. Several other researchers have also established a strong link between grassland bird communities and vegetation composition and structure (Rotenberry & Wiens 1980; Fletcher & Koford 2002; Giuliano & Daves 2002). In dispersed and clustered housing developments where plant cover was largely non-native, native grassland nesting birds were present and nested in much lower densities than in undeveloped areas characterized by native plant communities. Non-native vegetation may have simultaneously attracted generalist species to the housing developments.

Two factors influenced the plant community of these clustered housing developments. The first was land-use history. Without large pasturelands, the original landowners of the clustered developments may have planted non-native pasture grasses to produce greater forage in a small area. In addition, the disturbance associated with the construction of houses and roads (which often act as conduits of exotic species) (Trombulak & Frissel 2000), may have predisposed these developments to non-native species invasions. The second was land stewardship. The undeveloped areas we studied are managed for the health of native species. Management tools model important ecological processes and include prescribed burning, early spring and late fall grazing, and controlling invasive species. The stewardship of clustered housing developments may not include these tools, and is apparently unsatisfactory to ensure a resilient native plant community.

Future studies examining the conservation value of clustered housing developments should search for developments with larger outlots and higher-quality plant communities. Had this been the case in our study, we may have seen very different results.

Conservation Implications

Private lands in the American West have enormous potential to help conserve our natural heritage. It is essential that ecologists, land use planners, and landowners work together to achieve what Leopold (1991) called "... the oldest task in human history: to live on a piece of land without spoiling it." There is now wide agreement that dispersed, large-lot development does not accomplish this goal (Arendt 1996; Schueler 2001; Hansen et al. 2005). Clustered housing developments are a logical alternative: landowners pool their open space into a larger area that all can enjoy. However, our results imply that the intuitive assumption that clustered housing developments will always have more conservation value than dispersed housing developments may need to be reevaluated.

Establishing and following more rigorous ecological guidelines may result in clustered housing developments with greater conservation value. Clustering homes closer together and away from ecologically sensitive areas, requiring larger outlots, using native landscaping, keeping open space contiguous, and minimizing road density could all benefit species of conservation concern. Better stewardship practices might be even more effective. Controlling weeds and restoring some of the natural processes that historically maintained native-plant diversity, such as grazing, fire, and native insect pollination, could make these sites more resilient to invasion and greatly increase native biodiversity. In addition, establishing trails to restrict human use to certain portions of the property and putting bells, cat bibs (which throw off a cat's balance and prevent it from hunting), or leashes on cats and dogs could reduce the realm of human influence in these developments.

An even greater opportunity exists to plan clustered housing developments on a regional scale to create an interconnected network of protected lands (Arendt 1996, 2003). If each clustered housing development contributes a meaningful portion of open space to a larger protected area, the benefits to plant and wildlife communities might be synergistic. Boulder County planners realized that their clustered housing developments were not effectively protecting large ecologically intact landscapes. Presently, they are implementing a new planning tool referred to as transfer of development rights (Pruetz 2003). This allows them to successfully combine outlots to form larger protected areas that buffer incorporated cities (controlling their growth) and strategically protect lands of high natural-resource value while steering development into the planning districts of existing municipalities.

If land-use planners and conservation biologists work together to plan for growth on a regional scale and can aggregate larger areas protected from development, there will be more potential for effective land conservation and stewardship. With such planning, municipalities may be able to use clustered developments to protect lands in a way that brings human communities together to restore ecological processes, minimize habitat degradation, and preserve our rich natural heritage.

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Attachment 7

Odell and Knight 2001

Songbird and Medium-Sized Mammal Communities Associated with Exurban Development in Pitkin County, Colorado

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Abstract: *Residential development is occurring at unprecedented rates in the Rocky Mountain region of the United States, with unknown ecological consequences. We conducted our research in exurban development in Pitkin County, Colorado, between May and June in 1998 and 1999. Unlike suburban development, exurban development occurs beyond incorporated city limits, and the surrounding matrix remains the original ecosystem type. We surveyed songbirds and medium-sized mammals at 30, 180, and 330 m away from 40 homes into undeveloped land to examine the effect of houses along a distance gradient, and in developments of two different housing densities as well as undeveloped sites to examine the effect of housing density. We placed bird species into one of two groups for the house-distance effect: (1) human-adapted species, birds that occurred in higher densities close to developments and lower densities farther away and (2) human-sensitive species, birds that occurred in highest densities farthest from homes and in lowest densities close to development. For both groups, densities of individual species were statistically different between the 30- and 180-m sites. Six species were classified as human-adapted, and six were classified as human-sensitive for the house-distance effect. Dogs (*Canis familiaris*) and house cats (* Felis domesticus*) were detected more frequently closer to homes than farther away, and red foxes (*Vulpes vulpes*) and coyotes (*Canis latrans*) were detected more frequently farther away from houses. With respect to the effect of housing density, most avian densities did not differ significantly between high- and low-density development but were statistically different from undeveloped sites. Six species were present in higher densities in developed areas, and eight species were present in higher densities in undeveloped parcels. Similar results were found for mammalian species, with dogs and cats detected more frequently in high-density developments and red foxes and coyotes detected more frequently in undeveloped parcels of land. From an ecological standpoint, it is preferable to cluster houses and leave the undeveloped areas in open space, as opposed to dispersing houses across the entire landscape.*

Comunidades de Aves Canoras y Mamíferos Pequeños Asociadas con Desarrollo Exurbano en el Condado Pitkin, Colorado

Resumen: *El desarrollo residencial esta ocurriendo en el oeste de las Montañas Rocallosas a ritmos sin precedente, con consecuencias ecológicas desconocidas. Desarrollamos nuestra investigación en un desarrollo exurbano en el Condado Pitkin, Colorado entre mayo y junio de 1998 y 1999. A diferencia del desarrollo suburbano, el desarrollo exurbano ocurre más allá de los límites de la ciudad y en la matriz que lo rodea permanece el ecosistema original. Registramos aves canoras y mamíferos pequeños a 30, 180 y 330 m de 40 casas en terrenos sin desarrollar para examinar el efecto de las casas a los largo de un gradiente de distancia, y en desarrollos con dos diferentes densidades de casas para examinar el efecto de la densidad. Colocamos a las especies de aves en uno de dos grupos para el efecto casa –distancia 1) especies adaptadas al humano, aves con la mayor densidad cerca de los desarrollos urbanos y menor densidad lejos de ellos y 2) especies sensibles al humano, aves que ocurrían con la mayor densidad lejos de los hogares y menor densidad cerca del desarrollo urbano. Para ambos grupos, las densidades de especies individuales fueron estadísticamente distintas en*

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*los sitios entre 30 y 180 m. Seis especies fueron clasificadas como adaptadas al humano y seis fueron clasificadas como especies sensibles al humano para el efecto casa – distancia. Se detectaron perros (*Canis familiaris*) y gatos (*Felis domesticus*) con mayor frecuencia cerca de las casas que lejos de ellas, y se detectaron zorros rojos (*Vulpes vulpes*) y coyotes (*Canis latrans*) con mayor frecuencia lejos de las casas. Respecto al efecto de la densidad de casas, la mayoría de las densidades de aves no fueron significativamente diferentes entre el desarrollo de alta y baja densidad, pero fueron estadísticamente distintas de los sitios sin desarrollo. Seis especies tuvieron mayor densidad en los sitios desarrollados y ocho especies presentaron mayor densidad en las parcelas no desarrolladas. Se encontraron resultados similares para las especies de mamíferos, detectándose perros y gatos más frecuentemente en desarrollos con alta densidad; mientras que zorros rojos y coyotes fueron detectados más frecuentemente en las parcelas sin desarrollo. Desde una perspectiva ecológica, es preferible agrupar las casas y dejar las áreas sin desarrollo en espacios abiertos, y no dispersar las casas por todo el paisaje.*

Introduction

The American West is in the midst of an unprecedented period of growth (Knight 1998). According to U. S. census statistics, the population of the Rocky Mountain states increased 14.5% between 1990 and 1995, a rate more than 2.5 times the national average (U.S. Census Bureau 1998). Within this region, Colorado boasts one of the fastest growth rates (Poole 1996), which is occurring primarily in counties where the largest cities have populations below 50,000. Also, counties with federally designated wilderness areas show population increases six times the national average (Gersch 1996).

Concerns about increasing growth in the Rocky Mountain states focus not only on rates but also on patterns of development and their ecological consequences for the region's natural heritage (Blair 1996; Buechner & Sauvajot 1996; Bolger et al. 1997; Boren et al. 1999). *Exurban development* is the term for development that occurs, unlike suburban development, beyond the limits of incorporated towns and cities (Knight 1999). In exurban landscapes, the surrounding matrix remains in the original ecosystem type, as opposed to suburban development where the surrounding matrix is urban land use. From 1982 to 1992, for example, over 1 million ha of rangeland in the United States were converted to residential development and roads (Flather et al. 2000). From 1992 to 1997, the average annual loss of farm and ranch land in Colorado to private and commercial development was nearly 110,000 ha (Colorado Department of Agriculture 1999).

Although conservation biologists have begun to realize that this conversion of private, undeveloped lands to human-dominated development will result in the simplification of our native biodiversity, the effects have been little studied in the rural West of the United States, (Knight 1999). Thus far, researchers examining avian responses to development have focused on urban development areas and have neglected exurban development (e.g., Emlen 1974; Beissinger & Osbourne 1982; Mills et al. 1989; Blair 1996; Bock et al. 1997; Bolger et al. 1997; Germaine et al. 1998). Although studies by Vogel (1989) on deer (*Odocoileus* sp.) and Harrison (1997, 1998) on bobcats (*Lynx rufus*) and gray foxes (*Urocyon cinereoargenteus*) have focused on the effects of exurban development, the trend for research examining responses of mammals to residential development has been toward areas within incorporated city limits (e.g., Beier 1995; Torres et al. 1996; Crooks & Soulé 1999).

Our first objective was to determined whether a "house-distance effect" exists. A house-distance effect is characterized by varied responses of wildlife species with increasing proximity to homes. It is caused by biotic and abiotic factors associated with a house and its occupants. We used songbird densities and the presence or absence of medium-sized mammals as indicators to determine how far disturbance from a rural house extends outward from the physical structure.

Our second objective was to examine wildlife populations within exurban developments of different housing densities. We surveyed songbirds and mammals in two areas of different housing density and in undeveloped sites to compare wildlife densities and composition along a development-density gradient.

Methods

Study Area and Site Selection

We conducted surveys between 24 May and 28 June 1998 and 1999 in Pitkin County, Colorado. Pitkin County (lat. 39°13′N, long 106°55′W) is in western Colorado and encompasses 241,984 ha, with 42,408 ha privately owned land and 199,576 ha publicly owned land. We limited all surveys to privately owned land between 2250 and 2500 m in elevation. The city of Aspen (population approximately 5500) and the town of Snowmass Village (population approximately 1800) are the largest population centers in the county. The Hunter-Fryingpan, Collegiate Peaks, and Maroon Bells–Snowmass Wilderness Areas and the White River National Forest are located at least partially within this county. Our study area was in a shrub-oak community dominated by Gambel's oak (*Quercus gambelii*), serviceberry (*Amelanchier alnifolia*), chokecherry (*Prunus virginiana*), and mountain sagebrush (*Artemesia tridentata vasayana*).

Individual homes for the house-distance aspect of the study were identified through a multistep process. Initially, we used geographic information system (GIS) database of the Pitkin County Assessor's Office to locate potential homesites and developments. We compiled a list of sites and groundtruthed each to ensure that they fit several criteria. Homes had to be located in mountain shrubland habitat, be a single-family residence, have no construction in progress, and be occupied throughout the study period. Groundtruthing eliminated some of the homesites from the initial list. We identified approximately 50 homes as suitable, and 40 homeowners granted us access to their property. For each home, we recorded house size, house age, and number of dogs, cats, and human occupants.

To select housing developments, we used the same criteria as for the examination of the house-distance effect. We classified developments as either high or low in density. Sites were located within developments of high density (1.04 ± 0.67 houses/ha), developments of low density (0.095 ± 0.083 houses/ha), and undeveloped areas (at least 700 m from any development). We surveyed 20 sites within each of the three density categories.

Distance and Density Effects

We established sampling stations at increasing distances away from houses (30, 180, and 330 m away from the edge of the house) onto a parcel of undeveloped land to examine the effect of proximity to development. To examine the effect of housing density, we surveyed points within patches of the shrub-oak community in the interior of the developments of the three density classes. For the high- and low-density housing developments, points were located within 50 m of a house. Points were situated so that a 50-m radius would intersect as few roads, landscaped yards, and buildings as possible. Points were located randomly in the undeveloped areas.

At sampling stations, songbirds were surveyed with a 50-m fixed-radius point count, shrub cover was estimated with line-intercept transects, and mammals were surveyed with scent-station track plates. Survey points used for the house-distance and house-density aspects of the study did not overlap.

Bird Counts and Shrub Cover

We conducted bird counts from dawn until 3 hours after sunrise. A 5-minute count period began at each point after a 1-minute quiet period, allowing any disturbance we created with our arrival at the point to diminish. Birds were identified by auditory and/or visual cues and identified to species. We estimated the distance to detection in 10 m wide increments up to 50 m from the point (Bibby et al. 1993). High-flying birds that did not land were not recorded. Birds originally detected outside the 50-m radius boundary but that later flew inside also were not recorded. We did not conduct surveys when it was raining or when wind would have interfered with audible detections. We made between one and three visits to each site during the 1998 field season (depending on homeowner permission), and two visits to each site during the 1999 field season.

We quantified shrub cover at every point where bird counts were conducted. Three compass bearings were chosen randomly at each point. For each of these bearings, an associated distance between 0 and 40 m was also randomly chosen. Along that bearing and at that distance, we used a 10-m transect to characterize vegetative shrub cover using line-intercept methods described by Canfield (1941). We recorded the shrub species and distance along the transect that was intersected by the shrub.

Scent Stations

We established mammal scent stations adjacent to the points where bird counts were taken (Roughton & Sweeny 1982; Conner et al. 1983; Andelt & Woolley 1996). A 1-m^2 metal plate was placed at each station. We sprayed a solution of 100% ethanol and unscented talcum powder (approximately 3.8 L ethanol to 475 cc talcum powder) on the plate. As the ethanol evaporated, a thin film of evenly spread talcum powder was left. We placed a scent attractant disk (Fatty Acid Scent scented predator survey disks, supplied by Pocatello Supply Depot, Pocatello, Idaho) in the center of each plate, and left the plate in place for 7 days (6 nights). We revisited the plates each afternoon and verified the presence of species by identifying tracks left on the plate (Murie 1974; Halfpenny 1986). Domestic dogs, coyotes, and red foxes were distinguished through a variety of measurements, including overall track size, size of individual pads, splaying of pads, and shape of heel pads (Halfpenny 1986). We redusted the plate and replaced the scent attractant if necessary.

Statistical Analyses

We used the program DISTANCE (Thomas et al. 1998) to analyze bird-count data for both the house-distance and house-density effects. DISTANCE is a data analysis tool that provides reliable estimates of the density of species through distance sampling (Buckland et al. 1993). A detection probability function is fit to the detections at each sampling location. The result is a density estimate and 90% confidence interval for each species at each of the three distance and density categories. DISTANCE requires a sufficient number of detections of each species to obtain a reliable estimate of the detection probability function. Twelve species were abundant enough for analysis of the house-distance effect, and 14 species were detected enough for the house-density effect. We then tested the null hypothesis of equal densities of each species at each sampling distance and density category for statistical significance using a one-way analysis of variance (general linear models procedure [GLM] of the Statistical Analysis System [SAS]; SAS Institute 1998). If the distance or density category was a significant factor, multiple comparisons were done with LSMEANS. We used PROC GLM in SAS to analyze the null hypothesis of equal shrub cover among the three distance categories and three housing-density categories.

For each species of medium-sized mammal, we used Cochran's *Q*, a chi-square approximation (Bishop et al. 1975), to test for the equality of detection among the three distances (30, 180, and 330 m). We conducted follow-up paired comparisons of the distance categories using an exact *p* value in a binomial test (Steel & Torrie 1980). For each medium-sized mammal species, we used a chi-square test to compare the total number of detections among the three density categories, and we used follow-up paired chi-square tests to compare each pair of density categories. For all analyses, we used an a priori alpha level of 0.10 to decrease the probability of a Type II error.

Results

House Characteristics

The average house size was 4500 (±2025) square feet, and the average house age was 13.5 (±8.7) years. Eighty-three percent ($n = 33$) of the homeowners did not have cats as pets; families at six houses each had one cat, and one family had two cats. Forty percent ($n = 16$) of the homeowners did not have dogs as pets, whereas 28% of the homeowners had one dog. The remaining 32% of the homeowners had two dogs as pets. Two or fewer adults occupied 75% of the homes, and 25% of the homes were occupied by at least one child.

Distance Effect

During two field seasons, we made 3845 detections of 30 different bird species. Based on density estimates at increasing distances from residential development, we separated individual bird species into two different categories. Species that displayed an affinity to homes (higher densities closer to homes) were termed human-adapted species, and species that occurred in lower densities closer to homes than farther away were termed human-sensitive species. Six species were classified as being human-adapted (Fig. 1), and six species were classified as human-sensitive (Fig. 2). All species that were detected with enough frequency to utilize DISTANCE were placed

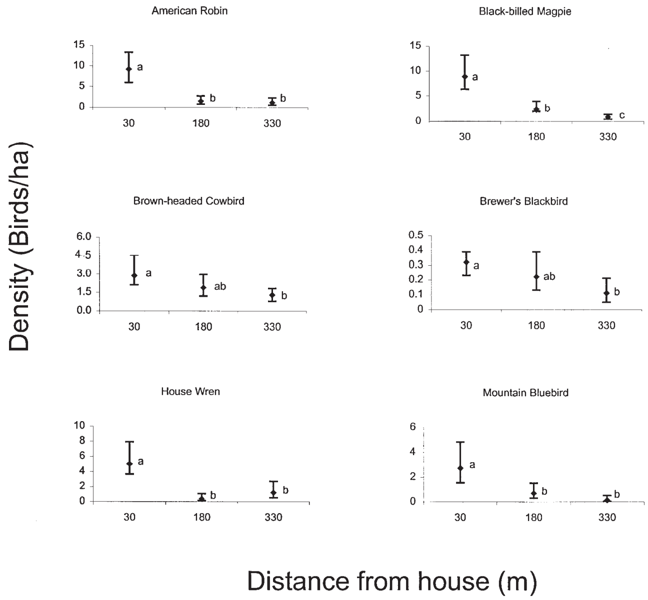

Figure 1. Density and 90% confidence interval of human-tolerant avian species at sampling points at increasing distances away from homes into natural areas. Density estimates with the same letter are not statistically significant at $\alpha = 0.10$.

into one of the above categories. No species showed a density response that suggested they were "indifferent" to development.

Domesticated dogs, house cats, red foxes, coyotes, porcupines (*Erethizon dorsatum*), black bears (*Ursus*

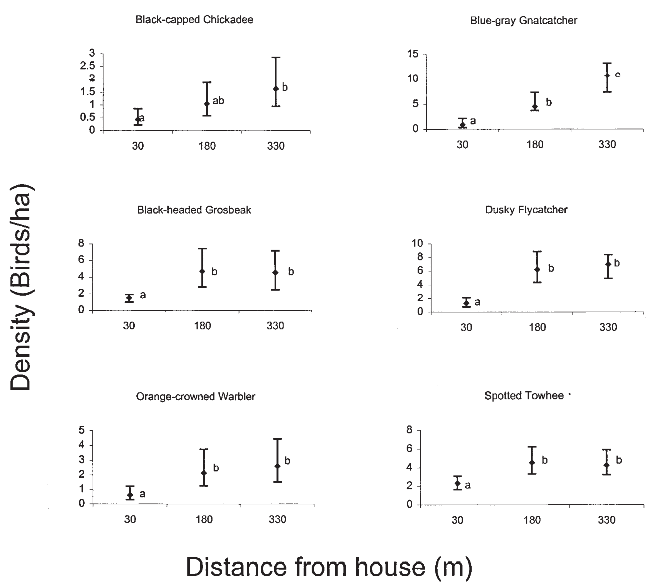

Figure 2. Density and 90% confidence interval of human-sensitive avian species at sampling points at increasing distances away from homes into natural areas. Density estimates with the same letter are not statistically significant at $\alpha = 0.10$.

americanus), mountain lions (*Felis concolor*), and skunks (*Mephitis mephitis*) were detected at scent stations. Porcupines (two detections at 330-m site), black bears (one detection at 180-m site, one at 330-m site), mountain lions (one detection at 30-m site, one at 330-m site), and skunks (two detections at 30-m site) were not detected enough to warrant statistical analysis.

Overall detections of dogs were not equal among the three distance categories ($p < 0.001$). Dog detections were significantly higher at 30 m than at 180 m ($p < 0.001$), at 30 m than at 330 m ($p < 0.001$), and 180 m than 330 m ($p = 0.019$). Overall detections for house cats were not equal among the three distance categories ($p = 0.003$). Frequency of house cat detections was significantly higher at 30 m than at either 180 m or 330 m ($p = 0.004$). Overall detections of red foxes were not equal among the three distance categories ($p < 0.005$); red fox detections were more frequent at 180 m than at 30 m ($p = 0.072$), more frequent at 330 m than at 180 m ($p = 0.072$), and more frequent at 330 m than at 30 m ($p = 0.002$). Overall detections for coyotes were not equal among the three distance categories ($p < 0.001$). Coyotes were detected at 180 and 330 m points only. Their detections were significantly higher at 330 m than 180 m ($p = 0.011$) (Fig. 3).

Density Effect

During two field seasons of sampling within the density categories, we made 2287 detections of 23 different bird species. Based on their densities in different-density housing developments, individual bird species were again separated into two categories. Six species had significantly higher densities in developments of high housing density (Fig. 4), and eight species had significantly reduced densities in high-density housing developments (Fig. 5).

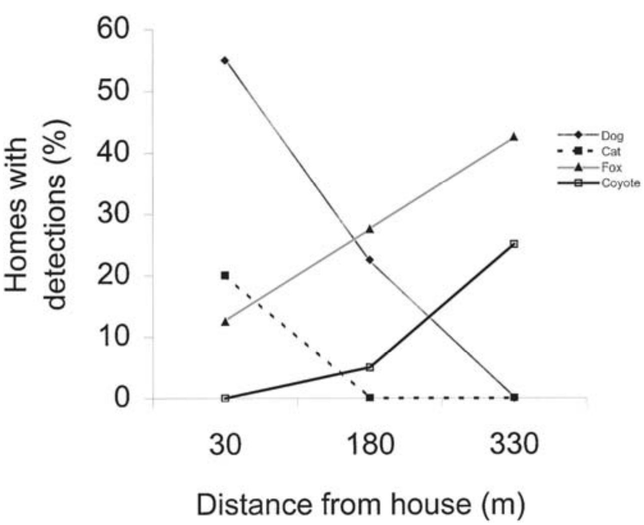

Figure 3. Percentage of houses at which each medium-sized mammal species was detected at each distance category.

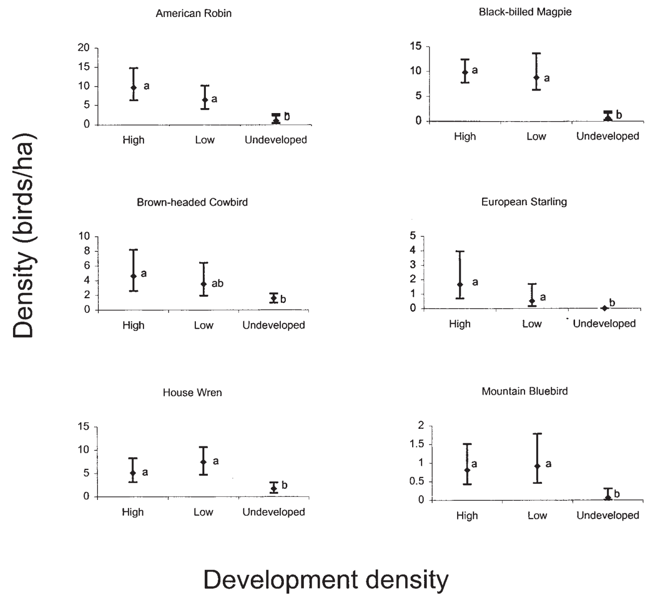

Figure 4. Density and 90% confidence interval of human-tolerant avian species at sampling points within developments of varying density. Density estimates with the same letter are not statistically significant at $\alpha = 0.10$.

Porcupines were detected only twice, both times in the undeveloped areas. Dogs were not detected equally among the three density categories ($p < 0.001$). Dogs were detected significantly more often at scent station plates placed in the high-density and low-density locations than at those placed in the undeveloped locations ($p < 0.001$ for both comparisons). Detection of dogs was not significantly different between high- and low-density locations ($p = 0.250$). Overall house cat detections were not equal among the three density categories ($p < 0.001$). House cats were detected significantly more often at sampling locations in the high-density sites than at either the low-density or undeveloped sites ($p < 0.001$ for both comparisons). The number of cat visits did not differ between the low-density and undeveloped sites ($p = 0.244$). Overall red fox detections were not equal among the three density categories ($p = 0.005$). Red foxes were detected more often at undeveloped sites than at either high-density or low-density sites ($p = 0.019$ for both comparisons). Red fox detections were not significantly different between high- and low-density sites ($p = 0.669$). Overall coyote detections were not equal among the three density categories ($p = 0.001$). Coyotes were detected significantly more often at the undeveloped sites than at either the high- or low-density sites ($p = 0.010$ for both comparisons). Site visitation for coyotes did not differ between high- and low-density sites ($p = 0.725$) (Fig. 6).

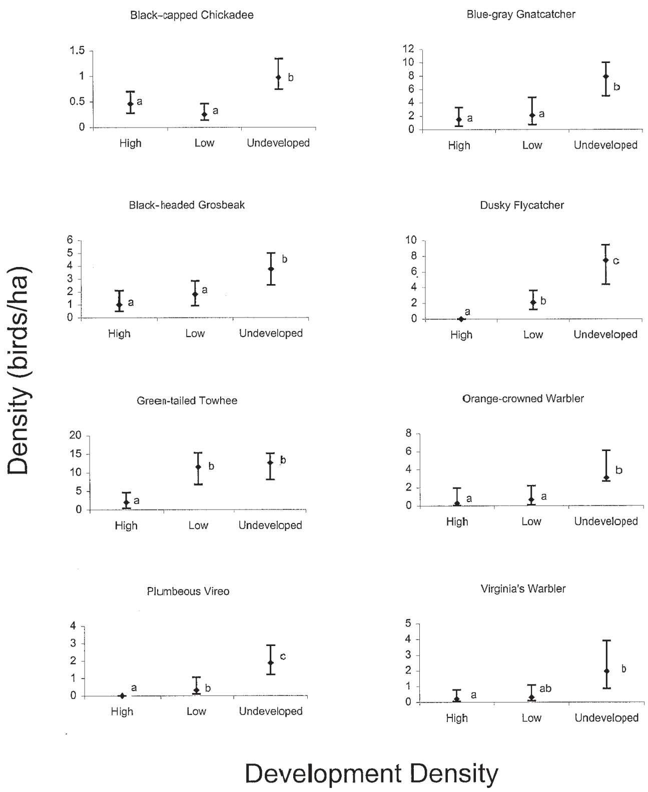

Figure 5. Density and 90% confidence interval of human-adapted avian species at sampling points within developments of varying density. Density estimates with the same letter are not statistically significant at α = 0.10.

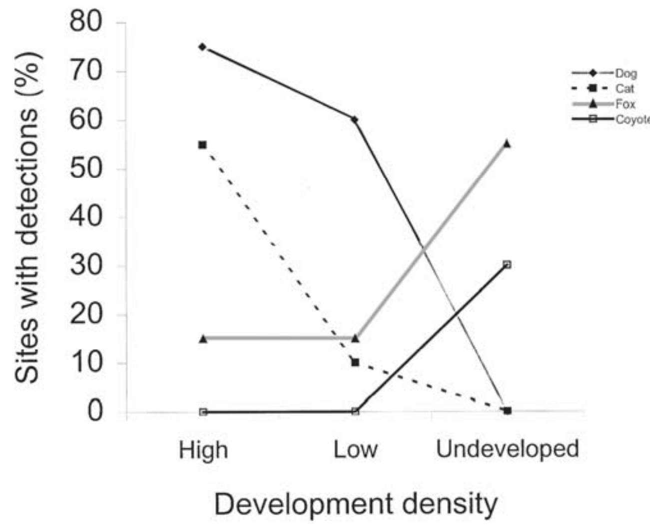

Figure 6. Percentage of sites at which each medium-sized mammal species was detected at each housing density category.

Vegetation

Gambel's oak and serviceberry dominated shrub cover. There was an average of 75.6% (± 10.5%) shrub coverage in the study plots. Shrub cover did not differ among the three distance categories ($p = 0.57$) or the three density categories ($p = 0.49$).

Discussion

Our results suggest that a house-distance effect exists in the shrub-oak habitat of Pitkin County, Colorado. Avian densities were altered up to 180 m away from homes on the perimeter of exurban developments. Songbird species existed in two general groups: human-adapted species that occur in higher densities close to homes, and human-sensitive species that exist in reduced densities close to homes. Previous work has demonstrated strong habitat associations between avian densities and vegetation structure (Rotenberry & Weins 1980; Mills et al. 1991; Knick & Rotenberry 1995). Shrub cover was not significantly different among the three sampling distances in this study, suggesting that the observed bird-density patterns were influenced by factors other than shrub-oak cover. Composition of medium-sized mammal species differed among the three distance categories, with dogs and cats detected more frequently near homes and coyotes and red foxes detected more frequently farther from homes.

Generally, the human-tolerant songbird species were present in the same densities in the interior of high-density housing developments as in low-density housing developments. A few of the human-sensitive species, such as the Green-tailed Towhee (*Pipilo chlorurus*), Dusky Flycatcher (*Empidonax oberholseri*), and Plumbeous Vireo (*Vireo plumbeus*), were present in higher densities in the low-density housing developments than in the high-density housing developments. All of the human-sensitive species occurred in higher densities in the undeveloped areas than in the high-density housing developments. Domesticated dogs and cats were detected more frequently in the high- and low-density housing developments, whereas red foxes and coyotes were detected significantly more often in the undeveloped areas.

The life-history attributes of wildlife species often shape their distribution and habitat use (Hansen & Urban 1992). We looked for discernable life-history characteristics that governed the classification of species as either human-adapted or human-sensitive, but we were unable to find patterns for which there would not be exceptions.

Ambuel and Temple (1983) suggest that human-adapted species may competitively exclude certain Neotropical migrants from small woodlots. In their study, this exclusion may have influenced the avian community more than area-dependent changes in habitat. Habitat interior species, formerly isolated from brood parasitism, have become increasingly exposed as development has increased the amount of habitat edge and thus provided greater access for cowbirds (Lowther 1993; Brittingham & Temple 1983). Factors associated with houses, such as the number and behavior of the occupants, are also likely to influence avian densities. Mancke and Gavin (2000) found that buildings near woodlots affected the densities of 21 of 36 species: 10 species increased (human-adapted species) and 11 species decreased (human-tolerant species), suggesting that certain species can persist only in the absence of nearby buildings. It is possible that these human-sensitive species would persist near buildings if the negative factors associated with houses were removed, but these factors have not been determined.

Collectively, these trends and consequences suggest that the composition of native wildlife will be altered in the vicinity of exurban housing developments (Knight et al. 1995; Buechner & Sauvajot 1996; Knight & Mitchell 1997; Knight & Clark 1998). Increasing exurban development contributes to the conversion of natural wildlife communities. In our study, there were marked increases in the numbers of human-adapted species, such as the American Robin (*Turdus migratorius*) and Black-billed Magpie (*Pica pica*), and a decrease in human-sensitive species, such as the Blue-gray Gnatcatcher (*Polioptila caerulea*) and Dusky Flycatcher, near rural homes. Determining the causes of these patterns remains an important research topic.

Land-use planners can also effectively contribute to the preservation of wildlife habitat. As opposed to dispersed development, clustered development involves concentrated development on a small portion of an area, leaving the remainder in its natural state. Placing the remaining portion under a conservation easement or similar development restriction ensures that the land will be protected in perpetuity. The result will be higher densities of development with less area of the landscape disturbed. Concentrating the disturbance into one area limits fragmentation and perforation from roads and homes, leaving the remainder of the landscape in a condition more suitable for native wildlife (Theobald et al. 1997; Mitchell et al. 2000). We have shown that houses have an associated zone of influence surrounding them. With clustered development, zones of influence from neighboring homes will overlap, thus minimizing the amount of an area affected by exurban development. But areas that are undeveloped may not all be productive habitat. When development borders wild or undisturbed lands, a buffer of up to180 m around the development should be considered affected habitat.

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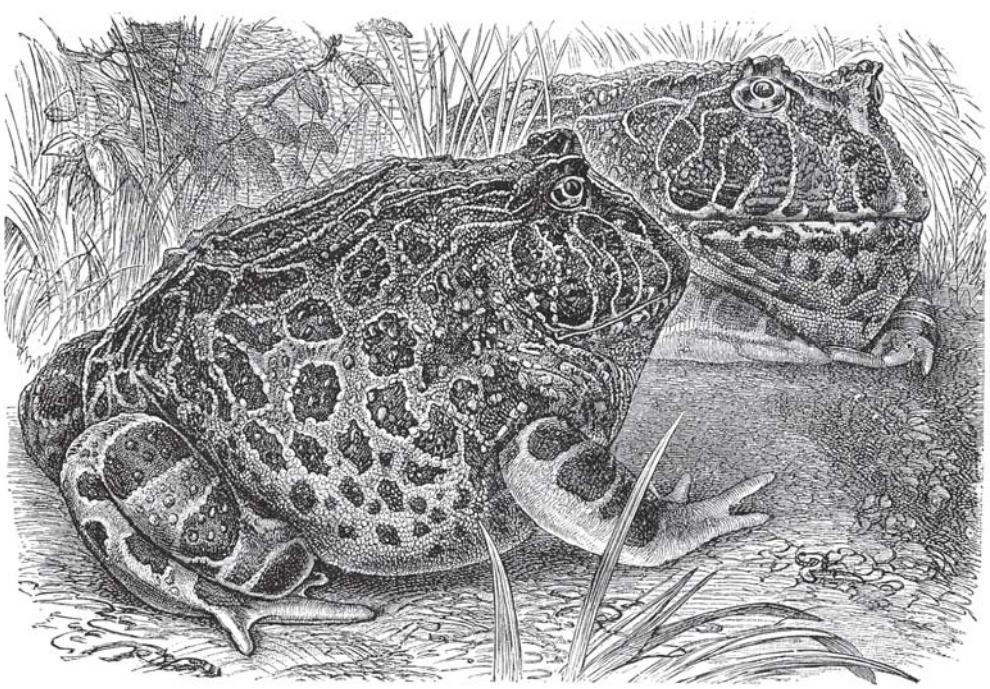

Attachment 8

Hansen and Rotella 2002

Biophysical Factors, Land Use, and Species Viability in and around Nature Reserves

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Abstract: *Many nature reserves are located in landscapes with extreme biophysical conditions. We examined the effects of interactions between biophysical factors and land use on bird population viability inside and outside of Yellowstone National Park. Our hypotheses were as follows: (1) biophysical factors constrain bird species richness and bird reproduction at higher elevations; (2) nature reserves are located at higher elevations, whereas private lands and more intense land use occur mostly at lower elevations with more mild climates and fertile soils; and (3) intense land use at lower elevations favors nest predators and brood parasites and thereby reduces reproductive output for some bird species. We used simulation models to evaluate whether favorable habitats outside reserves are population source areas and whether intense land use can convert these habitats to population sinks and reduce population viability within reserves. Bird species richness and abundance were high in small hotspots in productive, low-elevation habitats. Length of breeding season—and opportunity for renesting—was greatest at the lowest elevations for both American Robins (*Turdus migratorius*) and Yellow Warblers (*Dendroica petechia*). Nature reserves were higher in elevation than private lands, so hotspots for bird richness and abundance occurred primarily on or near private lands, where rural residential development was concentrated. Brown-headed Cowbirds (*Molothrus ater*) were significantly more abundant near rural homes, but nests of American Robins were not parasitized and their nest success did not differ with home density. Nests of Yellow Warblers were commonly parasitized by cowbirds, and their nest success was significantly lower near rural homes. Estimated intrinsic population growth (λ) for American Robins suggested that low-elevation hotspots were population source areas for this species. Estimated λ for the Yellow Warbler suggested that the entire study area was a population sink, likely due to the effects of intense land use at lower elevations and climate constraints at higher elevations. Removing the effect of land use from the simulations revealed that high-elevation hotspots were population sinks, whereas low-elevation hotspots were source areas. Our results are consistent with the possibility that bird-population source areas outside nature reserves can be converted to population sinks by intense human use, thereby reducing the viability of subpopulations within reserves.*

Factores Biofísicos, Uso de Suelo y Viabilidad de Especies en Reservas Naturales y sus Alrededores

Resumen: *Muchas reservas naturales se encuentran en paisajes con condiciones biofísicas relativamente extremas. Examinamos las interacciones entre los factores biofísicos y el uso del suelo en cuanto a la viabilidad poblacional de aves dentro y fuera del Parque Nacional Yellowstone. Nuestras hipótesis fueron las siguientes: (1) los factores biofísicos limitan la riqueza y la reproducción de especies de aves en alturas mayores; (2) las reservas naturales están a mayores alturas, mientras que los terrenos privados y los usos más intensos del suelo están principalmente a menores alturas con climas más templados y tierras más fértiles y (3) el uso intensivo de suelo a menores alturas favorece a depredadores y parásitos de nidos y, por lo tanto, reduce el éxito reproductivo de algunas especies de aves. Utilizamos modelos de simulación para evaluar si los hábitat favorables fuera de las reservas son áreas fuente para las poblaciones y si el uso intensivo de suelo puede convertir a esos hábitat vertederos y reducir la viabilidad poblacional dentro de las reservas. La riqueza y abundancia de especies fueron altas en pequeñas áreas en hábitat productivos situados a elevaciones bajas. La duración de la época reproductiva (y la oportunidad para volver a anidar) fue mayor a menores elevaciones para petirrojos (*Turdus migratorius*) y chipes amarillos (*Dendroica petechia*). Las reservas naturales estuvieron a mayor altura*

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que las tierras privadas; por lo tanto, las áreas de importancia para la riqueza y abundancia de aves principalmente se encontraron dentro de terrenos privados o cerca de los mismos, donde se concentró el desarrollo residencial rural. Molothrus ater *fue significativamente más abundante cerca de las casas rurales; sin embargo los nidos de petirrojos no fueron parasitados y los nidos exitosos no difirieron con la densidad de casas. Los nidos de chipe amarillo comúnmente fueron parasitados por* M. ater *y los nidos exitosos fueron significativamente menos cerca de las casas rurales. El crecimiento poblacional intrínseco (λ) estimado para petirrojos sugirió que los sitios de importancia en elevaciones bajas fueron áreas fuente para esta especie. La λ estimada para los chipes amarillos sugiere que toda el área de estudio fue un vertedero para la población, probablemente debido a los efectos del uso intensivo del suelo y las restricciones climáticas a mayores alturas. La exclusión del efecto del uso del suelo de las simulaciones indicó que las áreas de importancia a mayores alturas eran vertederos, mientras que las de áreas bajas eran fuentes. Nuestros resultados son consistentes con la posibilidad de que las áreas fuente de poblaciones de aves por fuera de las reservas naturales pueda convertirse en vertederos por el uso humano intensivos, reduciendo por lo tanto, la viabilidad de sub poblaciones dentro de las reservas.*

Introduction

Nature reserves are a cornerstone of strategies for conserving biodiversity, but native species are going extinct even in reserves (Newmark 1987*a*, 1987*b*, 1996; Woodroffe & Ginsberg 1998). These extinctions generally have been attributed to the small size and isolation of nature reserves (Wilcove & May 1986; U.S. General Accounting Office 1994). The effectiveness of reserves has also been questioned because their location is perceived to be nonrandom (Hansen & Rotella 2001). Nature reserves are disproportionately located at higher elevations and on less fertile soils, whereas the most productive landscapes occur largely on private lands (Hunter & Yonzon 1993; Scott et al. 2001). Because of these patterns of land allocation, habitat destruction through deforestation and agriculture has been concentrated on productive sites in lowland, coastal, and riparian areas (Huston 1993; Laurance et al. 1999). The implications of the nonrandom location of nature reserves and protected habitats for biodiversity are poorly understood. The topic is especially germane now because the remaining wild and semiwild habitats around many reserves are rapidly being claimed for intense human use, functionally increasing the biased location of natural habitats (Newmark 1996; Hansen & Rotella 2001).

Reserves located in especially cold, dry, or unfertile landscape settings (termed unfavorable landscape settings) may not be sufficient for protecting the biodiversity within them. Species within such reserves may also require more-favorable landscape settings with more moderate climate, fertile soils, and available water outside of the reserve. Because favorable landscape settings have often been claimed as private lands, land use may be intense in these settings. Thus, the negative influences of intense land use on biodiversity in favorable landscape settings outside of reserves may reduce the viability of native species within nearby reserves.

We speculate that the interactive effects of biophysical factors and land use can lead to complex population dynamics for some species. Subpopulations of a species within a reserve may suffer increased risk of extinction if population source areas outside the reserve are degraded by human activities (Sinclair 1998). Population sources are areas where births exceed deaths and the finite rate of population increase (λ) exceeds the replacement level of 1 (Pulliam 1988). Subpopulations may persist in sink habitats ($\lambda < 1$) if they receive sufficient immigration from source habitats ($\lambda > 1$) (Pulliam & Danielson 1991). We suggest that the harshness of physical factors in reserves may result in populations within nature reserves being dependent upon population source areas in more-favorable settings outside of reserves. As the more-favorable landscapes surrounding nature reserves are altered by human activities, population source areas may be converted to population sinks, thereby increasing the risk of extinction within reserves.

We examined interactions among biophysical factors, human land allocation and use, and the population attributes of bird species in the Greater Yellowstone Ecosystem. Hypotheses evaluated were as follows: (1) at higher elevations, biophysical factors constrain bird species richness, bird abundance, length of nesting season, and reproductive output, whereas at lower elevations, these factors are less constraining; (2) human land allocation and use has resulted in nature reserves being placed at higher elevations, whereas private lands and more-intense land use are at lower elevations with milder climates and more-fertile soils; (3) intense land use favors nest predators and brood parasites and thereby reduces reproductive output for some native species. If these hypotheses are correct, a potential consequence is that intense land use at lower elevations could convert population sources to sinks and increase the risk of extinction of subpopulations in nature reserves at higher elevations.

We tested these hypotheses with field studies. We then examined potential population consequences using simulation modeling of population growth rate and statistical extrapolation of source-sink status across landscapes. We focused on the reproduction and population growth of two species, the American Robin (*Turdus migratorius)* and Yellow Warbler (*Dendroica petechia*), that were expected to differ in response to land use because of their respective life-history attributes. For the Yellow Warbler, which was predicted to be sensitive to land use, we also evaluated the possibility that land use in population source areas outside reserves could reduce population viability in reserves.

Methods

Study Area

The 9500-km^2 study area included the upper Gallatin, Madison, and Henry's Fork watersheds in Montana, Idaho, and Wyoming (U.S.A.) (Fig. 1). These rivers originate on a plateau in Yellowstone National Park, pass through the Gallatin and Targhee national forests, and flow into privately owned agricultural floodplains in the lowlands.

Climate severity and soil quality varied with elevation in the study area. Mean annual temperature and growing-degree days varied from 5.8° C and 2787 days below 1500 m to 0.26° C and 1356 days above 2400 m during 1995–1997 (Hansen et al. 2000). Much of the precipitation fell as snow. Average snowmelt date during this period was 1 May at 1500 m and 1 July at 2400 m. The Yellowstone Plateau was created through volcanic activity. Hence, soils at higher elevations are largely nutrient-poor rhyolites and andesites with low water-holding capacity (Rodman et al. 1996). Valley bottoms and floodplains contain glacial outwash and alluvium soils that are higher in nutrients and water-holding capacity.

The vegetation of the study area was a mosaic of forests, shrublands, and grasslands (Despain 1990). Upland rhyolitic soils supported conifer forests. Sagebrush shrublands occurred on dry, fine-textured soils from low to middle elevations. Grasslands existed on fine-textured soils from valley bottoms up to middle slopes. Aspen (*Populus tremuloides*) was distributed in relatively small patches, primarily on moist toeslopes or on fractured rocks. Larger floodplains were dominated by black cottonwood (*Populus trichocarpa*) and narrowleaf cottonwood (*P. angustifolia*). Aboveground net primary productivity was related to elevation, soils, and cover type in the study area. It varied from 2964 kg/ha/year in subalpine conifer forests to 5508 in low-elevation, cottonwood forests (Hansen et al. 2000). Agriculture, range, rural-residential, and urban development were common land-use types on these private lands in the study area.

Bird Abundance, Richness, and Reproduction

We sampled abundances of landbirds on 100 sites stratified by cover type, seral stage, and elevation class during the breeding seasons of 1995–1997. Cover types included aspen, cottonwood, Douglas-fir (*Pseudotsuga menziesii*), grassland, sagebrush, and lodgepole pine (*Pinus contorta*), which were the major cover types of the study area below the alpine zone. We sampled in each of three seral stages of lodgepole pine: after recent fire, after recent logging, and mature and old growth. Elevation classes were <2200 m, 2200–2400 m, and >2400 m. Four to eight replicates were sampled per stratum. Sampling locations were located by inspection based on cover type, elevation class, geographic distribution, and access. We placed sampling sites widely over the study area to maximize the range of topographic, climatic, and soil settings, but we constrained sites to those within 1.5 km of a road to facilitate access. At each site, birds were counted on six 100-m radius points spaced >200 m apart by the fixed-plot method (Ralph et al. 1993). Two bird surveys were conducted during the 1995 breeding season, and three surveys were conducted each year in 1996 and 1997. The dates of the surveys varied with elevation to correspond to the height of bird breeding activity in each elevation class.

Elevation of sites was derived from digital elevation models and parent material from soil atlases. We estimated aboveground net primary productivity for each point, based on tree and shrub density and annual diameter growth, using dimension analysis (Hansen et al. 2000). We estimated bird density by correcting counts for detectability with the program DISTANCE (Buckland et al. 1993). Bird abundance, aboveground net primary productivity, elevation, and parent material were averaged for each site, and site was used as the unit of analysis.

Relationships between predictor variables (cover type, elevation, parent material, and estimated aboveground net primary productivity) and bird abundance and richness were quantified by multiple regression. Competing regression models were analyzed, best models were selected based on Akaike's information criterion (AIC) and parsimony (Burnham & Anderson 1998), and best models were then used to predict bird species richness and abundances over the study area. These projections were not validated against independent data, but the coefficient of variation of the predictions was quantified as a measure of the confidence that could be placed in the results. We report results for bird species richness, total bird abundances, and abundances of the American Robin and Yellow Warbler.

Bird reproduction was estimated within two deciduous forest-cover types that differed in elevation: five cottonwood sites at 1000–1500 m and four aspen sites at 2000–2500 m. The two cover types also differed in land-use intensity. Cottonwood stands were on floodplains and were surrounded by rural residential development.

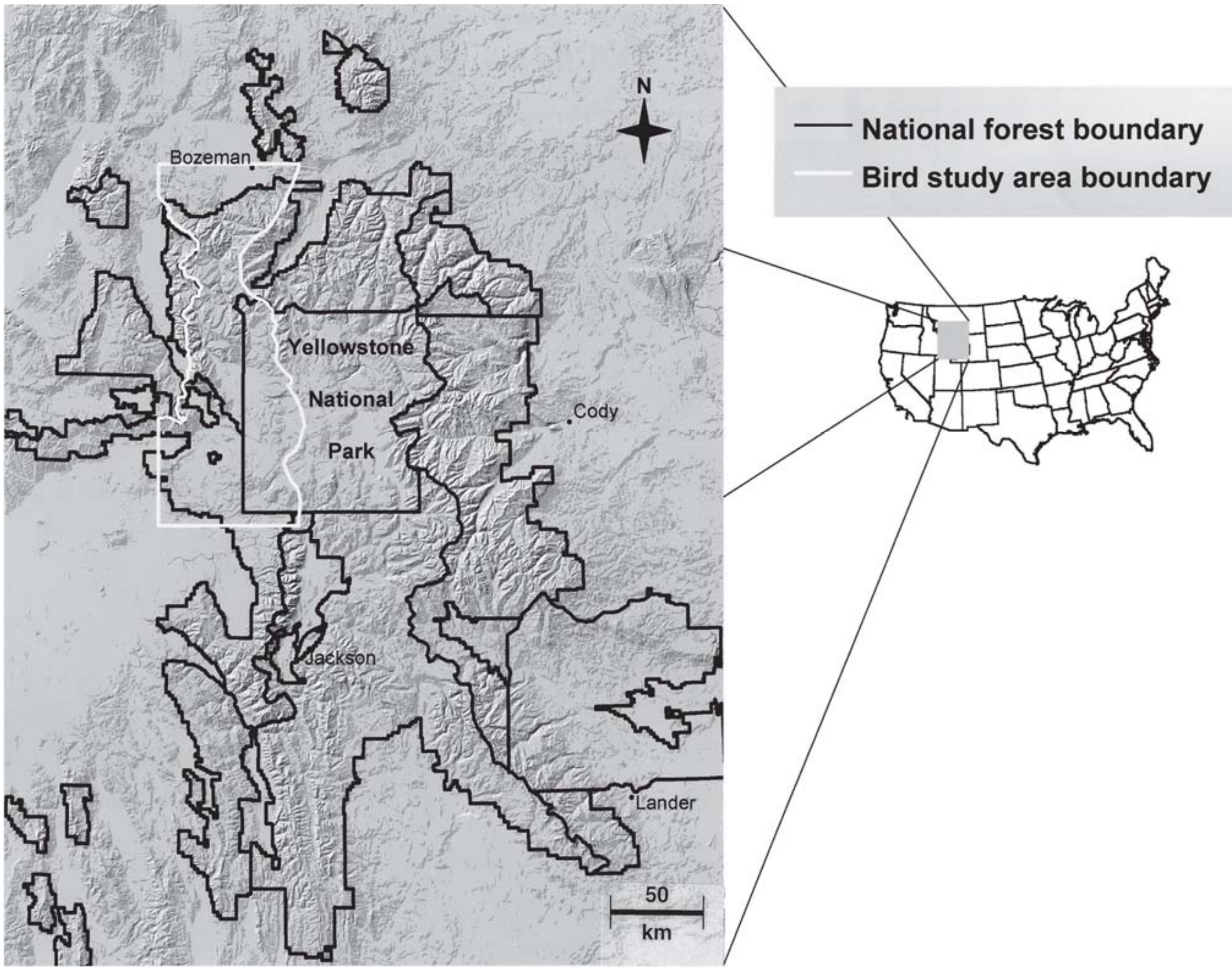

Figure 1. Location of the study area in the Greater Yellowstone Ecosystem.

Aspen stands occurred primarily on mountain-toe slopes and were distant from rural homes. On each site, we located and monitored the fates of nests (Martin & Geupel 1993) of several species during 1997–1999. Two bird species were selected for analysis based on adequacy of sample sizes and reported differences in their susceptibility to brood parasitism by the Brown-headed Cowbird (*Molothrus ater*), a bird associated with intense land use (Askins 1995). The species selected were the American Robin (never successfully parasitized) and the Yellow Warbler (commonly parasitized) (Ehrlich et al. 1988). American Robins also aggressively defend their nests and may be less vulnerable to predators than Yellow Warblers.

We searched for nests on each site every other day from mid-May through July. Each nest's contents and fate were monitored every 2 to 4 days until the nest failed or fledged young. For each nest, we recorded the number of eggs and young (host and cowbird) present during each visit and used these data to estimate production of eggs and young. Based on observed clutch sizes and dates for egg laying, hatching, and/or fledging of young, we estimated dates of initiation, hatching, and fledging for each nest. These data were then used to estimate and compare the distribution of initiation dates and the length of the nesting season in each cover type. Using *t* tests, we compared the range of nest-initiation dates on each site between cover types for each species. Data from nests that survived through the egg-laying stage were used to calculate the cowbird parasitism rate for each species in each cover type.

We used generalized linear models and data on nest fates and covariates of interest (Rotella et al. 2000) to estimate the daily survival rates of nests. This maximum-likelihood analysis is an extension of Mayfield's (1975) approach to estimating nesting success, which makes the same assumptions as traditionally applied methods. We evaluated the strength of relationships between nest fate and covariates of interest, such as nesting stage and cover type, with Akaike's information criterion and the principle of parsimony (Burnham & Anderson 1998). Estimates of daily survival rate from the most parsimonious model for each species were used to generate estimates of nesting success (i.e., daily survival rate was raised to a power corresponding to the number of days required to lay, incubate, and fledge young in the species).

Human Land Allocation and Use

As a measure of the allocation of lands relative to biophysical factors, we quantified the distributions of nature reserves, other public lands, and private lands across elevation. Included in the nature reserves were designated national parks, wilderness areas, and national wildlife refuges. Data on the boundaries of these land jurisdictions were obtained from the Montana State Library Natural Resource Information System.

Human population growth in the Greater Yellowstone Ecosystem has resulted in a rapid expansion of rural residential development (Hansen et al., 2002). Maps of home location were not available for the study area. County well records, recorded to a spatial accuracy of the quarter section, provided the best indication of home location. We assumed for this analysis that homes were built on locations where well permits had been granted, but the accuracy of this assumption could not be quantified fully. The actual locations of a subset of homes were known for about 20% of the study area. We found that the geographic distribution of the known home locations corresponded closely with the well-permit locations. The distribution of homes relative to bird hotspots was quantified by comparing the density of homes within 2 km of bird hotspots to the average density of homes across the private lands in the study area.

Land Use and Bird Reproduction

To evaluate whether land use negatively affected reproductive output, we compared various productivity measures between nests found in stands of aspen (low land-use intensity) and cottonwood (high land-use intensity). For the Yellow Warbler, we evaluated whether the probability of cowbird parasitism differed between cover types with a chi-square test. To evaluate whether nest survival differed between cover types for the American Robin and the Yellow Warbler, we used generalized linear models. For nests that did survive, we compared the number of young fledged per nest between cover types for each species with a *t* test.

Interactive Effects of Biophysical Factors and Land Use on Net Population Growth

To investigate potential population consequences of observed spatial patterns of species density and reproductive output, we estimated population growth rate (λ) for the American Robin and Yellow Warbler. We estimated λ for each species and cover type based on relevant estimates for simulated female success (proportion of females that successfully nested when potential renesting was considered), field estimates of females fledged per successful nest, and published estimates of adult and juvenile survival rate. To calculate λ, we used Pulliam's (1988) equation: λ = (annual survival rate for adults) + (survival rate for juveniles) $\times$ (number of females produced per female per year). We believe that this modeling strategy and structure represents a reasonable trade-off between simplicity and complexity (Levins 1966; Johnson 1996), given our objectives and the limited data on survival available for parameterizing the model. We considered the model adequately complex to further our understanding of the population dynamics of the species and for gaining information about the relative importance of different habitat settings. Given the simplifications and assumptions made, however, we recommend against using estimates of λ for predicting actual future population sizes.

We estimated female success with a stochastic model that incorporated field estimates of nesting success, average age of failed nests, and duration of the nest-initiation period by cover type. For each species and cover type, we used relevant field data and Monte Carlo simulations to estimate renesting potential and then combined renesting potential and nesting success to calculate female success. To estimate renesting potential, we (1) generated a distribution of initiation dates for 1000 initial nest attempts and all subsequent renest attempts for simulated females who repeatedly failed at nesting and (2) used that distribution to estimate the proportion of first, second, and third nesting attempts that fail in time to allow for a subsequent nesting attempt. To do this, we (1) generated a random initiation date for each female's first nest initiation (normally distributed based on observed data for the first 2 weeks of the nesting season, bounded by observed dates); (2) generated a random fail date for each nest (normally distributed according to observed survival times for all failed nests and bounded by observed nest ages at failure); (3) determined whether each nest failed in time to allow for another attempt (initiation date plus fail age plus 6 days of recovery time [Holcomb 1974]) before the end of the nesting season; and (4) repeated steps 1–3 (for a maximum of three renesting attempts) for females who failed and recovered in time for another nest attempt. Thus, female success was nesting success adjusted for up to three renest attempts and did not allow for multiple broods (the roles of third and fourth nesting attempts were modest in all habitat settings).

For each cover type and species, we multiplied simulated female success by the number of female young fledged per successful nest (a 50:50 sex ratio of young in each nest was assumed) to estimate the number of females fledged per female. Population growth rate was then calculated as described above, based on published estimates of survival. Because no estimates of survival were available for our area and rigorous estimates are

Table 1. Results of regression analysis of relationships between bird variables and biophysical factors (data from 100 stands distributed across the study area).

		Best model			
Variable	*Significant models* (R^2)	*model*	F	R^2	$p > F$
Species richness	elevation (0.19) parent material (0.41) ANPP* (0.56) cover type (0.64)	cover type, elevation, parent material	19.0	0.73	0.0001
Total abundance	elevation (0.29) parent material (0.27) ANPP (0.40) cover type (0.61)	cover type, elevation, parent material	20.0	0.70	0.0001
American Robin	elevation (0.16) parent material (0.18) ANPP (0.33) cover type (0.26)	cover type, elevation, parent material	4.0	0.34	0.0001
Yellow Warbler	elevation (0.45) parent material (0.48) ANPP (0.62) cover type (0.76)	cover type, elevation	19.5	0.81	0.0001

**Aboveground net primary productivity.*

rare for the species we studied, we reviewed available estimates (Roberts 1971; Ricklefs 1973; Karr et al. 1990; Martin & Li 1992), summarized data, and used 0.6 and 0.5 for adult and juvenile survival in both species. These rates are typical of those reported for the two species and their close relatives. This method of dealing with the lack of survival data and the equation used to estimate λ are both commonly used in avian demographic studies, especially for passerines (e.g., Brawn & Robinson 1996; Fauth 2001; Flaspohler et al. 2001).

We projected the net population growth of Yellow Warblers over the study area with and without the influence of rural residential development. Net population growth was modeled across the study area by 100-m elevation class as a function of the predicted abundance of breeding females (as derived with the regression function in Table 1) and predicted λ (derived as described above). To calculate λ for each elevation class under the current land-use scenario, we first estimated nesting success and female success for each elevation class and then used these values in the equation for calculating λ. We estimated nesting success for each elevation class through an estimating model that included as a predictor variable the density of homes within 6 km of a site (see results for additional model details). For each elevation class we used the estimates of nesting success and potential renesting relevant to that elevation class to calculate female success. We removed the estimated effect of homes in a second analysis of predicted net population growth by setting the density of homes to zero when predicting nesting success at each elevation.

Under each scenario, we first calculated the abundance and net change in abundance for each elevation class and then summed across all elevation classes to estimate the net change in population size across all classes. This method assumes that the species disperses among suitable habitats in the study area such that source habitats exchange individuals with sink habitats. This assumption seems plausible given the territorial nature of passerines, the large number of studies that have reported sequential habitat occupancy (reviewed by Newton 1998), and the number of passerine species that have been shown to regularly recolonize unoccupied suitable habitat (e.g., Opdam et al. 1995).

Results

Distribution of Bird Richness, Abundance, and Reproduction

Bird species richness, total bird abundance, and American Robin and Yellow Warbler abundances were positively associated with landscape settings that were lower in elevation, on alluvial parent materials, and/or had higher aboveground net primary productivity (Table 1). These sites were dominated by the deciduous forest-cover types of aspen, cottonwood, and willow. Extrapolating species richness and total bird abundance across the study area revealed that places predicted to have ≥60% of maximum richness and bird abundance were relatively rare (Fig. 2). These hotspots covered only 2.7% of the study area and occurred primarily at lower elevations. Yellow Warblers were largely restricted to these hotspots, and American Robins were significantly more abundant in hotspots. Confidence in the predicted distribution of hotspots was bolstered by the low coefficients of variation of predicted bird richness and abundance. For species richness and total abundance in deciduous habitats, which were generally classified as hotspots, mean coefficients of variation were 0.087 (SD = 0.030) and 0.089 (SD = 0.021), respectively.

We obtained reproductive data from 441 American Robin and 340 Yellow Warbler nests. The nesting season was longer at lower elevations for both American Robins ($p = 0.02$) and Yellow Warblers ($p < 0.01$) (Table 2). At lower elevations, the nest-initiation period was extended by 14 days (SE = 4.4 days) for robins and 22.7 days (SE = 4.5 days) for warblers. Thus, there was significantly more time for renesting attempts by each species in cottonwood stands than in aspen stands. Other measures of reproductive output were not greater at lower

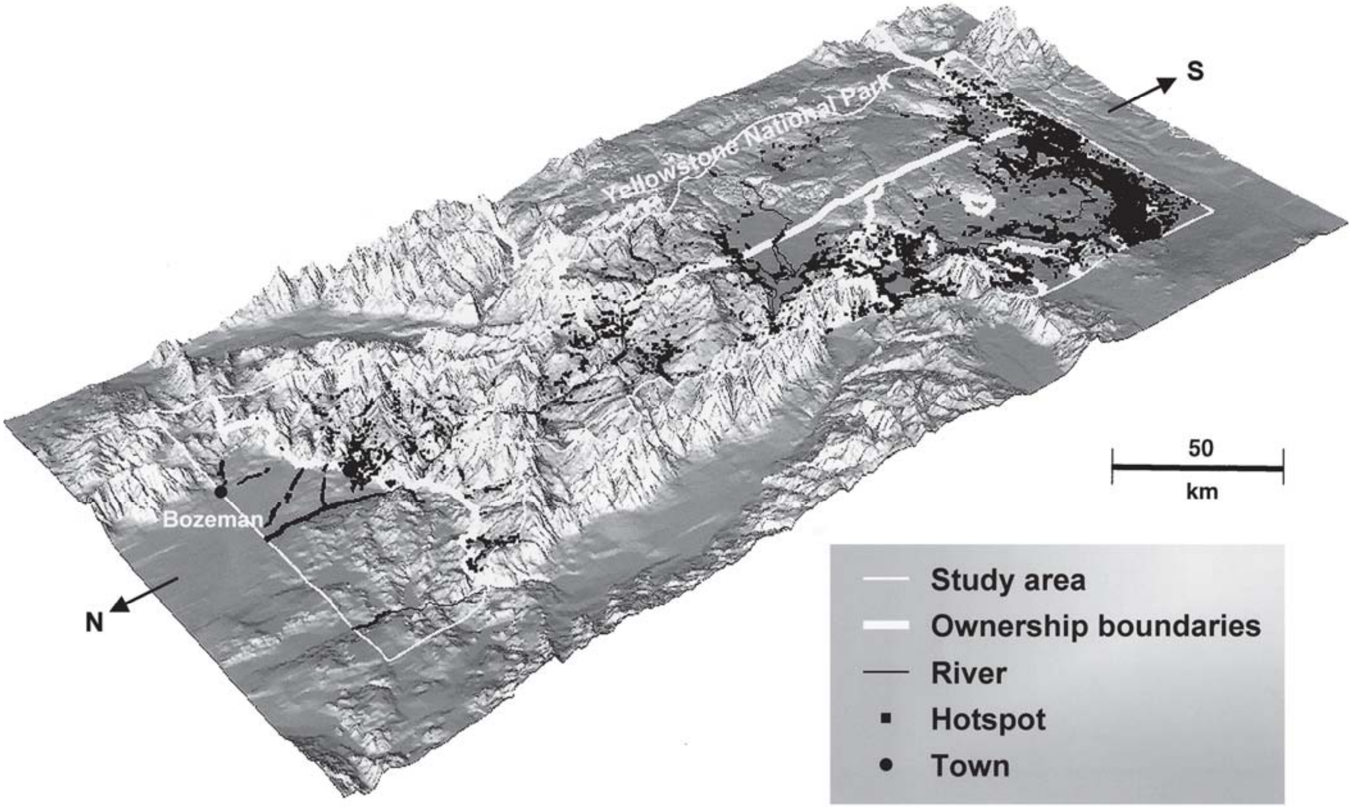

Figure 2. Distribution of bird hotspots (bird species richness and total abundance ≥60% of maximum) across the study area (YNP, Yellowstone National Park; TNF, Targee National Forest; GNF, Gallatin National Forest).

elevations, which may be explained by the more intense land use associated with lower-elevation sites.

Distribution of Human Land Use

Human impacts on natural habitats in the study area were not random relative to biophysical gradients. The elevational range of reserves was higher (1700–3400 m) than that of private lands (1200–2600 m) (Fig. 3). The majority of the areas high in aboveground net primary productivity (> 4500 kg/ha/year) occurred on private lands; only 1.0% of these areas occurred in nature reserves (Hansen et al. 2000). Consequently, hotspots for bird richness and abundance occurred primarily on or near private lands. Sixty-seven percent of hotspots were found on or within 6 km of private lands, whereas only 6.5% were found in nature reserves. Within private lands, rural residential development was placed disproportionately close to bird hotspots. Home densities within 2 km of hotspots were 67% higher than at random locations on private lands.

Effects of Land Use on Reproduction

Lower-elevation sites had more intense land use and greater densities of brood parasites and avian predators. The density of homes within 6 km of cottonwood stands (986/ha, SE = 70.2) was higher than that around aspen stands (153/ha, SE = 38.7). Cowbird density was positively related to home density within 6 km of a site ($n = 11$, $F = 64.7$, $R^2 = 0.89$, $p < 0.0001$) and was higher in stands of cottonwood (2.58/ha, SE = 0.13) than in aspen (0.70/ha, SE = 0.03). Similarly, the abundance of the avian nest-predator guild was also positively associated with home density ($n = 11$, $F = 32.3$, $R^2 = 0.78$, $p < 0.0003$). We were unable to determine the proportion of nest failures due to nest predation but did quantify the proportion of nests that were parasitized. No American Robin nests contained cowbird eggs. In contrast, Yellow Warbler nests were commonly parasitized, and the rate was 5.1 times greater ($p < 0.001$) in cottonwood (44.2%) than in aspen stands (8.7%).

For American Robins, which were regularly seen chasing brood parasites and avian predators on our sites, nesting success did not appear to differ between cover types. For robins, a model that estimated a common daily survival rate for aspen and cottonwood stands was slightly more parsimonious (difference in AIC values for the two models = 0.84) than one that provided separate estimates. Estimated nesting success was 0.33 for American Robins when cover type was ignored (Table 2); when estimated separately, success was 0.29 in aspen and 0.35 in cottonwood.

Table 2. Average reproductive success and population growth rate (λ) for American Robin and Yellow Warbler in two cover types as derived from field measurement or computer simulation.

Species (no. of nests)	*No. of stands*	*Elevation class (m)*	*Cover type*	*Measured nest success*	*Range of nest initiation dates (SE)*	*Cowbird parasitism, % (SE)*	*Deterministic estimate of λ*
American Robin (441)	5	1000–1500	cottonwood	0.33	72.8 (3.8)	0.0	1.17
	4	2000–2500	aspen	0.33	58.8 (2.3)	0.0	1.00
Yellow Warbler (340)	5	1000–1500	cottonwood	0.22	41.2 (3.9)	44.2 (3.3)	0.94
	4	2000–2500	aspen	0.40	18.5 (0.9)	8.7 (4.2)	0.89

In contrast, Yellow Warbler nesting success was much lower in the cover type with more-intense land use. For this species, a model that provided separate estimates of daily survival rate for aspen and cottonwood stands was much more parsimonious (difference in AIC values for the two models = 4.4) than one that provided a single estimate. Estimated nesting success was 0.40 in aspen but only 0.22 in cottonwood (Table 2). A model that replaced cover type with home density within 6 km of a stand was slightly more parsimonious (difference in AIC values = 0.6) and indicated that land-use intensity was negatively related to nesting success (regression coefficient for home effect = −0.003 [95% CI: −0.001 to −-0.005]).

For nests that were successful, production of young did not differ ($p > 0.21$) by cover type in either species. For the American Robin, successful nests fledged 3.0 young (SE = 0.1, $n = 60$) in aspen and 2.8 young (SE = 0.1, $n = 161$) in cottonwood. Successful Yellow Warbler nests fledged 2.9 young in aspen (SE = 0.2, $n = 29$) and 2.8 young in cottonwood (SE = 0.1, $n = 98$).

Interactive Effects of Biophysical Factors and Land Use on Net Population Growth

Estimated female success for American Robins was 0.54 in aspen and 0.76 in cottonwood stands when nesting success (0.33 in each cover type) and potential renesting opportunity were combined. Given that the two cover types yielded similar estimates of females fledged per successful female and were assigned the same juvenile and adult survival rates, λ was estimated as higher in cottonwood (1.17) than in aspen (1.00) (Table 2). Thus, for American Robins, our data and modeling indicate that low-elevation hotspots with lengthier breeding seasons may act as important population source areas.

In contrast, results for the Yellow Warbler indicated that both cover types may potentially be population sinks. The longer nesting season in cottonwood caused our estimate of female success (0.53) to be well above estimated nesting success (0.22) in this habitat. Nesting success in cottonwood was so low, however, that even when repeated renesting increased female success, our model still estimated that the habitat was a population sink (λ = 0.94). In aspen, the short nesting season prevented female success (0.41) from being substantially higher than nesting success (0.40). Consequently, aspen was also estimated to be a population sink (λ = 0.89).

Simulations of net population growth for Yellow Warblers under current home densities revealed that the study area was a strong population sink, with population growth negative both in nature reserves because of elevation constraints and on private lands because of land-use constraints (Table 3). Net population growth of Yellow Warblers was positive only on public lands at mid-elevations where elevation constraints were intermediate and home densities are low. When the home effect was removed from the model, the study area was projected to be a strong population source area, with negative population growth only in nature reserves.

Discussion

Our results indicate that bird species richness and abundance were high only in the small portion of the landscape where biophysical factors were favorable. Because nature reserves in our study area occurred at higher elevations, avian hotspots were found primarily outside reserves, with the majority located on or near private lands. Biophysical factors constrained reproduc-

Table 3. Simulated population dynamics of Yellow Warblers in the study area with and without the influence of rural residences.

Ownership	*Area (ha)*	*Current population size*	*Simulated net annual population change without home effect*	*Simulated net annual population change under current home densities*
Private	808	2942	309	−85
Public, general	4251	2003	41	6
Public, nature reserves	984	804	−28	−35
Total			322	−114

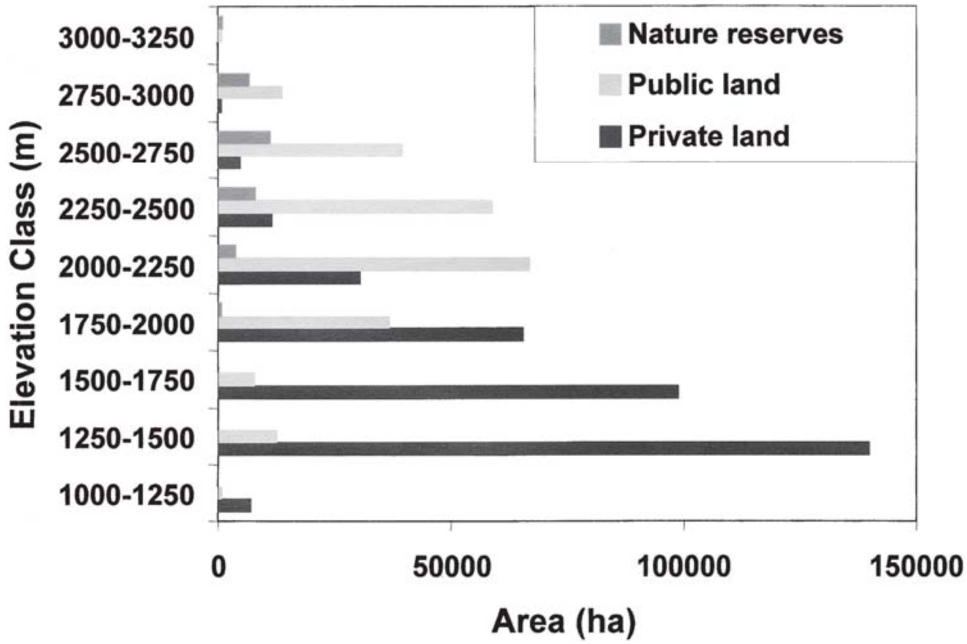

Figure 3. Elevational distributions of nature reserves (U.S. national parks and national wildlife refuges, U.S. wilderness areas), other public lands, and private lands across the study area.

tion in the American Robin and Yellow Warblers. Climate conditions at higher elevations resulted in short breeding seasons and little opportunity for renesting. Consequently, the estimated λ for both species was lower in aspen (intermediate elevation) than in cottonwoods (low elevation). For the American Robin, estimated λ in aspen was near 1.0, the threshold where net population growth is 0. In cottonwoods, estimated λ was well above 1.0, suggesting that this habitat is a population source for this species. We speculate that deciduous habitats at high elevations in the study area were population sinks because of the short breeding season.

Land use also influenced bird reproduction. Within private lands, rural residential development was located disproportionately close to bird hotspots. High densities of homes and associated high rates of nest predation and parasitism in cottonwoods likely depressed reproduction of Yellow Warblers below that expected based on the favorable elevation of these sites. Thus, our estimated λ for the Yellow Warbler was well below replacement levels both in cottonwood stands with high land use and in aspen stands at high elevations where the nesting season was shorter. A simulation that removed the effect of home density suggested that low-elevation hotspot habitats were strong population sources prior to rural residential development, whereas high-elevation habitats were population sinks because of the short breeding season. These results are consistent with the possibility that for some bird species population sources can be converted to population sinks by intense human use.

In total, our results suggest that the location of nature reserves in less favorable landscape settings and the concentration of intense land use in more favorable landscape settings have important implications for maintaining biodiversity. The population sizes of species in nature reserves at high elevations may be substantially constrained by unfavorable climate, infertile soils, aridity, and/or low food availability. If net population growth is sufficiently low in such reserves, small population sizes and increased likelihood of extinction are expected. Such populations within reserves may be bolstered by immigrants from population source areas in more-favorable landscape settings outside reserves. If intense land use converts such population sources to sinks, increased risk of species' extinction within nature reserves may result.

Our ability to rigorously estimate population growth was impaired, however, by lack of data for some vital rates. In particular, monitoring nesting histories of individually marked birds would allow estimation of renesting potential and the frequency of multiple broods and would permit researchers to evaluate the importance of these factors to reproductive output. Given the assumptions we made in modeling, we can envision reasons that our estimates of λ might be too high or too low. Our model, which allowed up to three renesting attempts, may have allowed for more renesting by American Robins and Yellow Warblers than is realistic and thus may have biased estimates toward high value of λ. But this was unlikely a large source of bias because renesting is well documented in both species, and initial renesting attempts were most important to our results. Furthermore, other studies have shown that birds adjust to environmental variation by adjusting the number of renesting attempts (Rodenhouse & Holmes 1992). In contrast, our estimates of λ for American Robin may be biased toward low values because we did not allow double brooding, which probably does occur to some extent in this species at northern latitudes and would increase estimates of λ.

Future estimates of the interactive effects of biophysical factors and land use on net population growth would be improved if data were obtained in multiple years across a range of climate and land-use conditions while controlling for cover type. Such a design would be less confounded than ours and would provide estimates of spatial and temporal variation in vital rates. Such a design will be extremely difficult to implement, however, given the spatial patterning of climate, cover types, land ownership, and land use. Furthermore, field estimates of survival rates of juveniles and adults will likely remain elusive for passerines, especially across a range of covariate conditions. Despite these difficulties, we do believe that future research designed to improve our understanding of the spatial patterning of demographics is warranted given the rapid changes occurring on private lands found in favorable biophysical settings.

Further study is needed to determine how interactions among biophysical factors, land use, and source-sink population dynamics may influence other groups of species in the Greater Yellowstone Ecosystem. We speculate that such interactions may explain the extinction of arctic grayling (*Thymallus arcticus*), the near extinction of the Trumpeter Swan (*Cygnus buccinator*), and the current precipitous drop in pronghorn antelope (*Antilocarpra americana*) in Yellowstone National Park (Hansen & Rotella 2002). We further speculate that these factors influence species in other nature reserves where harsh biophysical factors constrain distributions of native species and human land use.

Assessment of the biodiversity consequences of the nonrandom location of many of the world's nature reserves is especially important now. Our findings suggest that alteration and destruction of the remaining productive habitats outside nature reserves will pose dire threats to many wildlife populations. Globally, human population density and growth rates are disproportionately high near biodiversity hotspots (Cinotta et al. 2000). Both human population density and land-use intensity are now increasing on the private lands surrounding nature reserves (Newmark 1996). Thus, seminatural habitats outside nature reserves are likely declining, possibly reducing the size of population source areas. These trends cast doubt on the viability of current strategies that rely on nature reserves for wildlife conservation and ignore intervening lands. Conservation strategies to protect population source areas outside reserves are likely necessary to reduce rates of future extinction in nature reserves.

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Attachment 9

Maestas et al. 2003

Biodiversity across a Rural Land-Use Gradient

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Abstract: *Private lands in the American West are undergoing a land-use conversion from agriculture to exurban development, although little is known about the ecological consequences of this change. Some nongovernmental organizations are working with ranchers to keep their lands out of development and in ranching, ostensibly because they believe biodiversity is better protected on ranches than on exurban developments. However, there are several assumptions underlying this approach that have not been tested. To better inform conservation efforts, we compared avian, mesopredator, and plant communities across the gradient of intensifying human uses from nature reserves to cattle ranches to exurban developments. We conducted surveys at randomly selected points on each type of land use in one Colorado watershed between May and August of 2000 and 2001. Seven bird species, characterized as human commensals or tree nesters, reached higher densities (all* $p < 0.02$*) on exurban developments than on either ranches or reserves. Six bird species, characterized as ground and shrub nesters, reached greater densities (all* $p < 0.015$*) on ranches, reserves, or both of these types of land use than on exurban developments. Domestic dogs (*Canis familiaris*) and house cats (*Felis catus*) were encountered almost exclusively on exurban developments, whereas coyotes (*Canis latrans*) were detected more frequently (*$p = 0.047$*) on ranchlands than exurban developments. Ranches had plant communities with higher native species richness and lower non-native species richness and cover than did the other types of land use (all* $p < 0.10$*). Our results support the notion that ranches are important for protecting biodiversity and suggest that future conservation efforts may require less reliance on reserves and a greater focus on private lands.*

Biodiversidad a lo largo de un Gradiente de Uso de Suelo Rural

Resumen: *Los terrenos privados del oeste de América están experimentando una conversión del suelo de un uso agrícola a un uso urbano, aunque se conoce poco acerca de las consecuencias ecológicas de este cambio. Algunas organizaciones no gubernamentales están trabajando con granjeros para que sus tierras permanezcan sin urbanizar, ostensiblemente porque piensan que la biodiversidad se protege mejor en tierras rurales que en urbanizaciones. Sin embargo, hay varios supuestos subyacentes a este modelo que no han sido comprobadas. Para informarnos mejor sobre los esfuerzos de conservación, comparamos comunidades de aves, mesodepredadores y plantas a lo largo del gradiente de intensidad de uso humano de reservas naturales, granjas y zonas de urbanización. Realizamos muestreos en sitios seleccionados aleatoriamente en cada uso de suelo en una cuenca del Colorado entre mayo y agosto de 2000 y 2001. Siete especies de aves, caracterizadas como comensales humanos o nidificantes arbóreos, alcanzaron densidades más altas (todas* $p < 0.02$*) en urbanizaciones nuevas que en granjas o reservas. Seis especies de aves, caracterizadas como nidificantes de suelo y arbustos, alcanzaron densidades mayores (todas* $p < 0.015$*) en granjas, reservas o usos mixtos del suelo que en las nuevas urbanizaciones. Se encontraron perros (*Canis familiaris*) y gatos (*Felis catus*) domésticos casi exclusivamente en nuevas urbanizaciones, mientras que se detectaron coyotes (*Canis latrans*) más frecuentemente (*$p = 0.047$*) en granjas que en nuevas urbanizaciones. Las granjas tenían comunidades de plantas con mayor riqueza de especies nativas y menor riqueza y cobertura de especies no nativas que en todos los demás usos de suelo (todas* $p < 0.10$*). Nuestros resultados apoyan la noción de que las granjas son im-*

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portantes para la protección de la biodiversidad y sugieren que los futuros esfuerzos de conservación pueden requerir de menos confianza en las reservas y un mayor enfoque en terrenos privados.

Introduction

A profound change in human population size and land use is currently underway in the Rocky Mountain states (Arizona, Colorado, Idaho, Montana, Nevada, New Mexico, Utah, and Wyoming) of the American West. With population growth rates two to three times the national rate, this region had the five fastest growing states in the country between 1990 and 2000 (Perry & Mackun 2001). Although metropolitan areas have accommodated much of this in-migration, growth in rural areas is occurring at a faster rate and is requiring more land because of the large lot sizes associated with rural development (Sullins et al. 2002). Between 1994 and 1997 in the United States, nearly 80% of the land used for constructing houses was in nonmetropolitan areas, with 57% of houses being built on lots ≥4 ha in size (Heimlich & Anderson 2001). Driven by economic and quality-of-life factors such as outdoor recreation, people are choosing to live where they play (Power 1996; Masnick 2001). Concomitantly, the region is experiencing a conversion in private land use from ranching and farming to rural residential—or exurban—development (Riebsame et al. 1996; Sullins et al. 2002).

Outside incorporated city limits, three of the principal types of land use in the Rocky Mountain West are livestock ranching, nature protection, and exurban development (Vesterby & Krupa 1997). On ranches, the primary human use is livestock production. Protected areas, or nature reserves, provide some degree of protection from the permanent conversion of natural land cover and support human uses such as nature conservation and outdoor recreation. Exurban developments are low-density residential developments (typically one house per 4–16 ha) that occur beyond incorporated city limits, with lands being used for either part-time or year-round residence. The amount of land being designated as nature reserves is increasing slowly, with small portions being acquired annually by both governmental and nongovernmental natural resource and conservation organizations. Land in ranching and development is changing rapidly, however, as private ranches are sold and converted to exurban developments. Between 1990 and 2000, approximately 12 million ha were developed at exurban densities nationwide (Theobald 2001).

Although it is seldom the focus of scientific investigation, this conversion in land use has alarmed conservationists because of its potential implications for native biodiversity (Knight 1997; Hansen & Rotella 2002; Hansen et al. 2002). Wildlife and plant communities have been well studied in and adjacent to metropolitan areas (e.g., Emlen 1974; Beissinger & Osborne 1982; Mills et al. 1989; Engels & Sexton 1994; Blair 1996; Germaine et al. 1998; Bock et al. 1999; Crooks & Soulé 1999), whereas few studies have examined wildlife communities on exurban developments (Vogel 1989; Harrison 1997, 1998; Odell & Knight 2001; Hansen & Rotella 2002) and none have assessed plant communities in exurban areas. Little is known about the ecological consequences of converting ranchland to exurban development, yet some conservationists suspect that it is resulting in a simplification of our natural heritage by promoting species that are adaptable to human-altered environments and eliminating specialist species (Knight 1997; Marzluff et al. 1998; Boren et al. 1999; Hansen & Rotella 2002).

The threat of population declines for species sensitive to exurban development has generated a new response to biodiversity protection among conservation organizations in the Rocky Mountain region. The traditional means of protecting biodiversity from intense human land uses has been to purchase land and designate it as a nature reserve. One emerging technique for conserving biodiversity is to work with ranchers to keep private land out of development. Typically, this is accomplished through conservation easements that restrict development rights but allow livestock production to continue (Morrisette 2001; Alexander & Propst 2002). This approach is becoming increasingly popular, especially among nongovernmental organizations such as The Nature Conservancy and state and local land trust groups (Morrisette 2001). To date, more than 1200 land trusts in the United States have protected over 1 million ha of land through conservation easements (Land Trust Alliance 2001).

Underlying this emerging response to biodiversity protection are some fundamental assumptions that have not been tested. First, it is assumed that biodiversity is better served on intact ranches than on land that is subdivided for rural residences (Morrisette 2001). Nongovernmental organizations continue working with ranchers even though there has been no scientific examination of this assumption. Additionally, some environmentalists argue that ranching is not compatible with the maintenance of native biodiversity in the West (Fleischner 1994; Wuerthner 1994). Second, this conservation approach is commonly used as a means by which to expand the size of nature reserves by buffering core reserve areas with private ranchlands (Morrisette 2001; Hansen & Rotella 2002). This assumes that a land-use gradient exists for biodiversity protection, in which nature reserves are the most effective, ranches the next most effective, and exurban developments the least effective for maintaining native biodiversity. Yet conservation planners acknowledge that biological resources on many existing nature reserves have been poorly inventoried (Groves et al. 2002), so the assumption that biodiversity is best protected on these lands may not be justified.

We examined biotic communities associated with these three types of land use to test the assumptions of this conservation strategy. We limited our study to avian, mesopredator, and plant communities because these groups contain many species with diverse life-history requirements, and they could be sampled reliably within our logistical constraints. We compared these three taxonomic groups along the gradient of intensifying human use from nature reserves to cattle ranches to exurban developments in one watershed.

Methods

Study Area and Sampling Design

We restricted our study to the north fork of the Cache la Poudre River watershed in northern Larimer County, Colorado (lat. 40°50′N, long. 105°15′W). The nearest metropolitan area, Fort Collins, is 40 km southeast of the watershed. The land-use matrix of the region is a mixture of private ranchland, nature reserves, and exurban developments. The plant community type is a mosaic of shrub and grassland, with some trees occurring on moister sites and higher elevations. Dominant grasses include needle-and-thread (*Hesperostipa comata*), blue grama (*Bouteloua gracilis*), western wheatgrass (*Pascopyrum smithii*), and cheatgrass (*Bromus tectorum*). Mountain mahogany (*Cercocarpus montanus*), skunkbush sumac (*Rhus trilobata*), and bitterbrush (*Purshia tridentata*) constitute most of the shrub overstory. Common forbs include fringed sage (*Artemisia frigida*) and hairy goldaster (*Heterotheca villosa*). Average annual precipitation ranges from 33 to 46 cm, with 75% of it falling between April and September (Moreland 1980).

In this watershed, we randomly located 93 points over 20,000 ha to sample avian, mesopredator, and plant communities among the three land-use types. To reduce confounding variables among points due to biophysical features (Hansen & Rotella 2002:1121), we limited sampling points to sites with the same shrub-grassland plant community type, elevations ranging between 1740 and 2200 m, and similar mixtures of soil type (Rocky Loam, Stony Loam, Loamy Foothill Range sites) (Moreland 1980). Also, points were randomly located on areas that met the following criteria: >75 m from riparian areas, <35% slope, >20 m from built structures and roads, and >300 m from the next nearest sampling point. The 93 points covered two nature reserves (n = 30), three ranches (n = 30), and two exurban developments (n = 33). These seven sites constituted our replicates of land-use type.

Nature reserves were Wildlife Areas of the Colorado Division of Wildlife that were protected 18 and 33 years prior to our study. These lands were used principally for wildlife protection and outdoor recreation, with livestock grazing, logging, mining, and water development activities prohibited. Management activities on reserves were primarily custodial, restricted largely to road and fence maintenance.

Ranches were privately owned and used for cattle production, with grazing managed through deferred-rotation systems. Although specific grazing intensities on these ranches were not obtained, visual inspections of forage utilization suggested that all three ranches were moderately grazed. These areas have been in livestock production for >100 years.

Exurban developments have been built up over the last 25 years, the average house age being 9 years (range: 1–25). The average lot size per house was 16 ha (range: 14–20), with 93% of the houses being used for year-round residences. The amount of forage utilization varied from no livestock use to high-intensity grazing, with 72% of homeowners having at least one grazing animal (e.g., horses).

Avian Sampling

We surveyed birds at the 93 sampling points four times, twice during each of the breeding seasons (mid-May to mid-June) in 2000 and 2001. We conducted 75-m fixed-radius point counts to record bird species detected visually or aurally and the distance, in meters, to those detections. We collected distance data to obtain detectability-based density estimates, which are more reliable than traditional index counts and provide a more valid basis for inference (Rosenstock et al. 2002). Point counts were 8 minutes long, with an initial 30-second quiet period, and were conducted within a 3-hour period after sunrise. Birds that flushed upon arrival on or departure from the point and within the 75-m radius were recorded as being at the station (Ralph et al. 1995). Surveys were not conducted when it rained or when wind was >3 (19.3 km/h) on the Beaufort wind strength scale. The same observer conducted all point counts and was extensively trained in bird identification and distance estimation prior to sampling.

Mesopredator Sampling

We monitored scent stations to record the presence of medium-sized mammalian predators at each of the 93 avian sampling points between May and August of 2000 and 2001. We established scent stations by clearing vegetation, rocks, and other debris from a circle of ground 1 m in diameter (Linhart & Knowlton 1975). Soil from within that station was sifted with a 2-mm-mesh screen to create a uniform tracking surface approximately 0.5 cm thick (Roughton & Sweeny 1982; Andelt & Woolley 1996). In 2000, one fatty acid scent tablet (scented predator survey disks; Pocatello Supply Depot, Pocatello, Idaho) was placed in the center of the station as an attractant, and each station was monitored for one 4-day period. In 2001 each station was again monitored for one 4-day period, but we used a fatty acid scent tablet the first day and a perforated can of tuna (170 g) the next 3 days. Tuna cans, with labels removed, were secured to the center of the station with a 14-cm nail. Stations were examined daily for the presence of mesopredator tracks. We identified tracks left in the soil using field guides by Murie (1974) and Halfpenny and Biesiot (1986). We re-established and monitored stations for an additional day if weather or excessive use rendered them unreadable. Mesopredators observed at or near a scent station during predator sampling were recorded as being present at that point.

Vegetation Sampling

We used a modified version of the Daubenmire cover method to sample plant communities between late June and mid-July of 2001 (Daubenmire 1959). Because we kept our sampling within this period of peak plant biomass, we were only able to survey 69 points (23 per land use) of the original 93 avian and mesopredator points. Thirty-meter transects were established in the four cardinal directions (N, S, E, W) radiating out from each sampling point (no transects intersected gardens, non-native lawns, ornamental landscaping, irrigated pastures, or built structures). Sampling occurred within 20 × 50 cm microplots placed on the left side of each transect at 10, 20, and 30 m from the point, for a total of 12 microplots per point. Canopy coverage (i.e., cover) of individual plant species, as well as percentages of rock, litter, and bare ground, were estimated to the nearest percent within each microplot. Lichens were not recorded separately, and sedges (*Carex* spp.) and mosses were not identified to the species level. A trained plant taxonomist made all cover estimates, while another observer recorded the data to reduce observer bias. Plants that could not be identified in the field were collected and identified in the herbarium at Colorado State University. Less than 1% of species encountered could not be identified and were categorized as unknown.

Statistical Analyses

We used distance sampling data and the program Distance 3.5 to estimate bird densities (birds/ha) for species that had reliable detection functions (Thomas et al. 1998). We selected models for detection functions by using Akaike's information criterion (AIC) and by inspecting probability density functions and chi-square goodness-of-fit statistics (Buckland et al. 1993). If more than one model seemed plausible, we model-averaged density estimates to reduce bias associated with estimates from a single selected best model (Burnham & Anderson 1998). We calculated final density estimates for bird species for each study site and compared means using one-way analysis of variance (PROC GLM, SAS Institute 1999). We conducted pairwise comparisons of individual means by the least-significant-difference (LSD) method when the overall F test was significant ($p < 0.10$). Confidence intervals were log-based because the density parameter was strictly >0, and the sampling distribution was assumed to be log normal (Burnham et al. 1987).

We used data collected from scent stations during each 4-day sampling period to estimate the proportion of points visited by mesopredator species within each land-use category. To test for statistical differences among these detection frequencies, we used Fisher's exact test (PROC FREQ, SAS Institute 1999). We also used Fisher's exact test to conduct pairwise comparisons of proportions if the overall test was statistically significant ($p < 0.10$).

For plant communities, we calculated the average cover and species richness for the microplots surveyed. We used one-way analysis of variance to test for statistical differences in cover and species richness across types of land use (PROC GLM, SAS Institute 1999). When the overall F test was significant ($p < 0.10$), we conducted a least-significant-difference means comparison. To meet assumptions of normality and homogeneity of variances, data were square-root transformed for analysis, but results are presented in the original scale. An $\alpha = 0.10$ was established a priori for all analyses to decrease the probability of committing a Type II error.

Results

Avian Communities

We made a total of 4964 detections of 58 different bird species over two field seasons, with 39 species detected on reserves, 41 on ranches, and 52 on exurban areas. We were able to generate reliable density estimates for 17 of these species based on the total number of individuals recorded and detectability models. Seven species reached their greatest densities on exurban developments ($p < 0.02$) (Fig. 1). Six species reached their greatest densities on ranches, reserves, or both of these

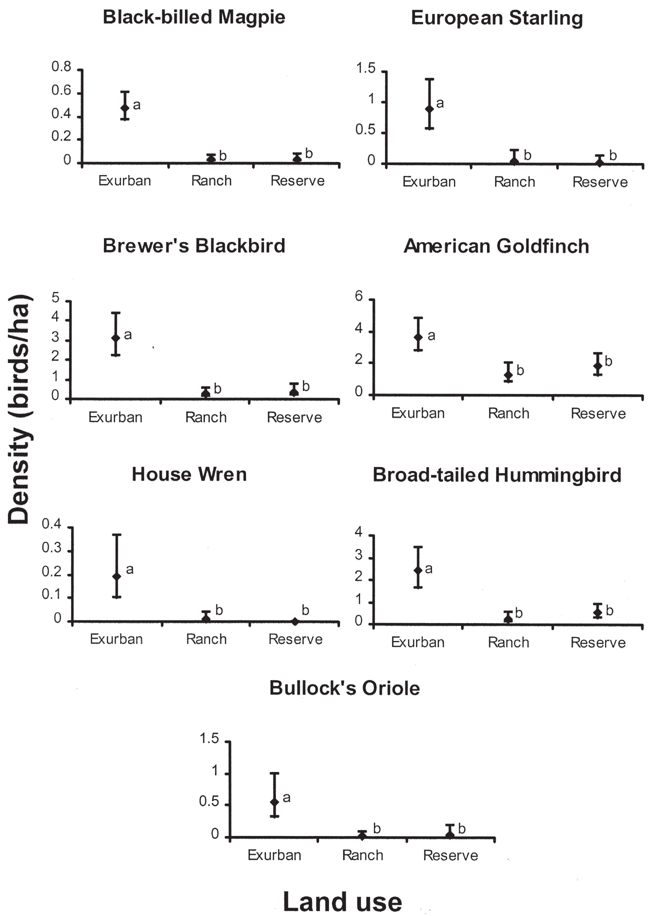

Figure 1. *Densities and 90% log-based confidence intervals of bird species that reached their greatest densities on land used for exurban development. Different letters next to density estimates indicate a statistically significant difference at the 0.10 level.*

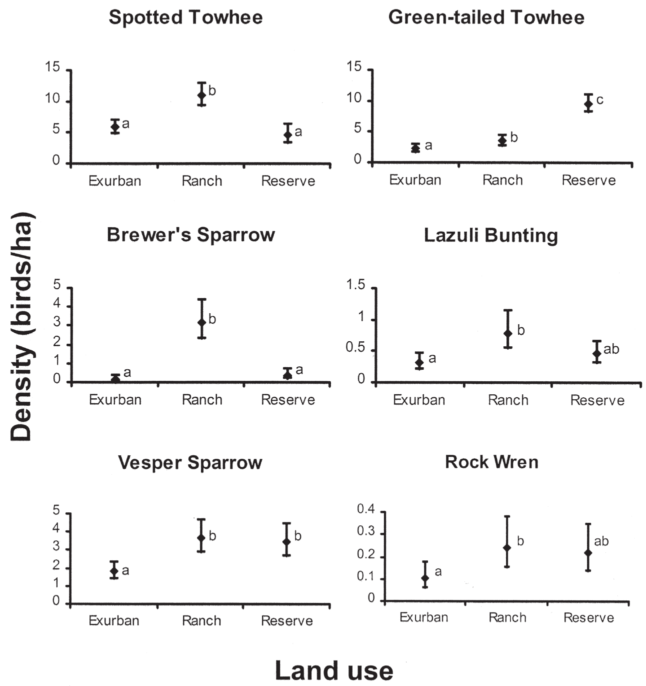

Figure 2. *Densities plus 90% log-based confidence intervals of bird species that reached their greatest densities on land used for ranching or reserves. Different letters next to density estimates indicate a statistically significant difference at the 0.10 level.*

types of land use ($p < 0.015$) (Fig. 2). The Lark Sparrow (*Chondestes grammacus*), Western Meadowlark (*Sturnella neglecta*), and Mourning Dove (*Zenaida macroura*) reached their greatest densities on ranches and exurban developments ($p < 0.03$). No statistical difference among sites was observed for the Brown-headed Cowbird (*Molothrus ater*) ($p = 0.50$). Although we could not obtain reliable density estimates for many species, it is worth noting that some species occurred on only one type of land use (Table 1).

Table 1. Bird species detected on only one of the types of land use in the north fork of the Cache la Poudre River watershed, Colorado.*

Species	*Presence of species by land use (+)* Exurban	Ranch	Reserve
House Finch (*Carpodacus mexicanus*)	+		
Red-winged Blackbird (*Agelaius phoeniceus*)	+		
Common Raven (*Corvus corax*)	+		
Mountain Chickadee (*Parus gambeli*)	+		
Say's Phoebe (*Sayornis saya*)	+		
White-crowned Sparrow (*Zonotrichia leucophyrs*)	+		
Killdeer (*Charadrius vociferus*)	+		
Eastern Kingbird (*Tyrannus tyrannus*)	+		
Lewis' Woodpecker (*Melanerpes lewis*)	+		
Lark Bunting (*Calamospiza melanocorys*)		+	
Horned Lark (*Eremophila alpestris*)		+	
Savannah Sparrow (*Passerculus sandwichensis*)			+

** Each species was detected <12 times, so we could not obtain reliable density estimates.*

Mesopredator Communities

We detected coyotes, bobcats (*Lynx rufus*), red foxes (*Vulpes vulpes*), striped skunks (*Mephitis mephitis*), domestic dogs, and house cats at scent stations over the two field seasons of sampling. Red foxes (two detections on ranches, one on a reserve) and striped skunks

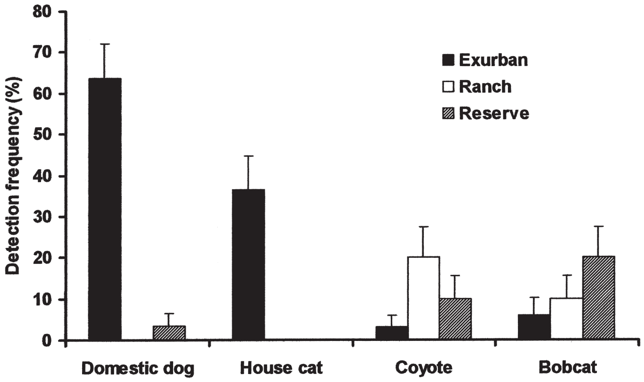

Figure 3. Frequencies (+SE) of mesopredator detections at scent stations surveyed on exurban developments, ranches, and reserves.

(two detections on ranches) were not detected often enough to allow valid statistical analyses.

Detections of domestic dogs differed among the three land-use categories ($p < 0.001$) (Fig. 3). Dogs were detected more frequently on exurban developments than either ranches or reserves (both $p < 0.001$). House cats were detected only on exurban developments ($p < 0.001$). Detections of coyotes differed statistically among the three types of land use ($p = 0.093$). Detection frequencies were higher on ranches ($p = 0.047$) than exurban developments but did not differ between ranches and reserves ($p = 0.472$) or reserves and exurban areas ($p = 0.340$). Detection frequencies of bobcats did not differ statistically across types of land use ($p = 0.262$).

Plant Communities

We identified 162 plant species among the three types of land use, 26 of which were non-native species. Cumulatively, land in exurban development had the greatest number of non-native species (Fig. 4). Mean non-native species richness and cover were higher on exurban developments and reserves than on ranches ($p < 0.03$) (Table 2). Mean native species richness was higher on ranches than on exurban developments ($p = 0.096$) and reserves ($p = 0.038$), but cover of native species did not differ among types of land use ($p = 0.204$) (Table 2).

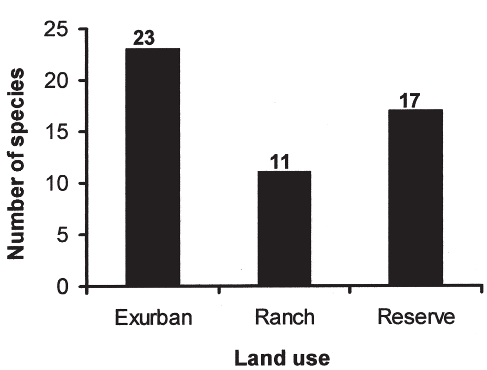

Figure 4. Cumulative number of non-native plant species by land use. The same number of microplots (n = 276) were sampled on exurban developments, ranches, and reserves.

Table 2. Mean species richness and percent cover of native and non-native plants among types of rural land use in northern Colorado.*

	Mean no. of species		*Mean percentage cover*	
Land use	*native (SE)*	*non-native (SE)*	*native (SE)*	*non-native (SE)*
Exurban	24.4a (1.0)	4.7a (0.4)	72.0a (3.7)	26.8a (3.7)
Ranch	27.0b (1.0)	3.2b (0.3)	80.4a (3.7)	17.0b (4.1)
Reserve	23.9a (1.2)	4.5a (0.5)	75.6a (2.3)	28.4a (2.4)

**Letters next to the means within a column represent the results of pairwise comparisons using the least-significant-difference method after conducting a one-way analysis of variance. Different letters indicate statistically significant differences at the 0.10 level.*

Examining plant cover by life form revealed that ranches had the lowest forb cover ($p < 0.10$). However, ranchlands had the lowest cover of non-native grasses ($p < 0.03$) and lower cover of non-native forbs than exurban areas ($p = 0.009$) (Table 3). The dominant non-native plant, cheatgrass, differed in cover among types of land use ($p = 0.009$); cover was higher on reserves ($p = 0.002$) and exurban developments ($p = 0.050$) than on ranches.

Discussion

Our results indicate that biotic communities differ along the rural land-use gradient. Exurban developments supported greater densities of tree-nesting and human-commensal bird species (Fig. 1) and elevated numbers of domestic mammalian predators (Fig. 3). Reserves and ranches, however, had increased densities of ground and shrub-nesting bird species (Fig. 2) and virtually no domestic mesopredators (Fig. 3). Ranchlands differed from both reserves and exurban areas in that their plant communities contained a smaller proportion of non-native species (Table 2). These patterns have ecologically plausible explanations and ramifications that are supported by previous research and species life-history information.

Bird species with elevated densities on exurban developments have likely responded to human-provisioned resources on those landscapes that were mostly absent from reserves and ranches. Bird feeders were common on exurban developments, which may allow some spe-

Table 3. Mean percent cover (±SE) of native and non-native plants by life form among types of rural land use.[a]

	Forb cover		*Grass cover*		*Shrub cover[b]*
Land use	*native*	*non-native*	*native*	*non-native*	*native*
Exurban	26.1a (2.3)	5.8a (1.4)	27.1a (2.0)	21.0a (3.3)	18.8a (2.3)
Ranch	24.0a (1.7)	2.2b (0.4)	36.9b (3.1)	14.8b (4.0)	19.6a (1.6)
Reserve	30.2b (1.5)	3.8ab (0.9)	30.9ab (1.7)	24.6a (1.9)	14.5a (1.8)

[a] *Letters next to the means within a column represent the results of pairwise comparisons using the least-significant-difference method after conducting a one-way analysis of variance. Different letters indicate statistically significant differences at the 0.10 level.*
[b] *No non-native shrubs were detected.*

cies such as the Broad-tailed Hummingbird (*Selasphorus platycercus*) to reach larger populations (Calder & Calder 1992). Artificial nest boxes erected throughout exurban developments may promote occupancy by cavity-nesters, such as the European Starling (*Sturnus vulgaris*) and House Wren (*Troglodytes aedon*) (Cabe 1993; Johnson 1998). Deciduous trees used for landscaping near houses may provide the vertical habitat structure, otherwise missing from this shrub-grassland plant community, for tree-nesting birds such as the Bullock's Oriole (*Icterus bullockii*) (Barrett 1998). Finally, human garbage and waste from horses and other pets may attract species such as the Black-billed Magpie (*Pica hudsonia*) and Brewer's Blackbird (*Euphagus cyanocephalus*), allowing them to occur at elevated densities (Marzluff et al. 1994). Similar opportunistic and human-commensal bird species are known to reach elevated abundances in urban and suburban areas (Emlen 1974; Beissinger & Osborne 1982; Mills et al. 1989; Blair 1996), but further research is needed to understand how human alterations of landscapes allow these species to proliferate.

Patterns we observed in the mesopredator communities are consistent with the findings of other studies conducted on exurban developments. Domestic dogs and house cats used exurban areas almost exclusively, whereas coyotes were most common on ranchlands (Fig. 3). Odell and Knight (2001) recorded fewer coyotes and red foxes but more dogs and cats on exurban developments than on undeveloped lands. In central New Mexico, gray foxes (*Urocyon cinereoargenteous*) were tolerant of exurban developments with housing densities up to one house per 0.8–2 ha; beyond this threshold they avoided developments (Harrison 1997). Gray foxes also exhibited temporal avoidance of exurban developments. They used developments less during daytime and undeveloped areas more at nighttime, possibly because of the increased presence of dogs on developments during daytime (Harrison 1997). Although bobcats in our study showed no statistical difference among types of land use, detection frequencies were higher on the less intensive types (Fig. 3). This corroborates the results of a survey of exurban homeowners that reported bobcats being seen frequently near houses in developments but more often near undeveloped areas (Harrison 1998).

Elevated populations of human-commensal species on residential developments can be detrimental to other species (Marzluff et al. 1998). For instance, the Black-billed Magpie is a nest predator that may lower the reproductive success of other birds in an area. The Blue Jay (*Cyanocitta cristata*), a similar nest predator, has been shown to increase in numbers with urbanization and contribute to the decline of the endangered Golden-cheeked Warbler (*Dendroica chrysoparia*) (Engels & Sexton 1994). House cats and domestic dogs are subsidized mesopredators that can extend the realm of human influence and have negative impacts on wildlife populations (Churcher & Lawton 1987; Miller et al. 2001). House cats, in particular, have been implicated in the decline and extinction of scrub-breeding songbirds by two studies in California (Hawkins 1998; Crooks & Soulé 1999). Demographic evidence suggests that the long-term effect of increasing exurbanization could be added conservation problems caused by an escalating rate of expansion among opportunistic species and declining populations among sensitive species (Hansen et al. 2002).

We documented increased richness and cover of non-native plant species on exurban areas and reserves (Tables 2 & 3; Fig. 4). Human activities can change plant communities by accidentally or deliberately introducing invasive and non-native species (Mack et al. 2000). On exurban developments, disturbances caused by the construction of houses, roads, trails, or overgrazing by domestic animals may result in the increased prevalence of non-native plants. Roads and trails, in particular, are well recognized as corridors for the spread of non-native flora (Tyser & Worley 1992). Our nature reserves had few roads, but the trail systems were quite extensive and popular among motorized and nonmotorized recreationists, which may have helped spread non-native species.

Non-native plants can alter ecosystem dynamics by disrupting ecological processes and degrading the quality of wildlife habitat (Trammell & Butler 1995; Mack & D'Antonio 1998; Masters & Sheley 2001). For instance, cheatgrass proliferation in the Rocky Mountain West has altered historic fire regimes, favoring non-native, annual grasslands over native, perennial species. This invasive plant has displaced native plants and altered the occurrence of shrub-obligate songbirds that utilize these ecosystems (Rotenberry 1998). In our watershed, cheatgrass was more prevalent on reserves and exurban areas than on ranches. Also, 8 of 23 non-native plant species found on exurban developments were unique to that type of land use. Two of these species, spotted knapweed (*Centaurea maculosa*) and leafy spurge (*Euphorbia esula*), are noxious weeds that can lower the value of rangeland ecosystems, both ecologically and economically (Masters & Sheley 2001).

Finally, few bird species were completely absent from exurban areas (Table 1), but some ground and shrub-nesting bird species had elevated densities on land devoted to either ranching or reserves (Fig. 2). Previous studies indicate that floristic composition and structure are important factors associated with the distribution and abundance of these passerine species (Wiens & Rotenberry 1981; Knopf et al. 1990; Berry & Bock 1998). Brewer's Sparrows (*Spizella breweri*) reached higher densities on ranchlands than on either exurban areas or reserves, perhaps because of differences in habitat heterogeneity. Other factors may help determine species densities as well. For instance, Vesper Sparrows (*Pooecetes gramineus*) appeared sensitive to exurban development, which could be related to the elevated levels of human disturbance and increased numbers of avian and mammalian nest predators on developed areas. Demographic studies are needed to determine how these features affect population dynamics, especially for species of conservation concern such as the Vesper Sparrow and Brewer's Sparrow, which have shown long-term population declines across their ranges according to Breeding Bird Survey data (Sauer et al. 2001).

Our study was observational and was conducted in a single watershed, so inferences to other watersheds are not warranted. We assumed that sites had been in exurban development, ranching, or reserves long enough to help shape the communities we observed, but former types of land use can influence what species exist on a site. Both the reserves and the exurban developments had been in livestock ranching before their present uses. If these sites had been degraded through overgrazing before present uses, our results could be confounded. However, we observed several species of birds, predators, and plants that occurred solely on exurban developments, which suggests that, at a minimum, contemporary land uses influence what biodiversity exists on these sites. It is also important to note that our watershed is part of a region with a long evolutionary history of grazing, with factors such as climate playing more critical roles in determining plant community composition (Milchunas et al. 1988; Milchunas et al. 1990; Hart 2001).

Conservation Implications

Inferences beyond our watershed should be viewed as speculative but may serve to stimulate additional research. One generalization is that exurban developments promote non-native and human-commensal species, perhaps at the expense of other native species. Another generalization is that nature reserves may not protect biodiversity as well as they are assumed to. Both of these notions have implications for landscape-scale conservation and provide ecological justification for groups who work with private landowners to protect biodiversity.

Because privately owned ranches are often located on highly productive, low-elevation sites (Scott et al. 2001), development of these lands can be especially detrimental to wildlife. In the Greater Yellowstone Ecosystem, Hansen and Rotella (2002) showed that exurban developments occurred disproportionately close to bird hotspots. They also demonstrated that low-elevation lands serve as population sources for native bird species if they are not subdivided, but function as sinks when they are developed for rural residences. Exurban developments may have degraded habitat quality owing to human disturbance and invasive species and could operate as ecological traps, where wildlife assess land as suitable but, as a result of increased predation, competition, and parasitism, suffer reduced fitness when they attempt to reside there.

Because of biophysical factors and existing ecosystem conditions, nature reserves may currently be inadequate to fully protect biodiversity. Considering that most reserves occur on the least productive soils and at the highest elevations (Scott et al. 2001), it becomes apparent that these areas are biased toward the harsher environmental conditions. Furthermore, the population viability of some species on nature reserves could be threatened by the development of ranchlands because subpopulations on reserves rely on dispersal from undeveloped, low-elevation lands (Hansen & Rotella 2002). Reserves are often assumed to protect biodiversity, but our results suggest that reserves were somewhat ecologically degraded. Ranches can be more effective than reserves at maintaining native biotic communities in some instances, suggesting that the conversion of ranchland to exurban development has negative consequences that extend beyond administrative lines (Knight & Clark 1998; Hansen et al. 2002).

Cumulatively, these findings stress the relative importance of low-elevation ranchlands for conservation and support the emerging strategy for biodiversity protection. As private lands are increasingly converted to exurban development, the amount of low-quality habitat on western landscapes may become more prevalent and jeopardize the persistence of some species on private and public lands (Donovan & Thompson 2001; Hansen

& Rotella 2002). Efforts to protect the natural heritage of the Rocky Mountain West may require less reliance on nature reserves and a greater focus on private lands.

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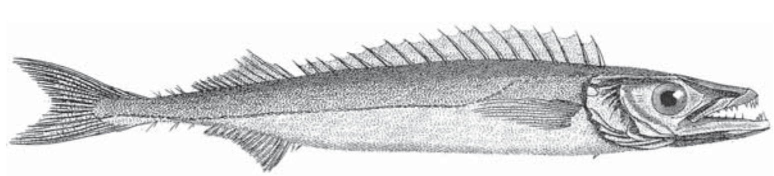

Attachment 10

Hansen et al. 2005

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EFFECTS OF EXURBAN DEVELOPMENT ON BIODIVERSITY: PATTERNS, MECHANISMS, AND RESEARCH NEEDS

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Abstract. Low-density rural home development is the fastest-growing form of land use in the United States since 1950. This "exurban" development (~6–25 homes/km^2) includes urban fringe development (UFD) on the periphery of cities and rural residential development (RRD) in rural areas attractive in natural amenities. This paper synthesizes current knowledge on the effects of UFD and RRD. We present two case studies and examine the patterns of biodiversity response and the ecological mechanisms that may underlie these responses. We found that many native species have reduced survival and reproduction near homes, and native species richness often drops with increased exurban densities. Exotic species, some human-adapted native species, and species from early successional stages often increase with exurban development. These relationships are sometimes nonlinear, with sharp thresholds in biodiversity response. These effects may be manifest for several decades following exurban development, so that biodiversity is likely still responding to the wave of exurban expansion that has occurred since 1950. The location of exurban development is often nonrandom relative to biodiversity because both are influenced by biophysical factors. Consequently, the effects on biodiversity may be disproportionately large relative to the area of exurban development. RRD is more likely than UFD to occur near public lands; hence it may have a larger influence on nature reserves and wilderness species. The ecological mechanisms that may underlie these responses involve alteration of habitat, ecological processes, biotic interactions, and increased human disturbance. Research on the patterns and mechanisms of biodiversity remains underdeveloped, and comparative and experimental studies are needed. Knowledge resulting from such studies will increase our ability to understand, manage, and mitigate negative impacts on biodiversity.

Key words: biodiversity; biotic interactions; ecological mechanisms; fire; habitat fragmentation; landscape management; land cover; land use; rural residential development; urban fringe development; weeds.

INTRODUCTION

Rural America is undergoing a dramatic transition. For the first time in more than a century, more people are moving to rural areas than from rural lands (Johnson 1998). Fleeing the cities, many retirees, entrepreneurs, and others are seeking the small-town lifestyles and natural amenities of rural landscapes (Rudzitis 1999). This rural in-migration is driving large changes in land use. The typical trajectory of land use change across the United States prior to 1950 was from wild land and resource extraction uses to agriculture and to suburban and urban uses. An entirely new land use has become prevalent in many parts of the United States since 1950. Many people are choosing to live "out of town" on small "ranchettes" and in rural subdivisions. Termed exurban development, low-density housing (~6–25 homes/km^2) within a landscape dominated by native vegetation is now the fastest growing form of land use in the United States (Brown et al. 2005). Land long used for forestry or ranching is now being converted to home sites. The effects of exurban development on native species and ecological communities have only recently been the topic of ecological studies.

Since 1950, there has been a five-fold increase in the area within the conterminous United States that is occupied at exurban densities (Brown et al. 2005). The

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PLATE 1. Rural residential development in the Greater Yellowstone Ecosystem near Red Lodge, Montana, USA. The rural homes are placed near low-elevation riparian forests that are especially important for biodiversity. Photo by A. Hansen.

exurban land use type currently covers nearly 25% of the area of the lower 48 states. The most rapid gains were in the eastern deciduous forest, the southwest, the western seaboard, the Rocky Mountains, and the upper Midwest.

This exurban development is manifest in two forms. Urban fringe development is the expansion of exurban densities on the periphery of cities. This urban fringe development (UFD) is largely driven by urban dwellers seeking more rural lifestyles while still having access to urban jobs and services (Ulmann 1954, Healy and Short 1987, Raish et al. 1997). Exurban development in counties adjacent to metropolitan counties increased six fold since 1950 (Brown et al. 2005). Over time, these exurban developments often transition to suburban and urban land uses.

A second form of exurban development is occurring distant from cities. It is focused on rural areas attractive in scenery, climate, outdoor recreation and other ''natural amenities'' (Rasker and Hansen 2000). Rural counties not adjacent to metropolitan counties increased fivefold in exurban area since 1950 (Brown et al. 2005). This rural residential development (RRD) is common in the rural counties of the Rocky Mountain West, the Pacific Northwest, the upper Midwest, and the southeastern United States (Gersh 1996). Rather than being randomly distributed, this development is often associated with the borders of national parks and other public lands; rivers, lakes, or coastal areas; areas of moderate climate and good outdoor recreational opportunities; and towns and small cities that offer national airports, high-speed internet access, and cultural amenities (Cromartie and Wardwell 1999, McGranahan 1999, Nelson 1999; see Plate 1).

The effects of both forms of exurban development on wildlife and biodiversity are poorly known. Relative to other types of land use, exurban development is substantially understudied. Miller and Hobbs (2002) found that only 6% of the papers on human landscapes published in *Conservation Biology* dealt with exurban and urban places. The majority of these consider the general gradient from rural to urban in and around cities. While these studies typically do not cleanly separate biodiversity in exurban places relative to suburban and urban places, they do provide a context for assessing general trends in biodiversity under land use intensification. RRD has been examined in only a few recent studies, with most of them being in the Rocky Mountain West.

Understanding the effects of exurban development on biodiversity is important to public policy. With a quarter of the nation's land area in this land use type, policies on exurban development may have a substantial effect on biodiversity nationwide. The general view among conservationists and the public is that exurban development alters ecological processes and biodiversity to a greater extent than forestry and agriculture (Marzluff and Ewing 2001). Hence, many initiatives have emerged to protect ''open space'' from exurban development through conservation easements and other approaches. There is also the view that the effects of exurban development are proportional to home density. Thus, zoning for lower density housing is often used to protect ecological resources.

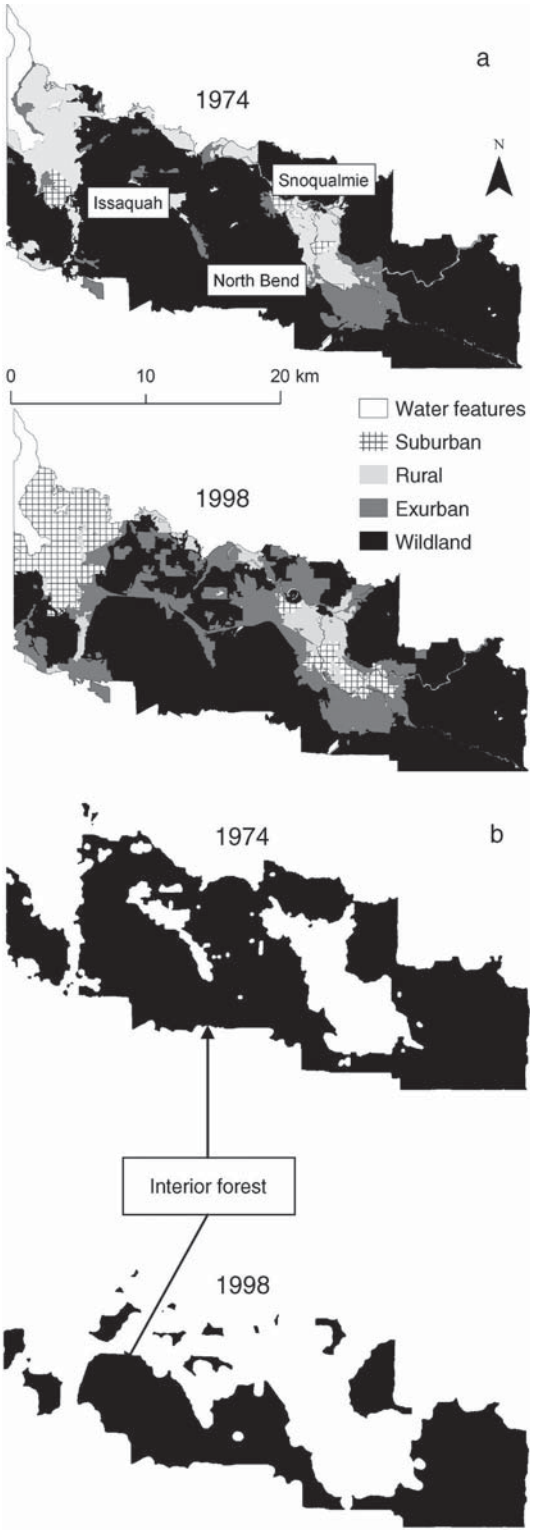

FIG. 1. (a) Change in land use in the urban fringe east of Seattle, Washington, USA. (b) Decline in interior forest resulting from changes in land use. The figure is from Robinson et al. (2005).

Several questions arise. How does exurban development change habitat and landscape patterns from those typical of lower intensity land uses? How do ecosystem, community, and population-level patterns vary as more natural habitats are converted to exurban? Are there thresholds in home density and spatial pattern where biodiversity is disproportionately affected? What ecological mechanisms underlie the response of biodiversity to exurban development? Can exurban development on private lands have consequences on adjacent or distant public lands? How do the effects of UFD and RRD compare?

In this paper, we synthesize current knowledge and attempt to answer these questions. We do so by first examining UFD and RRD and offer a case study of each. We then consider the ecological mechanisms linking both forms of exurban development to biodiversity. Where current research is insufficient to address the questions, we offer hypotheses in an effort to stimulate future research.

URBAN FRINGE DEVELOPMENT AND BIODIVERSITY

Case study: Seattle, Washington

The city of Seattle, in King County, Washington, lies between the Puget Sound and the Cascades Mountains. Like many metropolitan counties on the west coast, King County has been growing rapidly. The population size increased by 44% during 1970–2000 and the number of households grew by 72%. In an attempt to control sprawl around the city, the county instituted an urban growth policy aimed at confining high density development within urban growth boundaries while maintaining low-density housing in the surrounding rural lands. Robinson et al. (2005) quantified change in land use during 1974–1998 in a 474-km^2 study area extending east from Seattle towards the Cascade Mountains. The study area was a matrix of forest lands with dispersed agricultural, suburban, and urban, land uses.

The authors found that the primary trajectories of change were from wildlands to exurban and from exurban and agricultural to suburban. The area of exurban increased by 193%. Exurban and suburban covered 8% of the study area in 1974 and 33% in 1998 (Fig. 1a). The reduction of wildland and agricultural lands represents the conversion of 23% of the study area to development. These changes fragmented once contiguous forest and reduced interior forest area (>200 m from forest edge) by 60% (Fig. 1b). This land use change was largely driven by single-family housing. Despite the effort to concentrate growth within the urban growth boundary, 60% of the land committed to new residential development was outside urban growth boundaries.

This land conversion on Seattle's fringe changed plant, bird, and small mammal diversity. Native forb and tree diversity declined with loss of forest (Fig. 2a). A similar, but nonsignificant trend, was found for

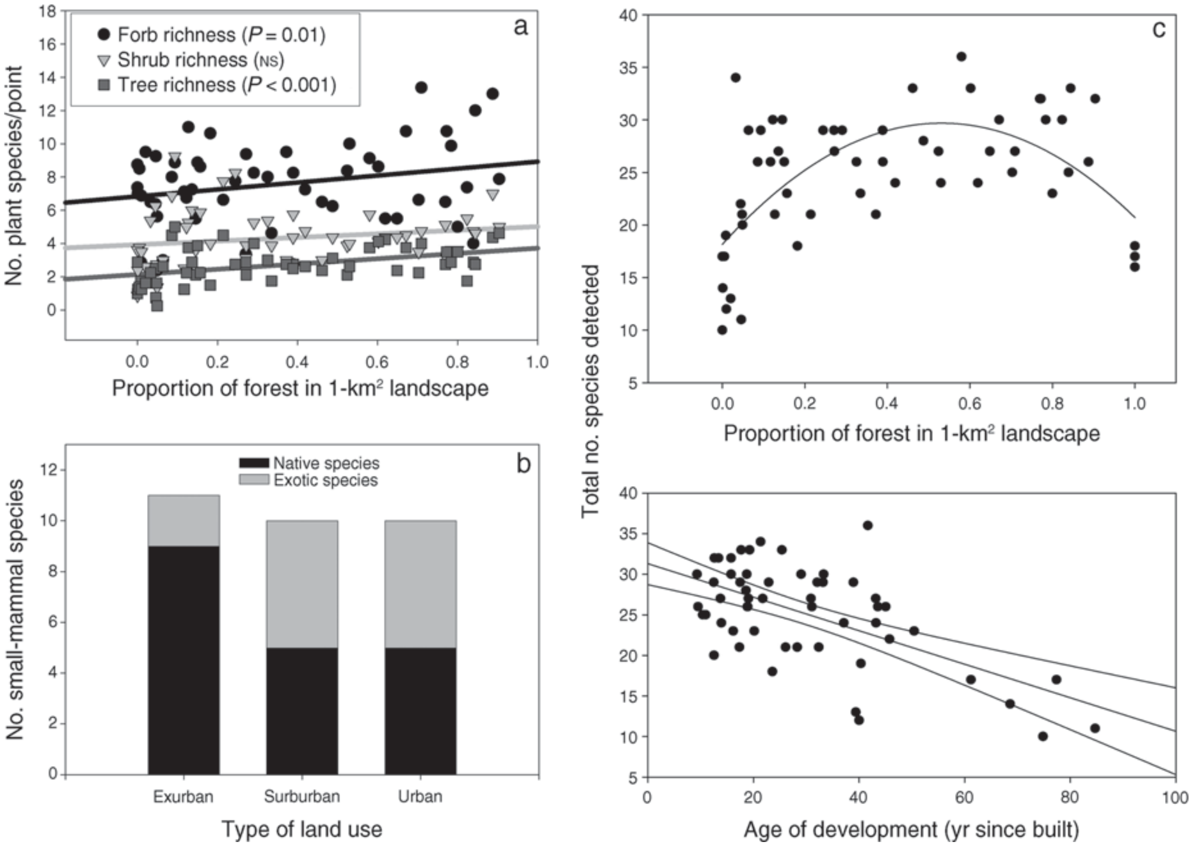

FIG. 2. Changes in biodiversity in response to urban sprawl in the Seattle metropolitan area. (a) Increases in plant species richness with increasing forest land cover. (b) Shifting composition of small mammal communities. (c) Correlation of bird species richness with amount of forest (upper panel) and age of development (lower panel). Bird data are from Donnelly (2002), Donnelly and Marzluff (2004), and Marzluff (*in press*).

shrubs. Alternatively, exotic ground cover increased significantly with development, especially with the interaction between age of development and interspersion of settled and forested remnants. The trends for plants were relatively linear. Small mammal communities changed abruptly from primarily native to mixtures of natives and exotics as landscapes were converted from exurban to suburban or urban (Fig. 2b). Bird species richness in combined samples of forest fragments and settled areas peaked at levels of settlement found in most single-family housing subdivisions (Fig. 2c). It dropped dramatically when development reached a threshold of approximately 80% developed, and when mature, second growth, coniferous forest cover occupied the entire 1-km² landscape (i.e., in relatively large forested reserves; Marzluff, *in press*). The peak in landscapes where forest and settlement are both abundant in the landscape occurs primarily because of colonization of early successional and deciduous forest species (Marzluff, *in press*). Native forest birds are predictably and linearly lost with increasing urbanization (Donnelly 2002, Donnelly and Marzluff 2004). Synanthropic birds, those ecologically associated with humans, predictably colonize landscapes as urban land cover increases. Species richness was also related to age of development, with bird species richness continuing to decrease more than 60 years after development. Average bird species richness dropped from about 35 at the time of development to below 15 by 80 years after development. This drop is accentuated by concomitant loss of forest cover with subdivision age in the sample, but additional research of similarly forested, but variously aged subdivisions confirms a general, but less extensive loss of species (Ianni 2004). Species diversity declines as subdivisions age because of losses in native mature forest birds and native birds not typically found in mature forests that colonized the openings, grasslands, ponds, and deciduous forest characteristic of new subdivisions. The loss of bird species was not explained by poor reproductive success. Nest success remained relatively high in developed study plots for all the bird guilds studied, but the numbers of active nests were greatly reduced in densely settled areas (Donnelly and Marzluff 2004). The authors concluded that the reduction in richness was primarily due to the loss of species dependent upon forest habitats,

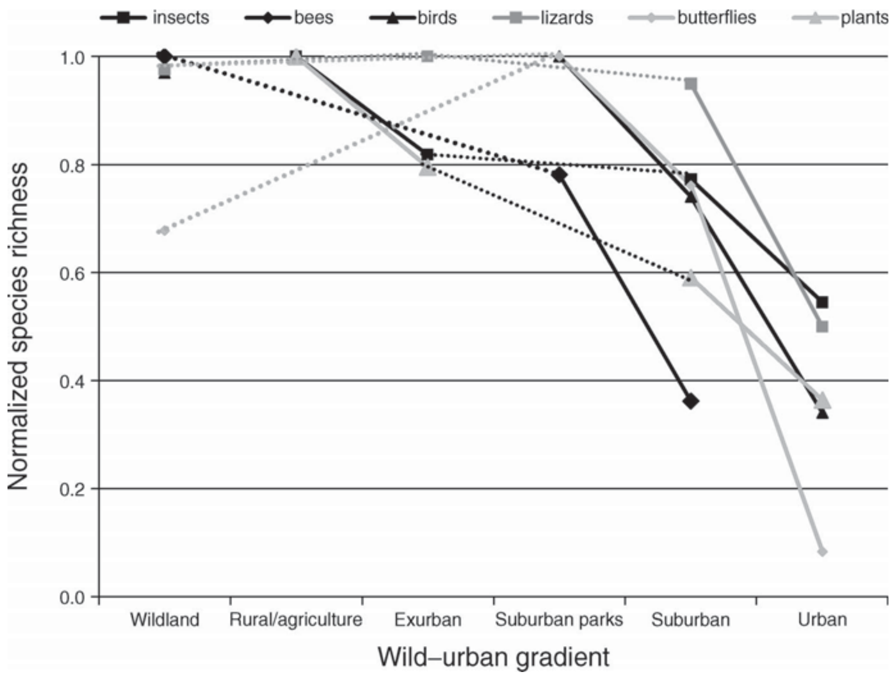

FIG. 3. Distribution of species richness across a gradient in land use for studies of various organisms. Normalized species richness is calculated as a function of the maximum number of recorded species at a point on the development gradient. Dashed lines represent unsampled portions of the gradient. Sources: insects, Denys and Schmidt (1998); bees, McIntyre and Hostetler (2001); birds, Blair (1996); lizards, Germaine et al. (1998); butterflies, Blair (1999); plants, Denys and Schmidt (1998).

rather than to increased predation levels. Reduced survival of adults and newly fledged birds is a potential factor currently being studied.

General biodiversity responses to land use intensification on the urban fringe

The results above are consistent with the growing body of literature finding that the quantity and pattern of urban fringe development strongly influence both native and nonnative flora and fauna. The responses at the community level are a function of species response patterns, which are in turn a function of the demographic responses of individual organisms (Marzluff and Ewing 2001).

Community patterns.—For many plant and animal communities, species richness decreases as housing density increases along the rural–urban gradient. The literature abounds with examples for arthropods (Miyashita 1998), insects (Denys and Schmidt 1998), and amphibians (Lehtinen et al. 1999) (Fig. 3). Along a gradient from wild and undeveloped parks around the outskirts of Phoenix, Arizona, to residential sites in the city, both richness and abundance of pollinator bees (*Hymenoptera: Apoidea*) decreased markedly (McIntyre and Hostetler 2001). Similar results were documented in Tucson, Arizona, for native bird guilds, as housing density best explained the decrease in species richness along the rural–urban gradient (Germaine et al.1998). For native rodents in protected grasslands in Boulder, Colorado, the capture rate exhibited a strong negative relationship with the percentage of surrounding suburbanization (Bock et al. 2002).

While native species often decrease in diversity and abundance along the rural–urban gradient, the opposite is often true for nonnative guilds. In the Tucson study, housing density best explained the increase in species richness for nonnative birds (Germaine et al. 1998). Within plant communities in Ohio, the percentage of nonnative species increased along the rural–urban gradient (Whitney 1985).

Because of these contrasting biodiversity response patterns along the rural–urban gradient, community richness sometimes exhibits a non-linear response in which richness peaks at intermediate levels of development (McKinney 2002). Avian and butterfly richness and diversity were both higher at moderate levels of development than in natural reserves in various sites in California and Ohio (Blair 1996, 1999). Lizard abundance, richness, and evenness all peaked at intermediate levels of development in Tucson, Arizona (Germaine and Wakeling 2001). In shoreline cottage development in central Ontario, moderate levels of development supported the highest levels of small mammal diversity (Racey and Euler 1982).

A recent meta-analysis of avian community response patterns to increasing urbanization (Marzluff 2001) confirmed the patterns emerging from the individual studies summarized above. He found that richness decreased in 61% and evenness decreased in 56% of the studies (Marzluff 2001). Over 90% of the surveyed studies documented either an increase in exotic species or a decrease in interior habitat nesters with increasing settlement.

An important conclusion from the Seattle case study is that the biodiversity response to urbanization may continue to intensify for several decades after development (Donnelly 2002, Ianni 2004). Thus in the rapidly growing cities of the United States, the full effects of recent development are likely not yet fully manifest and native biodiversity will continue to erode for decades to come.

Species patterns.—The response patterns of individual species to the rural–urban gradient are complex and account for the variety of responses at the community level. Many species decline in abundance with increased intensity of land use. Of 21 species recorded at a nature reserve in Santa Clara County, California, only 14 of these species also occurred at a nearby recreation area, and only three of these species were also found at the most urbanized site (Blair 1996). The species found only in the nature reserves were all natives including Western Wood-pewee (*Contopus sordidulus*), Hutton's Vireo (*Vireo huttoni*), and Ash-throated Flycatcher (*Myiarchus cinerascens*). Other examples of species that are negatively correlated with development levels come from central Ontario where the masked shrew (*Sorex cinereus*), deer mouse (*Peromyscus maniculatus*), red-backed vole (*Clethrionomys gapperi*), and woodland jumping mouse (*Napeozapus insignis*) all decreased in abundance with increasing shoreline cottage development (Racey and Euler 1981).

Other species are able to tolerate and even increase under higher levels of development (Hoffman and Gottschang 1997). Higher densities of nesting Cooper's Hawks (*Accipiter cooperii*) were recorded in urban settings compared to rural settings in and around Tucson, Arizona (Boal and Mannan 1998). Schneider and Wasel (2000) found that the density of moose (*Alces alces*) in northern Alberta, Canada, increased near human settlement. Similarly, Racey and Euler (1982) observed increased capture success with increasing development level for eastern chipmunk (*Tamias striatus*), red squirrel (*Tamiasciurus hudsonicus*), and meadow vole (*Microtus pennsylvanicus*). Several other studies have documented a suite of common bird and mammal species that increase in abundance along the rural to urban gradient. Examples include the House Sparrow (*Passer domesticus*), European Starling (*Sturnus vulgaris*), American Crow (*Corvus brachyrhyncos*), Brown-headed Cowbird (*Molothrus ater*), skunk (*Mephitis mephitus*), raccoon (*Procyon lotor*), and opossum (*Didelphis virginiana*) (Odell and Knight 2001).

The relationship between species abundance and urbanization is often not linear; many species are most abundant at intermediate levels of development, as demonstrated by Blair (1996). Gray foxes (*Urocyon cinereoargenteus*) in several rural communities in New Mexico were found to be tolerant of RRD up to a threshold of 50–125 homes/km^2 (Harrison 1997). A similar nonlinear response was also documented for abundance of mule deer (*Odocoileus* spp.) in an urbanizing valley in southwest Montana (Vogel 1989). Short-tailed shrews (*Blarina brevicauda*) were documented to peak at intermediate lakeshore cottage development levels in central Ontario (Racey and Euler 1982).

The life history attributes of species that avoid or expand with urbanization are not well studied. McKinney (2002) suggested that many human-sensitive species include large mammals with low reproductive rates, birds specializing on natural habitats, and late successional plants. Species most abundant in suburbs may be edge-adapted generalists able to exploit the wider variety of habitat configurations and resources available at intermediate levels of development. Species associated with urban areas may be preadapated to human structures or able to use human-derived food or water supplies (McKinney 2002). However, more study is needed to evaluate these hypotheses.

Demographic patterns.—Patterns of reproduction, survival, and dispersal are drivers for species and community responses to exurban development, yet relatively few studies have quantified population vitality rates across the development gradient. Marzluff (2001) reviewed the literature for results of urbanization on avian breeding success. He found that most studies dealt with species that were most abundant in cities. For these species, breeding success improved with increased settlement. For other species however, research on bird nesting success indicated a negative relationship with increasing development. The abundance of human development was found to be the strongest predictor of brood parasitism by brown-headed cowbirds and reduced nest success of several species such as Yellow Warbler (*Dendroica petchia*) (Tewksbury et al. 1998).

In sum, three general patterns of species abundances emerge along the gradient from rural to urban: decreases, increases, and nonlinear responses (McKinney 2002). Species that decrease in abundance along the development gradient are termed ''human sensitive'' (Odell and Knight 2001) or ''urban avoiders'' (McKinney 2002). Species that increase are termed ''human adapted'' (Odell and Knight 2001) or ''urban adapted'' and ''urban exploiters'' (McKinney 2002). ''Suburban adaptables'' (Blair 1996) reach peak abundance at intermediate levels of development. At the community level, richness for native species generally decreases with increasing development while richness for nonnative species generally increases with increasing development. As a result, total community diversity often peaks at intermediate levels of development, because both native and nonnative species are present in the community (Marzluff, *in press*). The life history traits of individual species, native and nonnative, likely contribute to the variety of responses at the population and community levels.

Rural Residential Development and Biodiversity

Case study: Colorado

Colorado is representative of much of the new West. Growing at three times the nation's average, it was the sixth-fastest growing state in the United States in the 1990s (Knight 1998). Importantly, this population growth is occurring on rural landscapes as well as within urban areas. Indeed, from 1990 to 1998, population in rural areas grew faster than in urban areas in over 60% of the counties in the Rocky Mountain states (Theobald 2001, Odell et al. 2003).

In much of the Mountain West, there are three principal land uses beyond city limits: protected areas, ranches, and ranchettes. Maestas et al. (2003) examined songbirds, carnivores, and plant communities on these three land uses in Larimer County, Colorado. Importantly, their data came from sites that were similar in elevation, soil type, and plant community type. They found that the density of songbirds and carnivores were more similar between ranches and protected areas (without livestock grazing) than on the ranchettes. The songbirds and carnivores that were most abundant on the ranchettes included dogs, cats, Black-billed Magpies, European Starlings, and other human-adapted species. Songbirds and carnivores that occurred on ranches and protected areas were uncommon or did not occur on land in ranchettes. Importantly, many of these songbirds are of conservation concern, whereas the birds that did best on ranchettes are common and increasing across the West (Maestas et al. 2003).

The plant communities across these three land uses were even more distinct. Native plant species were more prevalent and nonnative species were less prevalent on ranches than in either protected areas or ranchettes (Maestas et al. 2002). The greatest number of nonnative species was found on the ranchettes, with eight of 23 nonnative species being found only on the ranchette developments. In addition, percent cover of nonnative plants was highest on the ranchettes and protected areas and was significantly lower on ranches.

The effects of RRD are often manifest as a function of distance from home site and roads. In Pitkin County, Colorado, the biodiversity responses to ranchettes extended out as far as 330 m into undeveloped areas, although most effects diminished at approximately 100 m from the homes (Odell and Knight 2001). Human-adapted species, such as Brown-headed Cowbirds,

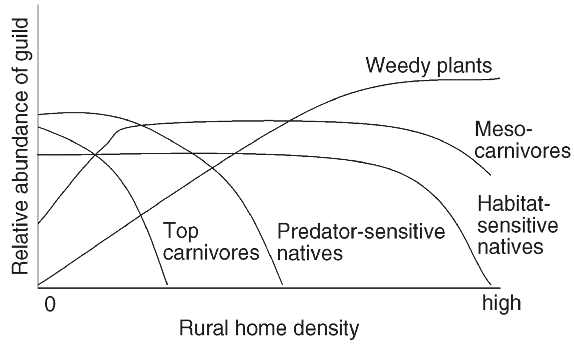

FIG. 4. Hypothesized responses of various guilds of species to rural home density.

Black-billed Magpies (*Pica pica*), and American Robins (*Turdus migratorius*), all occurred at higher densities near homes and at lower densities away from homes. Similarly, domestic dogs (*Canis familiaris*) and house cats (*Felis domesticus*) were more likely to be detected near homes than away from homes, while coyotes (*Canis latrans*) and red foxes (*Vulpes vulpes*) showed the reverse pattern (Odell and Knight 2001).

Such findings help elucidate the true ecological costs associated with RRD. Rather than simply acknowledging that rural residences perforate the landscape, one can begin to calculate the magnitude of land affected beyond the building site (Theobald et al. 1997). Assuming the depth of the house-edge effect is 100 m, and including a similar depth of road-effect (Forman 2000), Odell and Knight (2001) found that approximately one-fifth of the land area of the subdivided ranches they studied was affected by houses and roads.

General effects of RRD on biodiversity

Compared with the urban fringe, development in rural areas distant from cities generally involves the lower intensity land uses of exurban home development. The Colorado case study suggests that this low-density housing can have effects on biodiversity that are more extreme than traditional rural land uses such as such as protected areas or ranching. The relative impacts of RRD on biodiversity compared to other rural land uses such as logging, grazing, crop agriculture, and backcountry recreation, however, are little studied. We can speculate that each has unique influences on biodiversity that are related to the nature of the land use. The plowing associated with crop agriculture likely alters soil communities to a greater extent than does RRD, but has fewer impacts associated with roads or with human disturbance. Similarly, logging may more greatly change forest structure and composition and disrupt soil layers. There may sometimes also be considerable overlap in impacts among these land use types. A study in south western Montana found that density of cowbirds and parasitism of native bird species were significantly associated with density of homes, area in crops, and livestock densities within 6 km of riparian habitats (Hansen et al. 1999). Presumably this results because all three of these land use types provide supplemental foods that attract cowbirds. One way that RRD differs from the other rural land uses is its longevity. While logging and recovery typically occur in cycles, and livestock grazing and crop agriculture often have rest rotations, RRD is permanent on the order of decades or longer and its effects may intensify over this time.

The effect of land use is a function not only of land use type but also its intensity. In the case of RRD, home density is likely an important measure of intensity. A common perception is that homes scattered at low densities have little influence on biodiversity, while dense subdivisions have a large effect. Again, however, little research has examined how impacts on biodiversity vary with rural home density and development pattern.

As is the case with development intensity under UFD, we speculate that the relationship with rural home density under RRD varies among the different elements of biodiversity (Fig. 4). Top carnivores may be reduced even at low home densities as the expanding network of roads allows increased human access, hunting, and human disturbance. This may allow for an expansion of native or exotic meso predators and brood parasites. Consequently, native species vulnerable to predation and nest parasitism may undergo reduced survival and reproduction at low to medium densities of homes. Weedy plant diversity may increase at low home densities in association with roads, increase somewhat linearly with home density, then drop at high home densities as most of the land area is converted to lawns and ornamental plants. Suburban adaptables that benefit from human food sources and habitats may increase in proportion to home density. Finally, species richness of native species that require native habitats may decline only at higher home densities as the area of remaining habitat fall below key thresholds. Future research is needed to test these hypotheses and to identify key thresholds.

The effects of rural home density undoubtedly interact with the spatial distribution of homes and the behaviors of home owners. If homes are clustered, total road density is reduced and the ecological effects of each home overlap, allowing a larger proportion of the landscape to be free of these effects. Consequently, local planners often recommend clustered development to reduce ecological impacts and to reduce costs of government services (Daniels 1999). Also, home owners may reduce impacts on biodiversity by controlling weeds along roads, landscaping with native plant species, confining pets, covering compost, and managing livestock, pet foods, trash, and other artificial food sources including bird feeders to prevent access to wildlife.

A unique aspect of RRD compared with UFD is that rural homes are more likely to be placed in landscapes that include public lands with natural habitats and wilderness conditions. Typically, the sites productive for agriculture were claimed for private ownership, while less-productive mountain and desert settings remained under public control (Huston 2005). This has resulted in a high level of interspersion among private and public lands (Theobald 2000). An increasing number of people are now building homes on the edges of public lands for increased access to outdoor recreation, scenery, and solitude (Knight and Clark 1998). Consequently, the aura of impacts radiating from each home may extend hundreds of meters to kilometers within the public land boundary and alter biodiversity within this zone. Homes on the periphery of public lands may also attract wilderness species such as bears from the public lands, leading to increased mortality and declines in population sizes within the public lands (Mace and Waller 2002).

In the Greater Yellowstone Ecosystem, for example, national parks, national forests, and other public lands cover the majority (71.6%) of the land area. The private lands are largely in river valleys. These private lands have a longer growing season, better soils, and higher primary productivity than the public lands (Hansen et al. 2000). These same attributes make these settings attractive for native species. Consequently, the distribution of rural homes overlaps significantly with hotspots for birds (Hansen et al. 2002). The rural homes, livestock, and agriculture near the bird hotspots attract nest parasites and predators and result in reduced nest success of several native species (Hansen and Rotella 2002). P. H. Gude, A. J. Hansen, and D. A. Jones (*unpublished manuscript*) found that 49% of deciduous woodlands (the richest bird habitat in the area) across Greater Yellowstone are within 1 km of a home. Hence, even in this large, wilderness system, which is dominated by public lands, the effects of rural homes may extend over a substantial portion of key habitats.

We conclude that like exurban development on the urban fringe, exurban expansion in rural landscapes may have substantial negative impacts on native biodiversity. Considerable research is needed to better understand the effects of rural home density, spatial distribution, and homeowner behavior on biodiversity impacts. A particular concern about exurban development in rural areas is that it is more likely to be in close proximity to public lands and associated wilderness species.

Mechanisms Linking Exurban Development and Biodiversity

The mechanisms underlying these responses to land use are generally less well studied than the patterns described above. Case studies provide insights for some mechanisms, but adequate comparative study and experimentation is generally not available to allow for derivation of general predictive principles. Below we describe the suite of factors that have been suggested to explain biodiversity responses to exurban and urban development. These involve changes in habitats, ecological processes, interactions among species, and human-related disturbance of native species. Our goal is to encourage additional research on these mechanisms. Beyond improving scientific understanding, knowledge of these mechanisms may provide the basis for management strategies to reduce the effects of exurban development on biodiversity.

Habitat alteration

As human settlement progresses, conversion of native habitat to roads, yards, and structures tend to fragment the landscape (Soulé et al. 1998, Marzluff and Ewing 2001). Fragmentation influences biodiversity through reduction of habitat area, creation of dispersal barriers (Trombulak and Frissell 2000, Marzluff and Ewing 2001), disruption of nutrient cycling, and increases in predation, parasitism, and competition (Marzluff and Ewing 2001). In the Seattle case study, reduction in the area of forest patches was thought to explain the loss of forest-dwelling bird species. Isolation of small canyons in California by subdivisions lessened the dispersal capabilities of and resulted in decreased species diversity for chaparral-requiring birds (Soulé et al. 1988).

In addition to habitat fragmentation, residential development may change microhabitat features. For example, decreasing abundance of native plant cover with increasing urbanization was correlated with decreasing bee, bird, and lizard species richness in Arizona (Germaine et al. 1998, Germaine and Wakeling 2001, McIntyre and Hostetler 2001). In Illinois, replacement of natural sandy patches with grassy patches in a residential area resulted in decreased snapping turtle (*Chelydra serpentina*) nesting success (Kolbe and Janzen 2002). Reduced course woody debris input (Christensen et al. 1996) tied to exurban development in Wisconsin and Michigan lakes reduced growth rates of bluegill sunfish (*Lepomis macrohirus*) but did not significantly affect largemouth bass (*Micropterus salmoides*) (Schindler et al. 2000).

The nonrandom location of land use relative to biophysical gradients and biodiversity may cause the resulting habitat fragmentation resulting from human settlement to have disproportionately large effects. We described above the concentration of rural residences in productive valley bottoms in mountainous landscapes (Riebsame et al. 1996, Theobald et al. 1996, Soulé et al. 1998, Hansen et al. 2002, Seabloom et al. 2002). Other favored settings for RRD include lakeshores in the upper Midwest (Beale and Johnson 1998), coastal areas (Seabloom et al. 2002), and wetlands in the coastal states (Brady and Flather 1994). Because both humans and native species tend to concentrate in such locations (Hansen et al. 2002, Seabloom et al. 2002), the impacts of exurban development may be focused on the most critical habitats (see also Huston 2005).

Alteration of ecological processes

Less visible than habitat destruction, ecological processes such as disturbance regimes may be altered by exurban development and in turn influence habitats and biotic assemblages. In many parts of the arid west, humans have excluded fires from urbanizing landscapes to protect human property and lives. In Oklahoma, for example, such fire exclusion has led to increased juniper (*Juniperus* spp.) encroachment in suburban and rural habitats since 1950, as human population density increased (Coppedge et al. 2001). Correlated with the increase in juniper, the passerine community has also been altered. American Robin and Eastern Bluebird (*Sialia sialis*) abundance showed a unimodal trend with highest abundance at intermediate levels of juniper encroachment. Three species of potential juniper-feeders, Cedar Waxwing (*Bombycilla cedrorum*), Ruby-crowned Kinglet (*Regulus celendula*), and Yellow-rumped Warbler (*Dendroica coronata*), increased with juniper encroachment levels. Four species, Song Sparrow (*Melospiza melodia*), White-crowned Sparrow (*Zonotricha querula*), House Sparrow, and American Goldfinch (*Carduelis tristis*), declined with increased levels of juniper encroachment. In other urbanizing environments, in contrast, increased human ignitions have accelerated fire frequency and decreased later seral habitats (Keeley 2002).

Flood regimes may also be altered with urbanization with consequences for riparian communities. For example, plains cottonwood (*Populus deltoides*) establishment on the floodplain and terrace of Boulder Creek in Boulder, Colorado declined from 1937 to 1992 as stream diversion, straightening, stabilization, and clearing led to decreased channel movement, decreased peak flow and a decreased flooding frequency in the floodplain. Concurrently, species less tolerant to flooding events—including the exotics crack willow (*Salix rubens*) and Russian-olive (*Elaeagnus angustifolia*)—have encroached upon the floodplain (Auble et al. 1997).

Changes to nutrient cycles are also likely with conversion to exurban land uses. Along an urban–rural gradient in New York, nitrogen and phosphorous levels in oak forest soils increased with increasing urbanization (Pouyet et al. 1995). Increased nitrogen availability tends to simplify biotic communities and favor exotic species (Vitousek et al. 1997). Nutrient effects may be particularly manifest in aquatic systems. Natural-amenity exurban development around four Wisconsin lakes has affected water quality and altered diatom communities (Garrison and Wakeman 2000). As once-seasonal homes along these lakeshores were converted to year-long use, the amount of impervious surface increased and consequently run-off and sediment load to the lakes also increased. Increased levels of phosphorous, iron, and aluminum were tied to a shift from benthic to mainly planktonic diatoms and an increase in diatom taxa indicative of eutrophic conditions. Water quality in the higher alkalinity lakes showed improvement as construction slowed, but the lower alkalinity lakes appeared to be more sensitive to shoreline development, and water quality did not improve in these lower alkalinity lakes.

Alteration of biotic interactions

As human settlement alters species distributions, interactions among species may be changed with consequences for species viability and ecosystem function (Daszak et al. 2000, Marzluff 2001). Best studied among these changes in biotic interactions are predator–prey relationships. As illustrated by the Colorado case study, both native and nonnative predators may become abundant near human development and inflict heavy prey heavily upon other native species. Similarly, Wilcove (1985) found that suburban woodlots in Maryland experienced significantly higher rates of nest predation than did rural woodlots, likely as a result of higher densities of nest predators such as the Blue Jay (*Cyanocitta cristata*), Common Grackle (*Quiscalus quiscula*), gray squirrel (*Sciurus carolinensis*), and raccoon. Some predators may become abundant near human dwellings due to human subsidized food supplies (Marzluff 2001). This may also result from the loss of large carnivores that are intolerant to urbanizing landscapes, and the consequential release of mesopredators that are tolerant to human influences (Soulé et al. 1988, Crooks and Soulé 1999). Herbivores are also released by the elimination of large predators in developed areas, and the increased herbivory by deer and rabbits can have a major effect on plant diversity, both in urban parks and the surrounding landscapes.

Because predator occurrence and tolerance vary geographically, biodiversity response to urbanization may vary among regions of the United States. As described above, native songbird nest success declined in Montana as cowbird density in creased with rural home density (Tewksbury et al. 1998, Hansen and Rotella 2002). In contrast, the absence of Brown-headed Cowbirds in King County, Washington, may be a factor in the lack of nest parasitism in the Seattle case study (Donnelly and Marzluff 2004).

Changes in competitive interactions induced by development are well illustrated by invasive plant interactions with native species. English Ivy (*Hedera helix*) was introduced as an ornamental plant and kills native trees through competition for light (Reichard 2000) in much of the continental United States. Similarly, Norway maple (*Acer platanoides*), a shade tree introduced to eastern deciduous forests, out-competes native maples and beeches (Webb et al. 2001).

Many examples of the spread of infectious diseases related to human settlement exist. These can be classified as (1) human facilitated dispersal or translocation of hosts and parasites, (2) supplemental feeding, and (3) disease ''spill-over'' from domestic to wild populations (Daszak et al. 2000). Supplemental feeding of white-tailed deer at rural home sites was found to be directly related to the maintenance of bovine tuberculosis in Michigan deer populations (Michigan Department of Natural Resources 1999). Similarly, birdfeeders were found to increase the concentration of House Finches (*Carpdacus mexicanus*) and other bird species, enhancing the spread of mycoplasmal conjunctivitis (Fisher et al. 1997, Nolan et al. 1998). Last, many examples of ''spill-over'' of infectious diseases to wildlife involve domestic dogs. Canine distemper virus, canine parvovirus, and sarcoptic mange (*Sarcoptes scabiei*) are three pathogens known to have spread due to domestic dog–wildlife interactions, and are suspected to have caused population declines in the endangered gray wolf (*Canis lupus*) and black-footed ferret (*Mustela nigripes*) (Daszak et al. 2000).

Human disturbance

Finally, the presence of humans and their pets around home sites can directly influence biodiversity. Human presence in yards or on trails near homes may displace some species of wildlife. Bald Eagles (*Haliaeetus leucocephalus*), for example, may decline in number in areas with increasing human recreation (Brown and Stevens 1997, Stalmaster and Kaiser 1998). Pronghorn antelope (*Antilocapra Americana*) on Antelope Island State Park in Utah retreated further from trails once they were opened for recreational use (Fairbanks and Tullous 2002). Likewise, elk (*Cervus Canadensis*) approached by humans during calving season, were repeatedly displaced resulting in elevated calf mortality (Phillips and Alldredge 2000).

Pets may also displace, injure, or kill wildlife. Pet cats are responsible for the deaths of millions of birds in the United States every year, and in Wisconsin alone, an estimated 39 million birds per year are lost to domestic cats (Coleman and Temple 1996). Pet dogs also act as predators in many ecosystems. In Florida, pet dogs have effected the distribution of the endangered key deer (*O. virginianus clavium*), and are suspected to have eliminated them from several islands in the Florida Keys. In Colorado, the flushing distance of ungulates to human hikers was increased if a pet dog was present (Miller et al. 2001). Because rural pets kill more than their suburban and urban counterparts, adverse effects on native species are potentially greatest in the undisturbed habitat near new rural residential developments (Barratt 1998).

Another direct consequence of suburban and exurban residential growth in the United States has been an increase in vehicle miles traveled per person and per household, escalating the potential for roadkill. Between 1980 and 2000, overall per capita vehicular travel in the United States increased by 48.7%, of which the fastest growing component was ''home-based'' travel, including shopping, recreation, and driving to school. Although mortality of animals from collision with vehicles is best documented in large mammals, few terrestrial species are immune (Trombulak and Frissell 2000). Roadkill has affected the demographics and migrations of birds, snakes, invertebrates, and amphibians, and is a major cause of mortality for moose, lynx (*Felis pardina*), wolves, and American crocodile (*Crocodilus acutus*) in various regions of the United States (Trombulak and Frissell 2000).

Conclusion

Our major conclusion is that exurban development is a pervasive and fast-growing form of land use that is substantially understudied by ecologists and has large potential to alter biodiversity. Covering about 25% of the land area of the conterminous United States in 2000 (Brown et al. 2005), area in exurban land use increased since 1974 at rates in excess of area in urban or agricultural land uses. Ecologists have traditionally focused research on wild or semi-wild lands (Miller and Hobbs 2002). The relatively few studies on exurban development are mostly done as contrasts to urban land use. Consequently, knowledge of the effects of exurban density, spatial configuration, and homeowner behavior on biodiversity, and specific mechanisms for response is poorly developed.

The relatively few studies on exurban development suggest that its impacts on biodiversity may be substantial, both in the immediate vicinity of homes and even on adjacent or even distant public lands. These impacts are summarized as follows.

1) Many native species incur reduced survival and reproduction near homes and consequently native species richness generally drops with increased exurban densities. At the same time, some exotic species and some human-adapted native species generally increase with intensity of exurban development.

2) The relationship between these elements of biodiversity and intensity of exurban development are sometimes nonlinear, with sharp thresholds were biodiversity changes abruptly with incremental increases in exurban intensity. Knowledge of these thresholds is important for managing exurban development to achieve biodiversity objectives.

3) These affects may be manifest for several decades following exurban development, so that biodiversity is likely still responding to the wave of exurban expansion that has occurred since 1950.

4) The location of exurban development is often nonrandom relative to biodiversity because both are influenced by biophysical factors such that they are concentrated in more equitable landscape settings. Consequently, the effects on biodiversity may be disproportionately large relative to the area of exurban development.

5) The effects of exurban development on biodiversity likely differ among ecosystem types. Additional research is needed to derive generalities on the types of ecosystems that are relatively vulnerable to exurban development.

6) An identifiable set of ecological mechanisms link exurban development and biodiversity. More research is needed on these mechanisms and the resulting knowledge can help with understanding, managing, and mitigating these impacts.

7) In addition to local effects, exurban development may alter ecological processes and biodiversity on adjacent and distant public lands. Consequently, exurban development in rural areas may have even more important impacts than in the urban fringe because of the elevated influence on lands dedicated to conservation and on wilderness species that are rare in human-dominated landscapes.

It is our hope that this review inspires the additional research that is needed to better understand and manage the impacts of this important type of land use.

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Attachment 11

Blair 1996

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LAND USE AND AVIAN SPECIES DIVERSITY ALONG AN URBAN GRADIENT[1]

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Abstract. I examined the distribution and abundance of bird species across an urban gradient, and concomitant changes in community structure, by censusing summer resident bird populations at six sites in Santa Clara County, California (all former oak woodlands). These sites represented a gradient of urban land use that ranged from relatively undisturbed to highly developed, and included a biological preserve, recreational area, golf course, residential neighborhood, office park, and business district.

The composition of the bird community shifted from predominantly native species in the undisturbed area to invasive and exotic species in the business district. Species richness, Shannon diversity, and bird biomass peaked at moderately disturbed sites. One or more species reached maximal densities in each of the sites, and some species were restricted to a given site. The predevelopment bird species (assumed to be those found at the most undisturbed site) dropped out gradually as the sites became more urban. These patterns were significantly related to shifts in habitat structure that occurred along the gradient, as determined by canonical correspondence analysis (CCA) using the environmental variables of percent land covered by pavement, buildings, lawn, grasslands, and trees or shrubs. I compared each formal site to four additional sites with similar levels of development within a two-county area to verify that the bird communities at the formal study sites were representative of their land use category.

Key words: birds; canonical correspondence analysis; conservation; development; gradient analysis; human disturbance; land use; species diversity; species richness; urbanization.

INTRODUCTION

Land development and urbanization present particular challenges to conservation biologists. Although urban expansion has resulted in the conversion of cropland, pastures, and forests into built environments on a massive scale (Alig and Healy 1987), little is known about the effects of urbanization on ecosystems, communities, species, and populations because ecologists have traditionally worked in pristine, or relatively pristine, environments (Cairns 1988).

The objective of this study was to wed one well developed paradigm for ecological research, gradient analysis (sensu Whittaker 1967), with a new area of research for ecologists and conservation biologists, the effects of urbanization (Matson 1990). Specifically, I examined the responses of bird species and communities to urbanization by estimating summer resident bird densities in a series of habitats graded from relatively pristine to highly urban, and by comparing these estimates to human-induced changes in the landscape. The sites, all historically oak woodland, included a biological preserve, an open-space recreational area, a golf course, a residential area, an office park, and a downtown business district.

Since Whittaker (1967) championed the idea of examining plant communities with gradient analysis, the technique has been applied to studies of avian, mammalian, and aquatic communities, as well as to research on the functioning of ecosystems (for a concise review, see ter Braak and Prentice [1988]). Only recently, though, have ecologists considered employing the technique to examine the complex factors that occur in urban areas (McDonnell et al. 1993). Urban gradient analysis is not a simple examination of a feature in linear space, but rather a complex examination of the many, layered, interacting factors that reflect the fragmented and patchy nature of urban land use. Additionally, some factors may change monotonically from urban to rural areas (e.g., temperature or area covered by concrete), whereas others may peak at intermediate points along the gradient (e.g., amount of irrigation).

The effect of urbanization on bird communities has been a limited area of research, and has been only marginally considered over a full gradient of urbanization. Most researchers have compared the pre- and postdevelopment bird communities at a site (Graber and Graber 1963, Batten 1972, Walcott 1974, Aldrich and Coffin 1980), or have simultaneously compared two sites of differing levels of development (Tomialojc 1970, Emlen 1974, DeGraaf and Wentworth 1981, Beissinger and Osborne 1982, Bezzel 1985, Rosenberg et al. 1987). A few have attempted to examine a range of development by comparing residential areas of dif-

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ferent ages (Guthrie 1974, Vale and Vale 1976, Jones 1981) or a few types of land use (Hohtola 1978, Lancaster and Rees 1979, Green 1984, Ruszczyk et al. 1987, Jokimaki and Suhonen 1993). These researchers have identified several general patterns. First, all found that species composition changes in an area as it becomes urbanized. Second, all but one confirm that the number of species decreases with increasing urbanization. Last, all agree that bird density or abundance increases with urbanization.

Examination of an urban gradient suggests that the abundance and type of resources upon which birds depend, such as food, water, perches, roosts, and nesting sites, should change greatly with development (Emlen 1974, Mills et al. 1989). Typically, moderate development will increase ornamental vegetation, water sources, primary productivity, and the amount of edge between habitats. Extreme development, however, may decrease all of these factors when they are permanently replaced with pavement and structures (Whitney and Adams 1980, Godron and Forman 1983, Mooney and Gulmon 1983, Rudnicky and McDonnell 1989, Sisk 1991).

Because they affect resources that are linked to bird abundance and distribution, these urbanization changes should be reflected by individual bird species and the bird community as a whole. Some species, which I call "urban exploiters," should be adept at exploiting these changes and, consequently, should reach their highest densities in developed sites. Others, "urban avoiders," should be particularly sensitive to human-induced changes in the landscape and consequently, should reach their highest densities at the most natural sites. Finally, some "suburban adaptable" species should be able to exploit the additional resources, such as ornamental vegetation (Emlen 1974, Beissinger and Osborne 1982, Rudnicky and McDonnell 1989), that may accompany moderate levels of development. These changes in resource availability may alter community patterns as well.

Another way to assess the overall changes induced by urbanization is to focus on the predevelopment bird community. Species found in the native bird community should drop out across the urbanization gradient as the amount of native habitat is reduced and then eliminated. This does not imply that a species from the original community may not be suburban adaptive, and actually increase in density with some degree of development (cf. Mills et al. 1989). For this study, I assume that the bird community at a biological preserve is the best representative of the original community.

In short, with the help of gradient analysis, I examine whether or not: (1) urbanization affects the distribution and abundance of birds; (2) individual bird species respond differentially to increasing urbanization; (3) urbanization affects bird species richness, diversity, and density; (4) urbanization adversely affects the native bird community; and (5) these patterns relate to changes in habitat structure, which serves as a measure of resource availability.

METHODS

Field sites

The sites for this study are located within a 3-km radius centered at Stanford University near Palo Alto, California. I selected the sites as representative of typical forms of development in an urban–suburban matrix (Clay 1994). All sites have been developed since the 1890s, when the University and Palo Alto were founded, and all but the business district are located on university-owned land. I selected all sites to be as similar to one another as possible prior to development, based on the presence of mature coast live oak (*Quercus agrifolia*), valley oak (*Q. lobata*), or blue oak (*Q. douglasii*), and on early accounts of vegetation in the Palo Alto area (Cooper 1926).

The six sites include (1) biological preserve: the Jasper Ridge Biological Preserve is a 512-ha property traditionally used for biological research. Prior to 1974, portions of the preserve were leased for cattle grazing and public recreation. Currently, access is limited to researchers and visitors on docent-led tours; (2) open-space recreation area: this area was heavily grazed until 1989 and currently is used by joggers, dog-walkers, hikers, and equestrians. Motorized access is limited to maintenance vehicles; (3) golf course: the Stanford University Golf Course borders the open-space recreation area and was originally developed in 1930; (4) residential area: this area consists of single-family detached houses built mostly between 1930 and 1960. The larger area dedicated to housing (within which the study site is contained) shares borders with the open-space recreation area and the office park; (5) office park: the Stanford Research Park was created in the mid-1950s. The development of the specific study site began in 1965 and consists primarily of low-rise office buildings, parking lots, and landscaped areas. The research park borders the residential area; and (6) business district: downtown Palo Alto is separated from Stanford University buildings by an ≈1 km wide band of eucalyptus and oak woodland.

Survey methods

I estimated bird densities using variable circular plots (Reynolds et al. 1980). I established 16 survey points, each ≥100 m from its nearest neighbor, within each site. A field assistant and I surveyed each site a total of eight times in June and July 1992 and four times in June 1993 for a total of 192 point visits within each site. The open-space site was only visited six times in 1992 because it burned on 10 July 1992. A typical daily site survey began at dawn, consisted of 5-min visits to each of the 16 points, and lasted ≈2 h. We recorded the species of all birds identifiable by sight or song, and the distance from the point to each bird in 5 m wide increments up to 30 m from the point, and in the two 10 m wide increments between 30 and 50 m from the point. We did not record high-flying individuals, such as vultures and crows, that passed over the circle but did not land or forage within its perimeter.

I estimated the type and amount of land cover at each site from recent aerial photographs provided by Stanford University, the City of Palo Alto, and Jasper Ridge Biological Preserve. I calculated the area covered by buildings, pavement, lawn, grassland, and trees or shrubs in a 36.6- to 48.8-m radius (depending on map scale) centered at each survey point, and then converted the total amount to percentage of site covered.

Surveys of human activity were conducted simultaneously at all of the sites except the biological preserve (where there was no activity) on the morning of 15 April 1993 between 0800 and 1100. Two-person survey teams counted the number of pedestrians, bicyclists, and cars passing within 22 m (0.16-ha circles) of a point for 15 min. Six to eight points were surveyed within each site. Survey teams also noted the number of cars parked within each of the 0.16-ha circles.

Data analysis

I determined the rank order of the sites from most natural to most urban using the Delphi technique (Zuboy 1981, Blair 1994). Faculty, staff, and students ($n = 14$) working with the Center for Conservation Biology at Stanford were asked to rank the sites independently and anonymously from most natural to most urban, and to give the criteria they used. The results of the ranking were then distributed to the participants and the process was repeated until the group reached relative consensus on the ordering.

I calculated the density of each bird species based on the technique of variable circular plots, which allows for adjustments in detectability for individual species and sites (Reynolds et al. 1980). Using all occurrence data, I created histograms of the density of each species in each distance band for each site. I visually examined these histograms to locate the band in which a species' density (and, thus, detectability) was highest, and then excluded from further analysis at that site all records of that species occurring in bands at a greater distance from the survey point than the peak band. For example, in the office park, the histogram for Scrub Jay occurrence had no discernible peak, implying that jays were detected at the same rate in all of the bands up to 50 m. Consequently, I used all records of Scrub Jay occurrence and calculated densities based upon a 50-m radius. In contrast, Bushtits peaked at 25 m, implying that not all Bushtits were detected beyond that distance. Consequently, I excluded all records of occurrence at distances >25 m, and calculated densities based upon a 25-m radius.

Using these detectability adjustments, I calculated densities by combining point counts within a site per survey day, and then calculated the mean daily density of each species at each site. I combined the 16 point counts into a single daily count in order to meet assumptions of normality. I restricted the analysis to those species that were >1% of all observations within a site to assure that only resident species were considered; most of the excluded species were seen only one or two times within a site. At the golf course, I lowered this criterion to 0.5% of observations to accommodate the numerous transient bird flocks (e.g., Red-winged Blackbirds) that numerically overshadowed some of the resident, although less common, species.

I calculated species diversity using the Shannon Index (Shannon and Weaver 1963, Magurran 1988). I defined species richness for each site as the total number of species recorded, because effort and area covered were approximately equal at all sites. The average number of birds per hectare was the sum of the estimated daily density of all species. The grams of birds per hectare was the sum, over all species, of the estimated daily densities of each species multiplied by the average body mass of that species, according to Dunning (1993).

I used canonical correspondence analysis (CCA), performed with the program CANOCO (ter Braak 1992), to determine the influence of environmental factors on the distribution of individual species. CCA is a constrained ordination technique that incorporates the unimodal response of species to environmental variables. Linear combinations of environmental variables are selected to produce maximum separation of the species' distribution in the ordination space (ter Braak and Prentice 1988, Poulin et al. 1993, Grantham and Hann 1994). In this analysis, the species data consisted of the count of individuals in each species at a point, adjusted for detectability based on the method of variable circular plots, and summed over all days. The environmental data consisted of the percentage cover of buildings, pavement, lawn, grassland, and trees or shrubs of each sampling point.

Validation of sites

I compared each formal site to four additional sites with similar levels of development within a two-county area to ascertain that the bird communities at the formal study sites were representative of their land use category. I visited, each for 1 d in July 1993, the original study sites and four different business districts, office parks, residential areas, golf courses, open-space reserves that were heavily used for recreation, and open-space reserves that were infrequently used by hikers (because there were no additional biological preserves in the area). I surveyed the bird community with the same protocol as that used at the formal sites. I then performed a cluster analysis using the Goodman–Kruskal gamma correlation coefficient on the count of individuals within each species (not densities) of all birds observed (SYSTAT 1992).

Results

The rural–urban gradient

The ranking of the sites, by the Delphi technique, from most natural to most urban was: biological preserve, open-space recreational area, golf course, residential area, office park, and business district. This ranking was confirmed empirically by the preponderance of unimodal distributions in types of land cover, amounts of human use, and the distributions of individual species when the sites were ranked in this order. In other words, many of these factors were highest at one site and decreased smoothly at sites with more or less disturbance, according to this ranking (Figs. 1 and 2).

All measures of landscape cover had unimodal distributions across the urbanization gradient except the area covered by trees and shrubs, which had an additional local maximum in the residential area. The percent of land covered by trees and shrubs was highest at the preserve. The percent area of land covered by grassland was highest at the open-space recreational area. The percent area of land covered by lawn was highest at the golf course. The percent of land covered by pavement was high in both the office park and business district. The percent of land covered by buildings was highest in the business district (Fig. 1).

The intensity of human use varied among sites. The average number of pedestrians, bicycles, and moving cars passing by survey points in 15 min was greatest in the business district. The greatest numbers of parked cars was in the office park (Fig. 2).

Avian community changes along the rural–urban gradient

The densities of all bird species (Appendix) varied to some degree across the gradient (Fig. 3, Table 1). Of the 40 species encountered, 31 species had unimodal distributions and seven had disjunct (bimodal) distributions because they were absent from one or more intervening sites along the gradient. For example, the Chestnut-backed Chickadee was found in the golf course and the preserve, but not in the open-space recreational area.

Seven species were "urban avoiders," with maximum densities reached at the preserve: Dark-eyed Junco, Blue-gray Gnatcatcher, Ash-throated Flycatcher, Steller's Jay, Wrentit, Western Wood-Pewee, and Hutton's Vireo. Thirty species were "suburban adaptable": Plain Titmouse, Bewick's Wren, European Starling, Cliff Swallow, Nuttall's Woodpecker, and Violet-green Swallow (maximum densities in the open-space recreational area); Brewer's Blackbird, Scrub Jay, California Thrasher, Mallard, Pacific-slope Flycatcher, Barn Swallow, Western Bluebird, Black Phoebe, Rufous-sided Towhee, Acorn Woodpecker, Red-winged Blackbird, California Quail, and White-breasted Nuthatch (maximum densities in the golf course); American Robin, Brown-headed Cowbird, Mourning Dove, Anna's Hummingbird, California Towhee, House Finch, Northern Oriole, Lesser Goldfinch, and Northern Mockingbird (maximum densities in the residential area); and Chestnut-backed Chickadee and Bushtit (maximum densities in the office park). Three species were "urban exploiters," with maximum densities in the business district: Rock Dove, White-throated Swift, and House Sparrow.

Most of the original oak woodland species (defined as those found at the biological preserve) gradually dropped out along the gradient as the sites became more urbanized. The only species from the preserve that were also present in the business district were Scrub Jay, Anna's Hummingbird, and Mourning Dove (Table 2).

Most community measures were greatest at intermediate levels of development (Fig. 4). The distribution of species richness, diversity, and density were all unimodal and peaked at the golf course, open-space recreational area, and golf course, respectively. The distribution of avian biomass was bimodal, peaking in both the business district and the golf course. If Rock Doves were omitted, the distribution of avian biomass became unimodal, with a peak in the golf course.

The canonical correspondence analysis (CCA) detected a significant relation between the distribution of individual species and the environmental measures of percent area covered by buildings, pavement, lawn, grassland, and trees or shrubs at the individual sampling points. The CCA generates environmental, species, and sample plots of different scales that are then reconstructed to the same scale and superimposed upon one another. For the sake of clarity, I display the results of this CCA as two biplots: one of environmental arrows and sites (Fig. 5a) and one of environmental arrows and species (Fig. 5b).

In this study, the first two ordination axes explained 11.6% and 8.3% of the variance in the species data, with canonical eigenvalues of 0.469 and 0.334 in comparison to the sum of all unconstrained eigenvalues, which was 4.037. These percentages are a measure of the goodness-of-fit of the model, and they express the percentage variance of the weighted averages accounted for by the two-dimensional diagram (ter Braak 1986). The arrows for environmental variables in Figs. 5a and b, in conjunction with the species points, account for 49.4% of the variance in the weighted averages of the species with respect to each of the environmental variables on the first axis, and 35.1% of the variance on the second axis (ter Braak 1986, 1987).

The first two axes have species–environment correlations of 0.823 and 0.864. These correlations measure how well the extracted variation in community composition can be explained by the environmental variables and how the variation is equal to the correlation between the site scores that are weighted mean species scores and the site scores that are linear com-

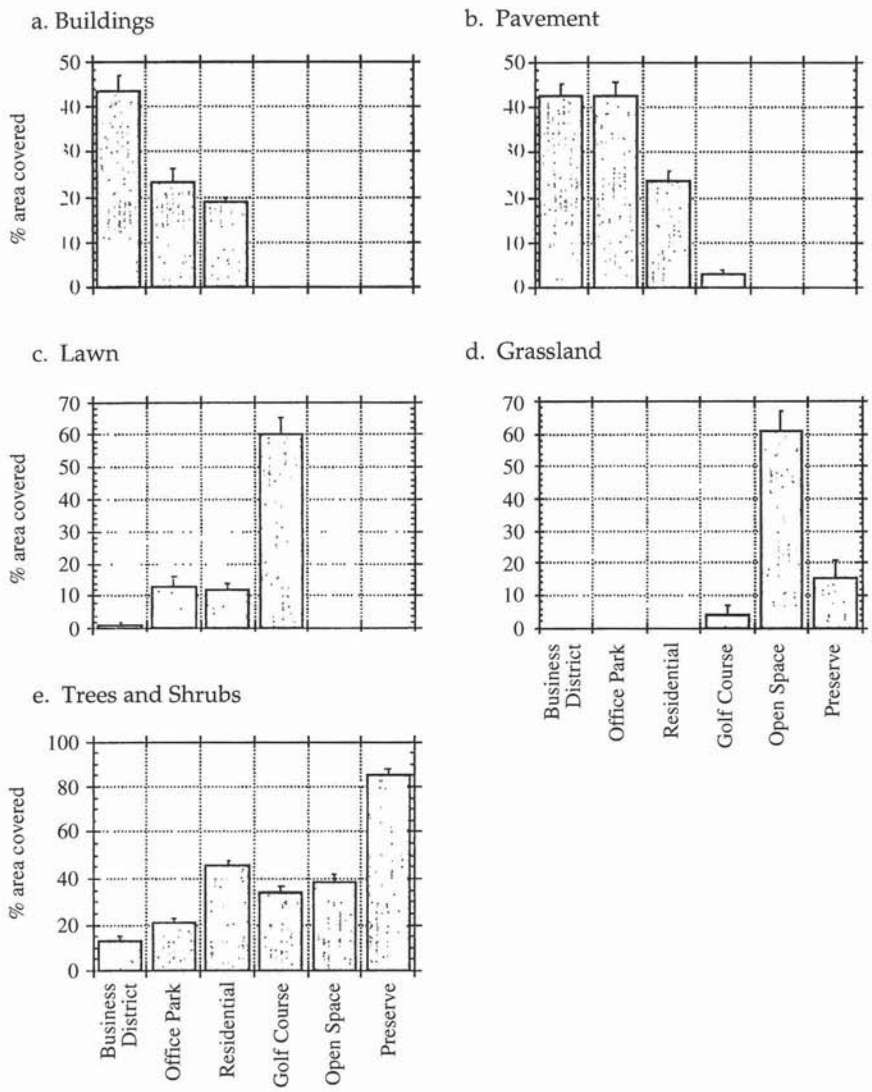

FIG. 1. Percent area (mean + 1 SE) covered by (a) buildings, (b) pavement, (c) lawn, (d) grassland, and (e) trees and shrubs as determined from aerial photographs of the six sites (n = 16 points within each site).

binations of the environmental variables (ter Braak 1986).

A Monte Carlo technique using 99 permutations found that the overall analysis and the two axes were significant (CCA, $P = 0.01$; Axis I, $P = 0.01$; Axis II, $P = 0.01$). Figs. 5a and b indicate that the most effective environmental variables for differentiating the sites and their bird communities were the amount of cover in buildings, lawn, and trees or shrubs. They also indicate that area covered by pavement and area covered by buildings are redundant measures.

Giving ecological meaning to the ordination axes is a heuristic, rather than a statistical, process (Liverman 1986) and, thus, not completely objective. Axis I (the horizontal axis) was successful in separating the most urbanized sites, namely the business district, office park, and residential area. This suggests that Axis I is a measure of the built environment. Axis II (vertical) was particularly successful in separating the three least urbanized sites, namely the golf course, open-space recreation area, and biological preserve. This suggests that Axis II is a measure of vegetative complexity, with complex structure (trees and shrubs) at the top of the axis and much simpler structure (lawn) at the bottom. Interestingly, 25 of the 40 bird species are located in the top half of the diagram. If greater vegetative complexity does indeed support a greater number of species, then this reinforces the idea that Axis II is a measure of vegetative complexity.

A few simple patterns in feeding habit, size, or other life history characteristics have notable effects on the distribution of the individual species on these axes. In

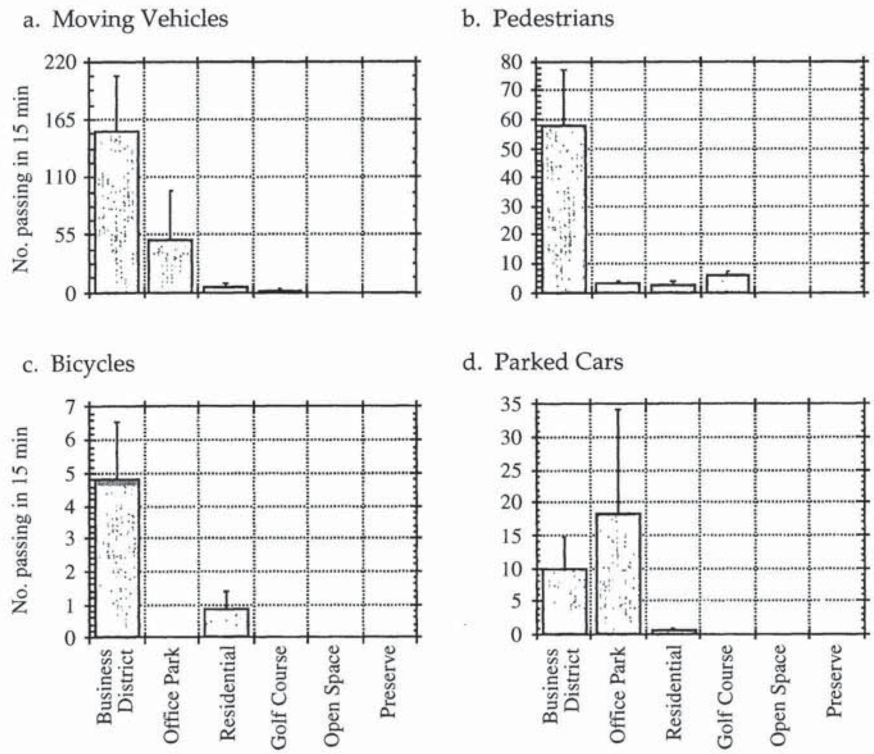

FIG. 2. Number (mean + 1 SE) of (a) moving vehicles, (b) pedestrians, (c) bicycles, and (d) parked cars passing within 22 m of a point in 15 min (n = 6 points within business district, office park, and residential area, n = 7 for golf course, n = 8 for open-space recreational area, n = 0 for biological preserve).

general, cavity nesters, such as the Plain Titmouse and the woodpeckers, are limited to the left portion of Axis I. This region represents the less-developed sites; presumably, the pattern arises because dead trees are removed from highly maintained, landscaped areas. Ground nesters, such as the quail and the junco, were limited to this area as well, presumably because less-urbanized areas support fewer predators such as house cats (Churcher and Lawton 1987). Two of the three exotics (Rock Dove and House Sparrow) were found principally in the business district, and the third (European Starling) was found in the open-space recreation area, which was the most urbanized site that also contained snags for nesting. All of these species are located on the lower portion of Axis II. Lastly, the variety of food and foraging techniques used by birds in the community tended to increase from the urban to the natural sites. For example, the ground gleaners, such as the seed-eating doves and House Sparrow, are limited to the right portion of the plot, whereas the insect foragers found in the upper left-hand quadrant use a wide variety of gleaning techniques.

Validation of sites

The bird species seen at the six formal study sites are representative of the species found at sites with similar levels of development in the San Francisco Bay area. All of the business districts, all of the office parks, all of the golf courses, all of the preserves, four of the open-space recreational areas, and four of the residential sites were grouped by cluster analysis into distinct subsets. Additionally, office parks were grouped as a distinct subset of the residential areas. One of the residential sites and one of the open-space recreational areas (not formal study sites) grouped by themselves (Fig. 6). These results suggest that the formal study sites were more similar, in both species composition and individual species densities, to sites of similar land use than to sites of differing land use.

DISCUSSION

Urbanization affects bird diversity in two highly distinct ways. Moderate levels of development may both increase overall species diversity and decrease native bird diversity. Increasingly severe development, however, lowers both total and native species diversity. These somewhat contradictory patterns could prove misleading if only gross measures of diversity, such as species richness or Shannon diversity, are used to assess the impact of development on the bird community. Moderate levels of development apparently increase diversity (Fig. 4), but closer examination reveals that the increase in species richness results from the addition of widely distributed species at the expense of the native species (Table 2). With respect to maintaining biological diversity, it is important to differentiate be-

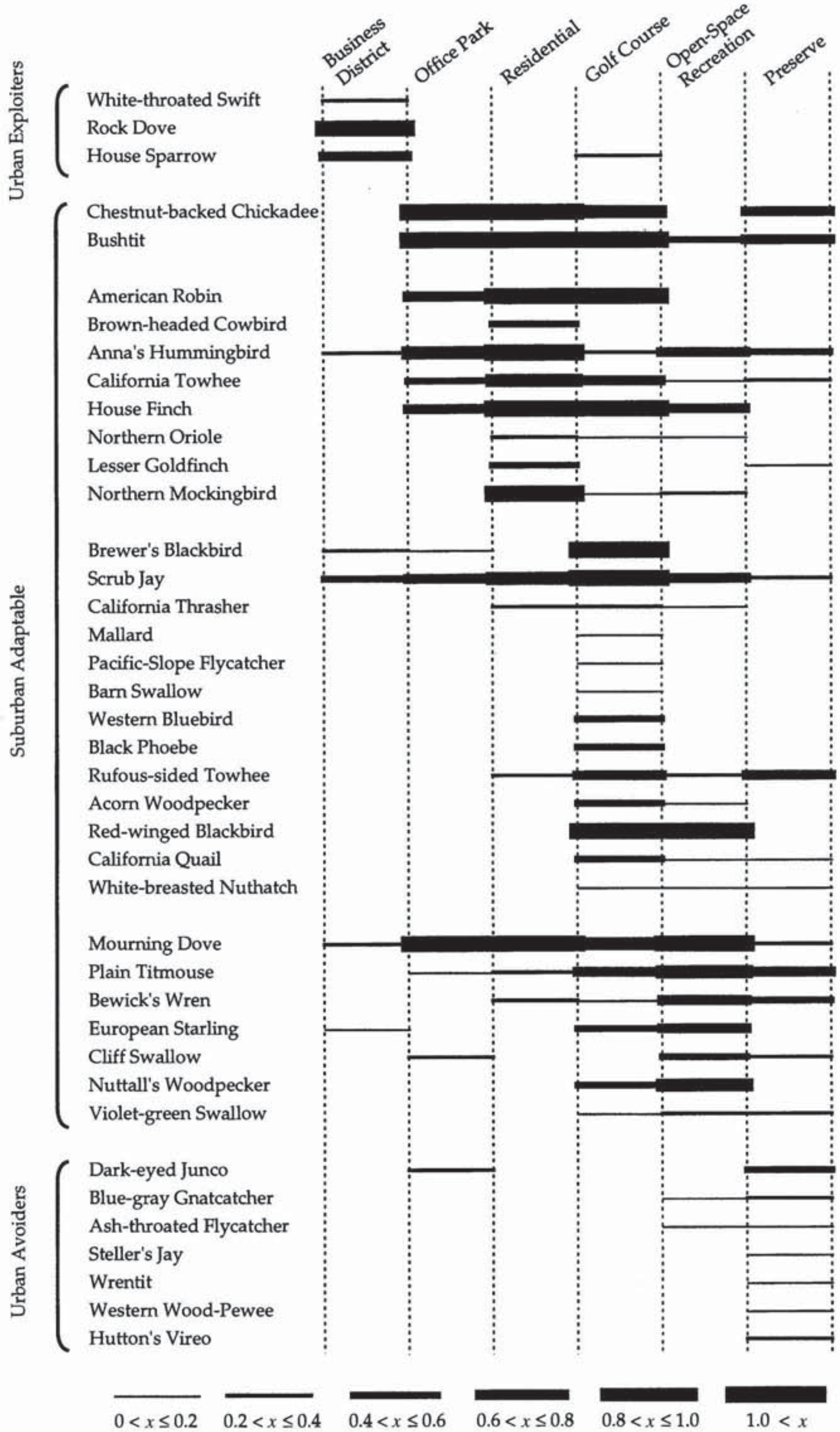

FIG. 3. Average daily densities of all bird species in all sites, arranged in order from greatest daily density in business district to greatest daily density in biological preserve (x = no. birds/ha).

tween the quality and the quantity of species that are represented in human-dominated areas.

The mechanisms that may cause these patterns should be considered. A cursory examination of the landscape changes that occur across an urbanization gradient suggests that lower levels of development, such as golf courses or residential areas with detached housing, increase the diversity and abundance of resources available to birds. Urbanization at this level tends to alter the composition of the plant community by introducing ornamentals and changing vegetation structure (Beissinger and Osborne 1982, Rudnicky and McDonnell 1989). It may also increase structural diversity (buildings as well as vegetation) of the habitat

TABLE 1. Mean daily density (no. individuals/ha) of all bird species in all land use sites (n = 12 d for all sites except the open-space recreational area, where n = 10).†,‡

Species	Business district	Office park	Residential	Golf course	Open space	Preserve	ANOVA P
Mallard	0	0	0	0.11	0	0	
California Quail	0	0	0	0.51^{a}	0.15^{b}	0.05^{b}	**
Rock Dove	4.03	0	0	0	0	0	
Mourning Dove	0.41^{a}	1.19^{ab}	1.53^{ab}	0.97^{ab}	2.12^{b}	0.34^{a}	**
White-throated Swift	0.31	0	0	0	0	0	
Anna's Hummingbird	0.22^{a}	0.88^{a}	2.15^{b}	0.28^{a}	0.62^{a}	0.52^{a}	**
Nuttall's Woodpecker	0	0	0	0.18^{a}	0.20^{a}	0	NS
Acorn Woodpecker	0	0	0	0.45^{a}	0.20^{b}	0	**
Ash-throated Flycatcher	0	0	0	0	0.03^{a}	0.17^{b}	**
Western Wood-Pewee	0	0	0	0	0	0.09	
Black Phoebe	0	0	0	0.41	0	0	
Pacific-slope Flycatcher	0	0	0	0.09	0	0	
Violet-green Swallow	0	0	0	0.18	0.33	0.29	NS
Cliff Swallow	0	0.26	0	0	0.45	0.19	NS
Barn Swallow	0	0	0	0.11	0	0	
Scrub Jay	0.45^{ab}	0.70^{a}	0.84^{a}	1.79^{c}	0.83^{a}	0.28^{b}	**
Steller's Jay	0	0	0	0	0	0.05	
Wrentit	0	0	0	0	0	0.17	
Plain Titmouse	0	0.09^{a}	0.30^{ab}	0.68^{b}	0.81^{b}	0.66^{b}	**
Chestnut-backed Chickadee	0	1.66	1.06	0.98	0	0.62	NS
Bushtit	0	2.55	1.49	1.75	0.50	0.80	NS
White-breasted Nuthatch	0	0	0	0.18	0.18	0.09	NS
Bewick's Wren	0	0	0.32^{ab}	0.18^{b}	0.76^{a}	0.41^{ab}	**
Blue-gray Gnatcatcher	0	0	0	0	0.12^{a}	0.37^{b}	*
Western Bluebird	0	0	0	0.44	0	0	
American Robin	0	0.66^{a}	1.51^{b}	1.17^{ab}	0	0	**
Northern Mockingbird	0	0	1.41^{a}	0.09^{b}	0.22^{b}	0	*
California Thrasher	0	0	0.25	0.37	0.18	0	NS
European Starling	0	0.10^{a}	0	0.58^{ab}	0.85^{b}	0	*
Hutton's Vireo	0	0	0	0	0	0.25	
Rufous-sided Towhee	0	0	0.37^{ab}	0.70^{c}	0.26^{b}	0.62^{ac}	**
California Towhee	0	0.54^{ab}	0.88^{a}	0.70^{ab}	0.15^{cb}	0.22^{cb}	**
Dark-eyed Junco	0	0.29	0	0	0	0.48	NS
Red-winged Blackbird	0	0	0	2.89	1.40	0	NS
Brewer's Blackbird	0.37^{a}	0.05^{a}	0	1.37^{b}	0	0	**
Brown-headed Cowbird	0	0	0.55	0	0	0	
Northern Oriole	0	0	0.30	0.17	0.13	0	NS
House Sparrow	0.72^{a}	0	0	0.22^{b}	0	0	**
Lesser Goldfinch	0	0	0.58	0	0	0.15	NS
House Finch	0	0.61^{a}	3.80^{b}	1.70^{b}	0.62^{a}	0	**

* $P \le 0.05$; ** $P \le 0.01$; NS, not significant ($P \ge 0.05$).
† Means within a row that have the same superscript letter are not significantly different from one another (Tukey's hsd).
‡ Only sites where species were present were used in the analyses.

and provide more sites for activities such as perching (Emlen 1974, Beissinger and Osborne 1982). The introduction of watering regimes, fertilizers, and regular maintenance in urban areas may also increase primary productivity (Mooney and Gulmon 1983). In contrast, more intense development, such as office parks or business districts, could decrease the amount of resources available to birds, as construction removes substantial areas from primary production, and landscaping becomes limited to the hardiest ornamental species, which are often exotic (Whitney and Adams 1980). A similar pattern of addition and then deletion of a resource can be seen in the amount of edge habitat available in the different sites. Moderate levels of development may fragment formerly continuous habitat, increasing the amount of edge habitat available. However, edge habitat will eventually decrease with increasingly severe urbanization, as all native habitat is eliminated with development (Godron and Forman 1983, Sisk 1991).

Results of this study suggest that individual species respond differentially to changes in resources brought about by urbanization. Three species in this study have maximal densities in the business district. Two, the Rock Dove and the House Sparrow, have been introduced by humans and are exotics in the classical sense. The third, the White-throated Swift, is native to the central coastal region of California but has expanded its range to inland Palo Alto. The swift requires cliffs for nesting but has managed to use the 'cliffs' provided by high-rise buildings in the area. These three species have been successful in co-opting resources that are evolutionarily novel to the native bird community. At the other end of the spectrum are those birds, all of which are native species, with maximal densities in the

TABLE 2. Loss of the original oak woodland bird species across the urban gradient. Only those species found at the biological preserve are listed. + symbol indicates presence.

Species	Biological preserve	Open-space recreation	Golf course	Residential area	Office park	Business district
Hutton's Vireo	+					
Western Wood-Pewee	+					
Steller's Jay	+					
Wrentit	+					
Dark-eyed Junco	+				+	
Ash-throated Flycatcher	+	+				
Blue-gray Gnatcatcher	+	+				
Cliff Swallow	+	+			+	
White-breasted Nuthatch	+	+	+			
California Quail	+	+	+			
Violet-green Swallow	+	+	+			
Rufous-sided Towhee	+	+	+	+		
Bewick's Wren	+	+	+	+		
Lesser Goldfinch	+			+		
Plain Titmouse	+	+	+	+	+	
California Towhee	+	+	+	+	+	
Bushtit	+	+	+	+	+	
Chestnut-backed Chickadee	+		+	+	+	
Scrub Jay	+	+	+	+	+	+
Anna's Hummingbird	+	+	+	+	+	+
Mourning Dove	+	+	+	+	+	+

most natural site. These species appear to decrease in number with any degree of human manipulation of the environment. In the middle of this spectrum is the most numerous group, the suburban adaptable species. These species appear to benefit from the greater quantity and variety of resources that occur with intermediate levels of development. Only two of these 30 species are non-native: the Brown-headed Cowbird (invasive) and the European Starling (exotic).

Patterns similar to these have been detected by other researchers working in urban areas. Mills et al. (1989) examined the influence of exotic and native vegetation on breeding bird densities in residential areas in Tucson, Arizona. They found that the density of territorial native birds correlated with the total vegetation volume of native plant species, whereas the density of exotic and nonterritorial birds correlated with the total vegetation volume of exotic plant species. They noted that several native bird species, including Anna's Hummingbird, Northern Mockingbird, White-winged Dove, Western Kingbird, and Hooded Oriole, occurred most frequently at urban sites. Mills et al. (1989) also described a category of birds, near natives, having densities that also correlated with total vegetation volume of exotic species. These near natives, which expanded their range into the Tucson Basin with the introduction of agriculture and urbanization, included Mallard, Inca Dove, American Robin, Great-tailed Grackle, and Bronzed Cowbird. Nine of the 10 species found by Mills et al. (1989) at urban sites, or described by them as near natives, are the same, or close relatives of, species classified as suburban adaptable in this study. These results support the idea that suburban development increases the abundance of critical resources that can be exploited by some native birds. For example, while conducting this study, I observed Anna's Hummingbirds taking advantage of the wealth of nectar sources in the residential area, and I often found American Robins foraging on the softer ground provided by irrigation at the golf course, residential area, and office park.

One caveat should be noted: high density of a species in a site does not indicate whether that particular site is self-sustaining, a population source, or a population sink. The site actually may be relying on dispersal of individuals from other sites to maintain high densities. In fact, R. Bowman (*personal communication*) has documented such a situation with the Florida Scrub Jay. He suggests that jays can be found at high densities in suburban residential sites, but these populations are not necessarily self-sustaining.

Patterns at the community level found in this study contradict the findings of almost every other study on the effects of urbanization on birds. Contrary to what would be expected from a survey of the ornithological literature (Graber and Graber 1963, Tomialojc 1970, Batten 1972, Emlen 1974, Guthrie 1974, Walcott 1974, Vale and Vale 1976, Hohtola 1978, DeGraaf and Wentworth 1981, Jones 1981, Beissinger and Osborne 1982, Green 1984, Bezzel 1985, Rosenberg et al. 1987, Ruszczyk et al. 1987), Shannon diversity, species number, bird density, and bird biomass (if Rock Doves were omitted) all peaked at intermediate levels of urbanization rather than at the most natural site or, with respect to biomass, at the most urban site. A potential explanation is that most previous studies examined shorter gradients of disturbance or compared only two points. Consequently, the most natural sites were more diverse than the most disturbed sites.

Aldrich and Coffin (1980), however, reached a dif-

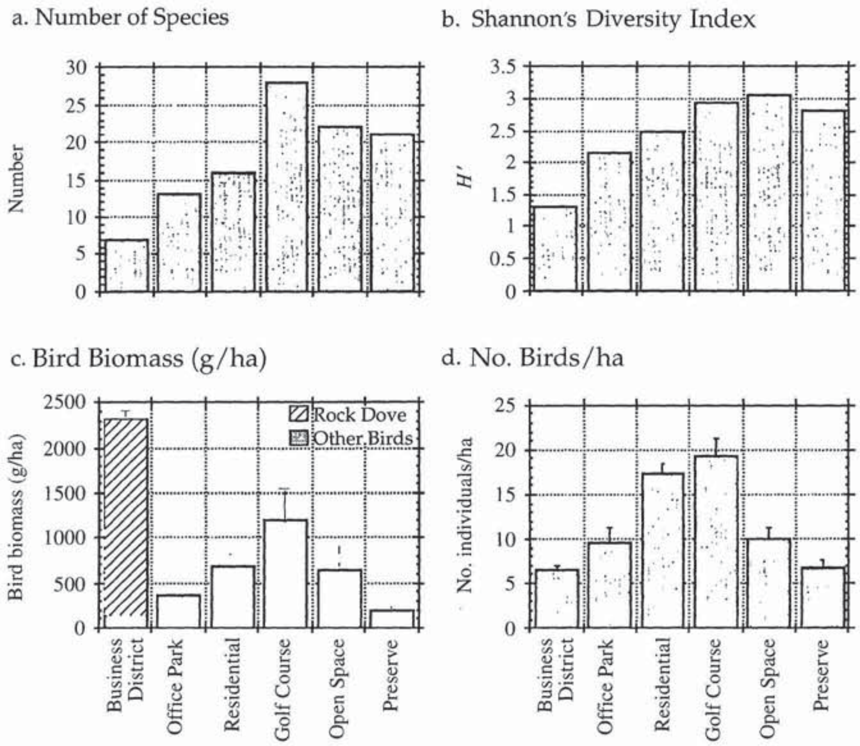

FIG. 4. Avian community measures across the urban gradient: (a) total number of bird species observed, (b) Shannon's diversity index (SE too small to display), (c) bird biomass (g/ha) with Rock Doves emphasized, and (d) number of birds per hectare. Data in (c) and (d) are based on average daily densities + 1 SE; n = 12 d in each site, except n = 10 for open-space recreational area.

ferent conclusion than did most researchers when they compared an undisturbed oak woodland censused in 1942 to the same suburbanized site in 1979. They concluded that bird species diversity increased in urban areas. Their results are congruent with this study because the most natural area was a low diversity, undisturbed woodland and their most urbanized site was a high diversity, moderately disturbed residential area. Data from two other studies (Lancaster and Rees 1979, Jokimaki and Suhonen 1993) also indicate increases in species richness and/or diversity at slight levels of development.

These community patterns are consistent with a number of other studies, both theoretical (Connell 1978, Grime 1979, Huston 1979, Tilman 1982, Denslow 1985, Petraitis et al. 1989) and empirical (Lubchenco 1978, Paine and Levin 1981, del Moral 1983), supporting the idea that species richness peaks at intermediate levels of disturbance. This body of work relating diversity and disturbance began with the intermediate disturbance hypothesis (Connell 1978). Connell suggested that maximum diversity should be found at sites that are disturbed at intermediate spatial or temporal scales. Because disturbance disrupts those species whose superior competitive abilities generally enable them to achieve dominance in a community, disturbance permits less competitive species to co-exist. If disturbance is too frequent or too severe, only those species that are good at dispersing and/or reaching maturity quickly will remain. If disturbance is too infrequent, those species that are good competitors will dominate the community.

McDonnell et al. (1993), using slightly different reasoning than Connell's, extended the idea of natural disturbance to include human land use. They predicted that species richness should peak at intermediate levels of development because biotic limitations are high at the rural end of an urban-to-rural gradient and physical limitations are high at the urban end. This study provides the first evidence that such a pattern exists, and suggests that the pattern may be brought about by these limitations.

One question that arises from extending theories relating diversity and disturbance to include human-induced landscape disturbance is how these types of disturbance differ from natural ones. A widely used definition of natural disturbance is "any relatively discrete event in time that disrupts ecosystem, community, or population structure and changes resources, substrate availability, or the physical environment" (White and Pickett 1985). White and Pickett state that, in order to build a theoretical framework to address questions about disturbance, disturbances need to be described in terms of spatial distribution, frequency, cycle (the

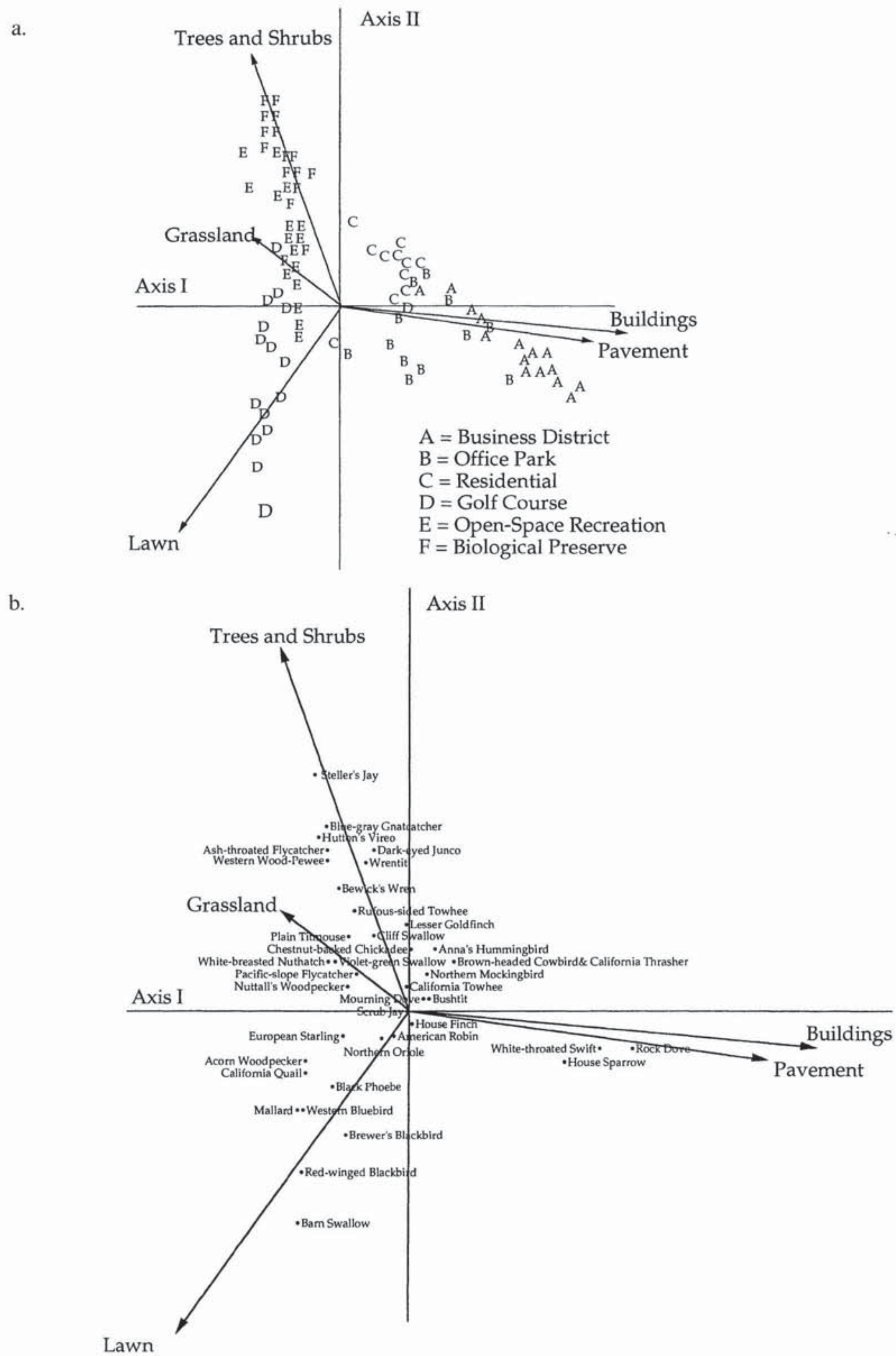

FIG. 5. Ordination diagrams of canonical correspondence analysis. (a) Sites as a linear combination of environmental measures. Letters represent points within each site (n = 16 for each site; some are printed on top of one another). Arrows represent direction of steepest change of environmental measures, and are oriented toward the direction of steepest increase of the variable. Arrow length indicates the importance of the environmental variable in the model, arrow direction indicates how well the environmental variable is correlated with the various axes, the angle between arrows indicates correlation

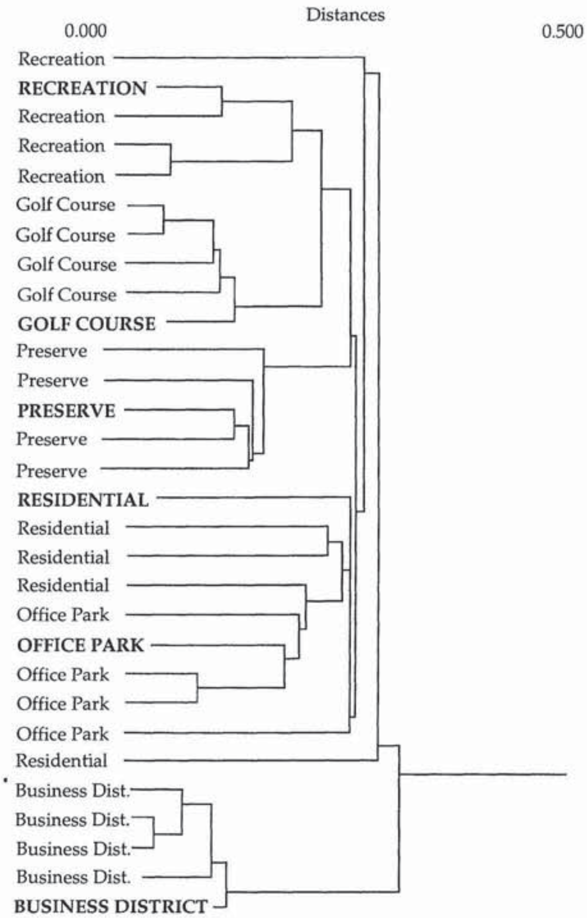

FIG. 6. Cluster analysis of validation of sites. Daily counts of species were taken at four different but comparable sites for each land use type in the Palo Alto area. These counts were clustered using distances computed with the Goodman–Kruskal gamma correlation coefficient. Formal study sites are emphasized in bold capitals.

inverse of frequency), rotation period, predictability, area, magnitude in terms of intensity (related to physical force) or severity (related to biological impact), and synergism with other disturbances.

By these standards, the disturbance caused by land development fits firmly into the framework traditionally used to describe natural disturbance, although the ways in which it differs should be highlighted. Land use development is similar to natural disturbance, such as hurricane or fire, in that it results in removal of biomass from a site, but it differs in the persistence of that disturbance. Rarely is a developed site allowed to revert to its "natural state." Rather, it is actively maintained to prevent such reversion. In effect, groundskeepers and maintenance regimes become frequent, low-magnitude disturbances at a site after the infrequent, large-magnitude disturbance caused by its initial development. Consequently, the level of disturbance in urbanized areas should not be measured by its intensity or how often it occurs at a site, as is the case with fires or hurricanes, but rather by what percentage of the area is initially taken out of primary production and how regularly the remaining portion is maintained.

The pattern of deletion of bird species from the original oak woodland community that occurred across this urban gradient suggests that any land use development is detrimental to the native bird community. Even minor perturbations, such as the grazing that formerly occurred in the open-space recreation area, apparently lead to a loss of species. Moreover, species that disappear at the lightly disturbed sites do not reappear at some more highly disturbed site.

This finding can be used to guide land use planning on a regional scale. If planners wish to maintain predevelopment levels of biodiversity, then development should be spatially concentrated. For instance, office parks may offer a veneer of landscaping but they apparently do not provide the full array of resources required to maintain the original biological community. Consequently, in order to maximize native biodiversity, it would be advisable to concentrate business endeavors in as small an area as possible to maximize the amount of undeveloped land. This study also indicates that golf courses are not as benign a land use as some people assume (Harker et al. 1993), leading to a loss of >40% of the species found in the predevelopment community. Golf courses may be greenways with an abundance of birds and high species diversity, but they do not maintain the original species composition or abundance of the predevelopment community.

One question that arises from this study is whether or not effects of urbanization on the distribution and abundance of birds observed at the local level have a measurable effect at a larger spatial scale. Root and McDaniel (1994), using Christmas Bird Count data, analyzed state-by-state trends of 50 songbirds with winter ranges that are apparently limited by colder temperatures in the north. They concluded that species of birds that eat seeds from grasses and forbs (e.g., sparrows and meadowlarks) are declining in number in

←

between variables (a small angle implies high correlation), and the location of a site score relative to arrows indicates the environmental characteristics of the site (Palmer 1993, Poulin et al. 1993). The longer the arrow, the greater the correlation between the variable and the ordination axes and, hence, the greater that variable's influence in explaining the pattern of community variation. This also indicates the variable's relative predictive ability (ter Braak 1986, Grantham and Hann 1994). (b) CCA ordination of species and environmental measures. Arrows represent direction of steepest change of environmental measures. The location of a species score relative to arrows indicates the environmental preferences of that species (Palmer 1993, Poulin et al. 1993).

more states than are birds that eat seeds or berries from shrubs and trees (e.g., Tufted Titmouse and Cedar Waxwing). They suggested that this may be attributed to modification of grassland and early successional habitats to the detriment of certain species, whereas ornamental fruiting bushes, shrubs, and trees planted in urbanized areas may benefit other species. This reinforces the idea that moderate levels of development increase resource availability for some birds, and that the pattern observed in this study is also detectable at a far larger scale.

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APPENDIX

Names of all bird species mentioned in text.

Common name	Scientific name	Common name	Scientific name
Mallard	*Anas platyrhynchos*	Bushtit	*Psaltriparus minimus*
California Quail	*Callipepla californica*	White-breasted Nuthatch	*Sitta carolinensis*
Rock Dove	*Columba livia*	Bewick's Wren	*Thryomanes bewickii*
White-winged Dove	*Columba asiatica*	Blue-gray Gnatcatcher	*Polioptila caerulea*
Mourning Dove	*Zenaida macroura*	Western Bluebird	*Sialia mexicana*
Inca Dove	*Columbina inca*	American Robin	*Turdus migratorius*
White-throated Swift	*Aeronautes saxatalis*	Northern Mockingbird	*Mimus polyglottos*
Anna's Hummingbird	*Calypte anna*	California Thrasher	*Toxostoma redivivum*
Nuttall's Woodpecker	*Picoides nuttallii*	Cedar Waxwing	*Bombycilla cedrorum*
Acorn Woodpecker	*Melanerpes formicivorus*	European Starling	*Sturnus vulgaris*
Ash-throated Flycatcher	*Myiarchus cinerascens*	Hutton's Vireo	*Vireo huttoni*
Western Kingbird	*Tyrannus verticalis*	Rufous-sided Towhee	*Pipilo erythrophthalmus*
Western Wood-Pewee	*Contopus sordidulus*	California Towhee	*Pipilo crissalis*
Black Phoebe	*Sayornis nigricans*	Dark-eyed Junco	*Junco hyemalis*
Pacific-slope Flycatcher	*Empidonax difficilis*	Red-winged Blackbird	*Agelaius phoeniceus*
Violet-green Swallow	*Tachycineta thalassina*	Brewer's Blackbird	*Euphagus cyanocephalus*
Cliff Swallow	*Hirundo pyrrhonota*	Brown-headed Cowbird	*Molothrus ater*
Barn Swallow	*Hirundo rustica*	Bronzed Cowbird	*Molothrus aeneus*
Scrub Jay	*Aphelocoma coerulescens*	Great-tailed Grackle	*Quiscalus mexicanus*
Steller's Jay	*Cyanocitta stelleri*	Northern Oriole	*Icterus galbula*
Wrentit	*Chamaea fasciata*	Hooded Oriole	*Icterus cucullatus*
Tufted Titmouse	*Parus bicolor*	House Sparrow	*Passer domesticus*
Plain Titmouse	*Parus inornatus*	Lesser Goldfinch	*Carduelis psaltria*
Chestnut-backed Chickadee	*Parus rufescens*	House Finch	*Carpodacus mexicanus*

Attachment 12

Santa Clara County 2012

Chapter 5
Conservation Strategy

5.1 Summary

The conservation strategy was designed to meet the regulatory requirements of ESA and the NCCP Act and to streamline compliance with CEQA, NEPA, and other applicable environmental regulations (see discussion in Chapter 1). The conservation strategy provides mitigation for impacts on covered species on the basis of species and habitat needs. The conservation strategy mitigates all of the impacts described in Chapter 4, including direct, indirect, temporary, and permanent impacts. To meet the NCCP Act permit standards, the conservation strategy also contributes to species recovery to help to delist the listed species and prevent the listing of non-listed species through the protection, restoration, and enhancement of natural communities and species habitat. The conservation strategy also achieves the objectives listed below, pursuant to the NCCP Act (Section 2820).

- Conserves, restores, and provides for the management of representative natural and semi-natural[1] landscapes.
- Establishes reserves that provide conservation of covered species within the study area (i.e., contributes to species recovery) and linkages to adjacent habitat outside the study area.
- Protects and maintains habitat areas that are large enough to support sustainable populations of covered species.
- Incorporates in the reserves a range of environmental gradients and high habitat diversity to provide for shifting species distributions in response to changing circumstances.
- Sustains the effective movement and interchange of organisms between habitat areas in a manner that maintains the ecological integrity of the Reserve System.

Because the conservation strategy achieves the standards of the NCCP Act to contribute to species recovery, the strategy therefore exceeds the mitigation standards of the ESA. The conservation strategy is based on the best scientific data available at the time of its preparation and takes into account the limitations of the baseline data available for the study area (see Chapter 3 and **Appendix D**).

[1] A semi-natural landscape is defined as one that is disturbed by human activity but still provides important habitat for a variety of native species.

The conservation strategy is born out of the biological goals and objectives developed for the Plan and described below. To achieve these goals and objectives, a series of conservation actions have been developed that often meet multiple objectives or goals. The chapter is focused on conservation actions that will accomplish the following.

- Create a Reserve System by Year 45 of the permit term that will preserve a minimum of 33,205 acres and an estimated 33,629 if all impacts occur of newly acquired land for the benefit of covered species, natural communities, biological diversity, and ecosystem function.
- In addition to newly acquired land, incorporate 13,291 acres of existing open space into the Reserve System to enhance their long-term management.[2] The total size of the Reserve System will be at least 46,496 acres and up to an estimated 46,920 acres.
- Protect 100 miles of streams.
- Preserve major local and regional connections between key habitat areas and between existing protected areas.
- Establish a framework for long-term management of the Reserve System and streams throughout the permit area to enhance populations of covered species and maintain biological diversity.
- Restore minimum of 70 acres and up to 428 acres of riparian woodland and wetlands to offset losses of these land cover types and contribute to species recovery. All restoration construction will be completed by Year 40.
- Create a minimum of 20 acres and up to 72 acres of ponds to offset losses and contribute to species recovery. All creation construction will be completed by Year 40.

All of these actions will be accomplished by the Implementing Entity with partnerships with the Permittees, Santa Clara County Open Space Authority, landowners, possibly non-profit land conservation organizations, mitigation banks, and the state and federal government (see Chapter 9 for funding and land acquisition partnerships). This chapter does not describe avoidance and minimization actions; these and all other conditions on covered activities are addressed in Chapter 6.

5.2 Framework

The conservation strategy was designed using a multi-scale approach in accordance with principles of conservation biology. At the largest scale, biological goals and objectives were developed to encompass ecological

[2] This is the maximum acreage of existing open space that would be credited toward the Reserve System size under the Plan. Additional acres of existing open space could be incorporated into the Reserve System; however, they would not receive credit toward the Reserve System size. Alternatively, the Implementing Entity may acquire new lands for the Reserve System in place of adding this acreage from existing open space, as long as the total Reserve System size requirements are met.

processes, environmental gradients, biological diversity, and regional wildlife linkages. Conservation actions were developed to implement these goals and objectives. These conservation actions occur at the *landscape level*, generally at the scale of miles or tens of miles. At the middle level, conservation actions were developed to address natural communities primarily through the enhancement, restoration, and management of vegetation types (i.e., land cover types). This medium scale is called the *natural community level*. The final level addresses the specific needs of covered species for protection and enhancement of individuals, populations, and groups of populations. *Species-level* conservation actions were developed to supplement and focus actions developed at the broader levels and to ensure that all the needs of particular species are addressed.

This framework for the conservation strategy follows the multi-scale structure and approach advocated by Hunter (2005) that combines “coarse filter conservation,” “meso-filter conservation,” and “fine-filter conservation” (see **Figure 5-1**).

The conservation actions are described in Section 5.3 *Conservation Actions*; they are divided into land acquisition actions and actions at the natural community and species levels. All conservation actions are designed to have enough detail and specificity to allow implementation. Because of the large scale of this Plan and its long timeframe, actions are also designed to be flexible. For example, natural community–level actions provide broad management guidelines and principles such that future land managers can implement specific techniques on the ground that are best suited to site conditions. Preserving this flexibility is an important part of the conservation strategy.

Implementation of many actions will require the preparation of site-specific implementation documents. These plans will be prepared during Plan implementation after land is acquired and specific restoration and management needs are determined. Reserve unit management plans will guide activities within specific reserve units. Reserve units are defined as groups of contiguous or neighboring parcels that have similar natural communities, covered species, and infrastructure and therefore similar management issues. Reserve unit management plans for individual reserve units will be completed within 5 years of the first acquisition (fee title or easement) of the land for that reserve unit and submitted to the Wildlife Agencies for review and approval.

All conservation actions will be implemented using an adaptive management approach that is closely tied to long-term monitoring (see Chapter 7 *Monitoring and Adaptive Management Program*).

5.2.1 Biological Goals and Objectives

The Implementing Entity will achieve landscape, natural community, and species-level goals and objectives. Goals are broad, guiding principles based on the conservation needs of the resources. Biological objectives are expressed as conservation targets or desired conditions. Objectives are measurable and quantitative when possible; they clearly state a desired result and will collectively achieve the biological goals **Figure 5-2**). Biological goals for covered species are required by USFWS's *5-Point Policy* to be included in HCPs (65 FR 35242, June 1, 2000)[3].

All the biological goals and objectives on which this Plan is based are presented in **Tables 5-1a through 5-1d**. The conservation actions in this chapter contain detailed information on all aspects of reserve acquisition and management. They provide a strategy for how the goals and objectives will be achieved. It is expected that many of the details of the conservation actions will be modified during Plan implementation through the monitoring and adaptive management program, while goals and objectives will remain relatively static.

The 21 biological goals and 94 objectives in **Table 5-1** are organized by level: landscape level (**Table 5-1a**), natural community level (**Table 5-1b**) and species level (**Tables 5-1c and 5-1d**). At the species level, wildlife and plants are separated in order to make the tables more accessible. The 135 conservation actions that were designed to achieve each objective are shown in **Tables 5-2a and 5-2b**. **Table 5-2a** lists sequentially all land acquisition actions; **Table 5-2b** lists all management actions, broadly defined. One conservation action may contribute to multiple objectives or goals.

In some cases, conservation actions include the phrase "biologically appropriate" or "biologically feasible". These phrases were added to conservation actions such as plant occurrence creation (see Section 5.3.1 subheading *Incorporating Covered Plant Species* for the definition of a plant occurrence) that are highly dependent on site conditions and other ecological contexts. These conservation actions will be implemented unless the Implementing Entity, with the concurrence of the Wildlife Agencies, determines based on further evaluation that the action is not biologically appropriate or biologically feasible but the biological goals of the Plan would still be fulfilled by implementing a more effective conservation action.

If the agreed upon conservation actions cannot be implemented and there are no alternatives that provide similar benefit and will achieve the biological goals, as agreed to by the Wildlife Agencies and the Implementing Entity, then coverage of the target species may need to be modified, reduced, or eliminated according to the process described in Chapter 10, Section 10.3 *Modifications to the Plan*.

[3] Due to the scope of this Plan, it was not possible to develop biological goals and objectives that strictly adhered to the Service's and NMFS' 5-Point Policy requirements as described in 65 FR 35251. That is, despite best efforts, the scope of the Plan precluded the Applicants from developing biological objectives that in all instances included species or habitat indicators, locations, actions, quantify/state, and timeframe. This information is presented in this chapter, which will be supplemented by implementation plans that will be reviewed and approved by the Wildlife Agencies (i.e., reserve unit management plans).

Process of Developing Biological Goals and Objectives

The biological goals and objectives were initially developed through a series of six workshops composed of key technical staff from ICF Jones & Stokes, experts from the Wildlife Agencies, biologists and species experts from SCVWD, Local Partner staff, and outside species experts.

The purpose of each workshop was to collaboratively develop working draft biological goals and objectives. Each workshop began with an overview of the relevant natural communities and species, including key threats, ecological needs, and issues for the conservation strategy (e.g., potential conflicts with other species) by technical experts. Participants then worked through a set of preliminary draft goals and objectives developed by ICF and provided to participants prior to the workshop. Follow-up web-based conference calls or meetings were held at least once for every workshop to refine the goals and objectives to a point where all meeting participants were satisfied.

Every effort was made to create biological objectives that were quantitative as well as measurable. Workshop participants acknowledged that quantitative biological objectives may be somewhat subjective, but at least these quantitative objectives are explicit, clear, and transparent, and they serve as a starting point for conservation actions in the study area, including adaptive management and compliance monitoring (Margules and Pressey 2000).

Goals and objectives were frequently refined and updated as new analysis or new information was developed. In some cases, several possible quantitative targets emerged for an objective. These were carried forward as alternative approaches to meeting the same goal, and formed the basis for the alternative conservation strategies that preceded the selected conservation strategy. Biological goals and objectives were developed using the primary sources listed below.

- Ecological data from species accounts (**Appendix D**) and natural community descriptions (Chapter 3).
- Existing conservation targets or management recommendations for covered species in state or federal recovery plans or status reviews (Hays et al. 1999; U.S. Fish and Wildlife Service 1998a, 1998b, 1998c, 2002, 2006a).
- Other sources with conservation targets or conservation recommendations that address the covered species or the study area (Harrison et al. 1988; Weiss 1999; California Partners in Flight 2002; Klute et al. 2003; Ehrlich and Hanski 2004; Haight et al. 2004; Riparian Habitat Joint Venture 2004; Hamilton 2004; Trenham and Shaffer 2005; The Nature Conservancy 2006a).
- Critical habitat maps and data in published critical habitat rules for covered species (U.S. Fish and Wildlife Service, 2005, 2006b, 2008, 2010).
- Habitat distribution models developed for most of the covered species (see Chapter 3 and **Appendix D**).
- Results of the conservation gap analysis (see below).

- Input from resource specialists outside workshops including staff from the Wildlife Agencies.

When developing quantitative objectives, workshop participants recognized that conservation encompasses both mitigation and the need to contribute to species recovery. The level of this contribution to recovery was based, in part, on the proportion of the species' range within the study area. Quantitative biological objectives were established on the basis of relevant species-specific data. When data were not available, general guidelines or conservation "rules of thumb" were used to help establish quantitative biological objectives on the basis of the proportion of the species' current range within the study area (Margules and Pressey 2000) (**Table 5-3**).

Conservation of ecological processes, environmental gradients, regional biological diversity, and regional wildlife linkages were addressed primarily in the landscape-level biological goals and objectives. These goals and objectives were inherently difficult to develop because of the large scale of the processes and the general lack of data regarding their operation in the study area. The land cover mapping described in Chapter 3 was assumed to be an adequate surrogate for regional biological diversity. If adequate and representative stands of all of these land cover types are preserved and enhanced, it is assumed that native biological diversity in general will be preserved and enhanced.

Biological Goals

Most of the biological goals and objectives are designed at least to conserve current populations of covered and other native species in the study area. In some cases, populations of covered species are expected to increase as a result of land preservation, improved water management, habitat enhancement, habitat restoration, and habitat creation.

Goals are listed below by level (see **Tables 5-1a through 5-1d**): landscape level, natural community level, and species level. The biological goals apply only to the Reserve System unless stated otherwise. Though most conservation actions will occur within the Reserve System, similar conservation approaches on private lands outside of the Reserve System will be encouraged during implementation. In cases where species conservation will occur outside the Reserve System (e.g., stream and riparian restoration), biological goals apply to the study area as a whole.

Landscape-Level Goals (Table 5-1a)

- **Goal 1a.** Protect and maintain natural and semi-natural landscapes.
- **Goal 1b.** Protect and maintain ecological (natural) processes.
- **Goal 2.** Maintain or improve opportunities for movement and genetic exchange of native organisms within and between natural communities inside and connecting to areas outside the study area.

- **Goal 3.** Enhance or restore representative natural and semi-natural landscapes to maintain or increase native biological diversity.

Natural Community-Level Goals (Table 5-1b)

- **Goal 4.** Maintain and enhance functional grassland communities that benefit covered species and promote native biodiversity.
- **Goal 5.** Maintain and enhance functional chaparral and northern coastal scrub communities to benefit covered species and promote native biodiversity.
- **Goal 6.** Maintain and enhance functional oak woodland communities to benefit covered species and promote native biodiversity.
- **Goal 7.** Maintain and enhance functional conifer woodland communities to benefit covered species and promote native biodiversity.
- **Goal 8.** Improve the quality of streams and the hydrologic and geomorphic processes that support them to maintain a functional aquatic and riparian community to benefit covered species and promote native biodiversity.
- **Goal 9.** Maintain a functional riparian forest and scrub community at a variety of successional stages and improve these communities to benefit covered species and promote native biodiversity.
- **Goal 10.** Maintain, enhance, and create or restore functional pond, freshwater perennial wetland, and seasonal wetland habitats that benefit covered species and promote native biodiversity.

Species-Level Goals (Tables 5-1c and 5-1d)

- **Goal 11.** Improve the viability of existing Bay checkerspot butterfly populations, increase the number of populations, and expand the geographic distribution to ensure the long-term persistence of the species in the study area.
- **Goal 12.** Not used.
- **Goal 13.** Increase the size and sustainability of the breeding population and increase the distribution of breeding and wintering burrowing owls in the study area.
- **Goal 14.** Increase the ability of San Joaquin kit fox to move into and within the study area and provide habitat to increase the likelihood of breeding.
- **Goal 15.** Provide for the expansion of a breeding population of least Bell's vireos into the study area and increase reproductive success of least Bell's vireo.
- **Goal 16.** Conserve existing populations of the foothill yellow-legged frog population where possible and increase the overall population of foothill yellow-legged frog in biologically appropriate locations in the study area.

- **Goal 17.** Conserve existing populations of California red-legged frog, California tiger salamander, and western pond turtle where possible, and increase the number of individuals and expand the overall distribution of populations of these species in biologically appropriate locations within the study area to maintain viable populations and contribute to the regional recovery of these species.
- **Goal 18.** Increase the population size of tricolored blackbird to enhance the viability of the species in the study area.
- **Goal 19.** Not used.
- **Goal 20.** Maintain viability, protect, and increase the size and number of populations of covered serpentine plant species, including Coyote ceanothus, Santa Clara Valley dudleya, Metcalf Canyon jewelflower, most beautiful jewelflower, smooth lessingia, fragrant fritillary, Mt. Hamilton thistle, Loma Prieta hoita, and Tiburon paintbrush, within the study area.
- **Goal 21.** Protect and increase the size and number of Loma Prieta hoita within the study area.

5.2.2 Avoidance and Minimization Measures

As required by ESA, the Plan includes measures to avoid or minimize the impact of the taking of covered species. The primary focus of these measures is to avoid or minimize take of *individuals* of covered species (i.e., death or injury to species) and of high-quality habitat, such as streams and riparian areas that may be affected by covered activities. Others forms of take (e.g., harm or harassment of covered species) will still occur.

For example, an intent of certain measures is to encourage individuals of covered wildlife species to avoid or escape project construction zones. Occurrences of covered plants will also be avoided when adequate conservation of these species is not available within the Habitat Plan Reserve System. Activities within streams will be carefully designed and implemented to minimize their effects on this important resource and habitat for covered species. Impacts will also be minimized by requiring development projects adjacent to the Reserve System to be designed in ways that reduce their impacts on covered species and natural communities (as described in Chapter 6).

Areas designated for conservation and described in this chapter include substantial amounts of high-quality habitat for covered species and of natural communities, as well as areas important for maintaining regional biological diversity. Covered activities that result in permanent impacts are anticipated to occur primarily in areas with low-quality habitat. This *regional avoidance and minimization approach* to conservation of land cover and species habitat reduces the need to avoid or minimize impacts on habitats at the small or project scale. Avoidance and minimization measures at the landscape level are accordingly built into the Plan. Most habitat preservation and enhancement will be concentrated away from covered activities in the high-quality habitat of the proposed Reserve System. Avoidance and minimization measures that apply to covered activities are described in detail in Chapter 6.

5.2.3 Reserve System

Land preservation is an important component of this conservation strategy. The term *land preservation* is intended broadly to specify the acquisition of terrestrial and aquatic land cover types. Land will be acquired from willing sellers in fee title or through establishment of conservation easements to create the Habitat Plan Reserve System. Land acquisition mechanics and processes are described in more detail in the Section 5.3.1 *Land Acquisition and Restoration Actions.* In order to become part of the Reserve System, lands must:

1. be consistent with the conservation strategy described in this chapter;
2. be approved by the Implementing Entity and Wildlife Agencies; and
3. be protected with a conservation easement[4] (see Chapter 8 for additional information).

Because management of riparian and stream land cover types takes place both inside and outside the Reserve System, specific acquisition and management priorities related to aquatic habitat are described in Section 5.2.4 *Aquatic Habitat Protection and Enhancement.*

Reserve Design Process

The process for delineating and prioritizing land for acquisition corresponds to the scalar approach of the conservation actions (landscape-level, natural community-level, and species-level). First, consideration was given to large, core reserves that could accommodate large blocks of key land cover types (e.g., serpentine grassland) and covered species with large geographical ranges and specific habitat needs (e.g., areas with high densities of ponds to accommodate covered amphibians and reptiles). This level of design also considered expanding existing open space to create larger core reserves. Linkages were also considered so that habitat connectivity goals and objectives could be met (see discussion below). Next, the conservation of rare land cover types (e.g., serpentine seeps and rock outcrops) was considered. Finally, the conservation of species with small ranges was considered (e.g., covered plants). For resources not protected by the core reserves or the habitat linkages, smaller, "satellite" reserves will be proposed when necessary to protect isolated but important resources such as occurrences of covered plants and rare land cover types. In all cases, the Reserve System was designed to adhere to the reserve design principles discussed below with the least amount of acreage in order to efficiently achieve the conservation targets.

[4] The exception to the conservation easement requirement is existing lands listed in **Table 5-5** and owned by the Open Space Authority. See Chapter 9 for details.

Land use and economic factors in the Reserve System design were also considered in a step-wise manner. The first draft maps of the proposed Reserve System considered biological goals and objectives and maximized conservation benefit with the minimum amount of land. The second iteration of the maps took into account relevant land use and broad financial considerations. For example, areas with larger parcel sizes were selected over areas with very small parcels, all else being equal, due to the higher per-acre cost of small parcels. Areas without extensive rural development were favored over areas with such development, all else being equal, due to the habitat incursions and edge effects around rural development. In cases where the conservation priorities overlapped with covered activities, alternative conservation sites were sought. If an alternative conservation site was not available, then the covered activity was scaled back or dropped to allow for the conservation to occur. For example, urban development has been limited along stream corridors to ensure adequate conservation of stream and riparian systems (see Chapter 6, Condition 11 *Stream and Riparian Setbacks*). This step-wise approach enabled the proposed Reserve System to be developed independently from the covered activities but in a manner that quickly identified and resolved conflicts between them.

The independent Science Advisors and stakeholders provided early feedback on draft reserve design and assembly principles and the preliminary reserve design process. Reserve design alternatives were reviewed by all of the major land management and conservation organizations in the study area: County Parks, Open Space Authority, State Parks, The Nature Conservancy, and the Peninsula Open Space Trust, as well as staff from the Wildlife Agencies. Their valuable input was incorporated into the conservation strategy presented here.

Reserve Design and Assembly Principles

The reserve design process utilized scientifically accepted tenets of conservation biology in concert with the best available biological data (Noss et al. 1995). Information on species (e.g., population biology, genetics, distribution, life history characteristics) and information on habitats (e.g., distribution, composition, ecological functions) informed the reserve design process. Relevant ecological data for covered species are summarized in the species accounts in **Appendix D**.

To be successful, a reserve system must be designed in consideration of multiple ecologically relevant spatial levels. Most small- and medium-level considerations are driven by the needs of covered species and natural communities. For example, at a small level, a reserve system must contain the microhabitats necessary for local populations of the species to survive. At a medium level, habitat patches must be large enough to support populations or important portions of populations of species and the seasonal movement of species (e.g., aquatic habitat for winter breeding of amphibians and upland habitat for non-breeding periods). At a larger level, natural communities must be well represented, and reserves must be linked to allow movement of species for genetic exchange and for recolonization following local extirpation. Biological goals and objectives pertaining to the acquisition and management of the Reserve

System were developed at these three levels as discussed above (Section 5.2.1 *Biological Goals and Objectives*).

In addition to the biological goals and objectives, the principles of conservation biology summarized below (Soule and Wilcox 1980; Soule 1986; Primack 1993; Noss et al. 1997; Margules and Pressey 2000; Groom et al. 2006) were used as design criteria for the Reserve System. The reserve design and assembly principles must also be used to assemble the Reserve System during Plan implementation.

- **Maximize Size Efficiently.** The Reserve System will be as large as possible within funding and management limits. It must be large enough to mitigate impacts of covered activities and contribute to the recovery of covered species in the study area. A large reserve system is important to ensure viable populations or portions of populations of covered species, to maximize protection of species sensitive to disturbances from adjacent land use, and to maximize the protection of biodiversity. Large reserves tend to support more species for longer periods of time than small reserves. Large reserves are also generally easier to manage on a per-acre basis because, for example, a large reserve reduces conflicts that may arise when managing for covered species with very different habitat requirements. Large reserves also better allow for large-scale management treatments such as prescribed burning and livestock grazing and the maintenance of natural disturbance regimes such as flooding. The only way to maximize size within funding and other constraints is to protect areas efficiently.
- **Preserve Irreplaceable and Threatened Resources.** Irreplaceability is a measure of the degree to which conservation goals can be met by preservation of multiple sites. A site with high irreplaceability has unique species or natural communities that cannot be preserved or restored elsewhere. An example of an irreplaceable resource in the study area is serpentine grassland, which cannot be replaced elsewhere once lost. Threatened resources are those most under threat from natural or anthropogenic factors. The Reserve System will first protect biological diversity and natural communities that have a high level of irreplaceability and a high degree of threat.
- **Preserve the Highest-Quality Communities.** The Reserve System will preserve the highest-quality natural communities and habitat for covered species in the study area. *Highest quality* is defined using various parameters and differs according to community type, but highest-quality habitats are frequently characterized by a high abundance and diversity of native species, intact natural processes, and few roads or other evidence of human disturbances. Degraded communities may need to be preserved as well to capture unique habitats or populations of covered species, to link preserve areas together, or to provide opportunities for land cover restoration required by this Plan.
- **Preserve Connectivity.** The Reserve System will link existing protected areas and proposed reserves inside and outside the study area to maximize habitat connectivity. This will maintain and enhance the ability of organisms to move between reserves; facilitate exchange of genetic material, species

migration, dispersal, and colonization; and increase the integrity of the network of reserves (e.g., reducing the extent of reserve edge that is in contact with adjacent land uses). Linking reserves may require acquisition of disturbed habitats that can be restored to facilitate better habitat and wildlife movement value. A single large reserve is generally better than several small, linked reserves of equal area in the context of maintaining viable populations of species. In some cases, however, small or isolated reserves are necessary to protect certain features or populations with high biological importance (e.g., covered plant species populations, unique or especially diverse land cover types such as serpentine grassland or scrub). Preserving connectivity will also tend to minimize habitat fragmentation.

- **Minimize Edge.** The Reserve System will share a minimum amount of edge (i.e., will have the greatest possible area-to-perimeter ratio) with non-preserve land, especially urban development, to minimize the indirect effects of adjacent land uses on the preserve resources and to minimize management costs. For example, preserves will tend toward round or square configurations rather than long and narrow ones. In some cases, however, preserves with low area-to-perimeter ratios may be appropriate to protect linear features with high biological value, such as streams, riparian woodland, valley bottoms, or ridgelines essential to wildlife movement.
- **Buffer Urban Impacts.** When adjacent to existing urban areas or planned urban areas (i.e., areas zoned for urban development), the Reserve System will include buffer lands within its boundaries. The purpose of this buffer land is to reduce indirect effects on covered species and natural communities from urban development and to provide a zone for fuel load management to reduce the risk of wildland fire spreading to adjacent development[5]. The size of the buffer will depend on site-specific conditions such as topography, the intensity of adjacent urban development, the natural community being separated from the development, the condition of the buffer lands, and whether covered species are or will be present near these lands. (See the section on *Buffer Zones within the Reserve System* below and Chapter 6, Section 6.4.6, subheading *Condition 10 Fuel Buffer*.)
- **Fully Represent Environmental Gradients.** The Reserve System will include a range of contiguous environmental gradients (e.g., topography, elevation, soil types, geologic substrates, slopes, and aspects) to allow for shifting species distributions in response to catastrophic events (e.g., fire, prolonged drought) or anthropogenic change (e.g., global warming).
- **Consider Watersheds.** The Reserve System will include a full range of catchment types, including watersheds, subwatersheds, and headwater streams that are not already in protected status; this approach can help to maintain ecosystem function and aquatic habitat diversity.
- **Consider Full Ecological Diversity within Communities.** The Reserve System will reflect the full ecological diversity within natural communities (e.g., species composition, dominant species, physical and climatic factors) in order to maintain sufficient habitat diversity and species and population interactions. This principle is also called *representativeness* and

[5] Consistent with California Public Resources Code 4291.

comprehensiveness. Some of the diversity within each of the Habitat Plan land cover types is described in Chapter 3.

- **Consider Management Needs.** Reserves will be manageable. That is, desired management treatments such as livestock grazing, prescribed burning, or invasive species control must be feasible on the reserve units and within the Reserve System. In general, larger reserves are easier to manage on a per-acre basis, but other factors such as adjacent land uses, topography, and parcel configuration must also be considered. Management needs may be driven by factors on or off site (e.g., adjacent land uses, watershed processes such as upstream erosion or ongoing contamination).

Requirements of Covered Species

The Reserve System is intended to preserve and in many cases enhance populations of covered species. The ecological information used to determine the needs of covered species is summarized in the species accounts (**Appendix D**) and in this chapter.

All Covered Species

The principles listed below, which apply to all covered species, were used to design the Reserve System and will be used to assemble the Reserve System during implementation.

- **Protect Multiple Populations of Covered Species.** In order to maintain viable populations of covered species, multiple populations of covered species will need to be protected and linked through existing or new protected lands to reduce the risk of local extirpation and ensure the genetic connectivity of populations. This is especially important for species that may function as metapopulations[6] or for species that naturally occur at low density or small population sizes.
- **Protect Higher-Quality Habitat for Covered Species.** Habitat Plan reserves were designed to protect the highest-quality habitat for covered species and allow most impacts to occur in lower-quality habitat.
- **Protect Suitable but Unoccupied Habitat for Covered Species.** Protecting suitable but unoccupied habitat for covered species creates opportunities to enhance habitat through improved management, attracting species to new areas and expanding their ranges and population sizes. Protecting unoccupied habitat also allows for future shifts in populations in response to natural and anthropogenic environmental change.

Consistent with the reserve design approach described above, the needs of covered species were considered at the landscape and habitat levels, and then

[6] A *metapopulation* is a group of partially isolated populations belonging to the same species that are connected by pathways of immigration and emigration. Exchange of individuals occurs between such populations, enabling recolonization of sites from which the species has recently become extirpated (locally extinct).

independently at the species level to ensure that each species' biological goals and objectives would be met. The conservation strategy in this Plan applies a "multi-species umbrella" approach (Lambeck 1997), where the species selected as covered species are the ones in the study area most under threat (i.e., those already listed or most likely to become listed during the permit term).

Bay Checkerspot Butterfly

Early in the development of this Plan, it was recognized that one covered species, Bay checkerspot butterfly, would greatly influence the design of the Reserve System, particularly for the serpentine grassland land cover type. Because the study area supports all of the known populations and individuals of this subspecies throughout its range, a relatively high conservation target was set to protect it so that this Plan could contribute substantially to its recovery (**Table 5-1c**). Many of the serpentine plant occurrences also coincide with habitat for Bay checkerspot butterfly. In this sense, Bay checkerspot butterfly serves as an umbrella species[7] for many serpentine plants. For these reasons, the reserve design process began by determining the preservation needs of Bay checkerspot butterfly.

The reserve design for this species was a major focus of discussion at the biological goals and objective workshop held for serpentine species. The reserve design for Bay checkerspot butterfly had the benefit of extensive previous research and recommendations for specific reserve design strategies (e.g., Thomas Reid Associates et al. 1985; Harrison et al. 1988; Murphy 1988; Weiss et al. 1988; Murphy et al. 1990; Hanski et al. 2004). In addition, the USFWS Recovery Plan and revised critical habitat designation recommend specific land acquisition actions that could result in delisting of the subspecies (U.S. Fish and Wildlife Service 1998c, 2008). Many of these recommended actions were incorporated into the conservation strategy.

Existing Open Space in the Reserve System

An estimated 117,686 acres, or 26% of the study area, are protected as Type 1, 2, 3, or 4 open space. These areas are already owned by public agencies or private conservation organizations or are subject to private conservation easements (**Figure 2-3**, **Table 2-2**, and **Table 5-4**). Type 1 open space is protected in perpetuity for the specific purpose of managing and protecting ecological integrity. Type 2 lands are also managed for the preservation of ecological integrity, but are not protected in perpetuity. Although ecological protection is not the primary management goal, Type 3 open space lands still provide some level of ecological value and function. Type 4 open space lands are not managed for ecological integrity and they offer little or no long-term or measurable ecological value. (See Chapter 2, Section 2.2.5 *Protection and Resource*

[7] *Umbrella species* are species whose occupancy areas are large enough and whose habitat requirements are broad enough that, once protection is established, it will bring other species under that same protection (e.g., Lambeck 1997; Fleishman et al. 2000; Rubinoff 2001).

Management Status of Open Space Lands for more discussion and examples of open space types.)

The Reserve System was designed to take advantage of the substantial amount of open space land already conserved within the study area. Existing Type 2 or 3 open space in the study area that contributes to the biological goals and objectives of the Plan are proposed for inclusion in the Reserve System as *existing open space***.** Enrolled existing open space must conduct their management and monitoring according to the requirements and guidelines outlined in this conservation strategy and in Chapter 7 *Adaptive Management and Monitoring Program*. In many cases, this new obligation represents a substantial improvement over the type and level of habitat and species management and monitoring practices that are currently in place. In other cases, this requirement will simply standardize management and monitoring to provide a cohesive Reserve System throughout the study area, and ensure consistent management and monitoring in perpetuity. This upgrade and standardization of management and monitoring on existing open space therefore constitutes an important part of this conservation strategy.

To determine which existing open space would be eligible for the Reserve System, the criteria listed below were applied to all existing Type 2 or 3 open space.

- The site contributes to the biological goals and objectives of this Plan and meets many of the reserve design principles described above.
- The site provides clear opportunities for habitat enhancement that would provide substantial benefits to one or more covered species.
- The site is owned by one of the Permittees and the management agency cannot afford to conduct biologically appropriate habitat management, enhancement, or long-term monitoring.
- Land uses on and surrounding the site are compatible with the management and monitoring required by the Plan (e.g., if the site is small, adjacent land uses will not preclude use of necessary management actions).

Existing Type 2 or 3 open space sites proposed for inclusion in the Reserve System are listed in **Table 5-5** and illustrated on **Figure 5-4**. This table also lists how these areas will be enhanced and how they will contribute to the biological goals and objectives of the Plan. **Table 5-5** lists six park units owned by County Parks. Up to 1,000 acres of lands owned by the Open Space Authority may also be included in the Reserve System. State Park lands were also considered for the Reserve System but were not included because that agency declined to participate in this Plan. The Implementing Entity, with review and approval by the Wildlife Agencies, may incorporate existing open space not included in **Table 5-5** or shown in **Figure 5-4** if it is determined that other lands are able to support the biological goals and objectives of the Plan.

For a site to qualify and receive credit as part of the Reserve System, the Implementing Entity will obtain a conservation easement or similar mechanism that is approved by the Wildlife Agencies over these lands. The conservation easement (or similar mechanism) will ensure that these lands are managed and monitored in perpetuity as part of the Reserve System and in accordance with the terms of the Habitat Plan (see Chapter 8, Section 8.6.3 *Conservation Easements* for details).

Conservation Gap Analysis

A key step in the development of a conservation strategy for a regional HCP or NCCP is to determine the existing level of protection for natural communities and covered species. Species or natural communities with low levels of existing protection may require greater emphasis in the Plan to ensure that their conservation in the study area is assured and the regulatory requirements of the NCCP Act are met. In contrast, species or natural communities that are well protected may need little or no additional protection by the Plan. For these species, the conservation strategy may instead focus on habitat restoration or improved habitat management. For all species it is expected that enhanced management and monitoring on existing and new protected lands will be needed.

The analysis conducted to determine the levels of existing protection of species and natural communities is called a *conservation gap analysis*. The methods used were based on similar approaches applied at the national, state, and local levels (Scott et al. 1993, 2001; Wild 2002).

The gap analysis was used as a preliminary step in the conservation planning process to guide the reserve design process. Conservation biology theory holds that by protecting a wide variety of ecosystems and natural communities or land cover types at a broad level (i.e., a coarse-filter and meso-filter approach; see **Figure 5-3**), the majority of the biological diversity contained within these natural communities will also be protected (Noss 1987; Hunter 2005). This approach is then complemented by focusing on finer-level resources such as species occurrences, species habitat, or unique physical features to conserve biological diversity not protected by the broader-level approaches.

Conservation Gaps in the Study Area

To determine the gaps in protection in the study area, the following GIS data layers were overlaid with the open space Types 1, 2, and 3 layer (**Figure 2-3**).

- Land cover (see Chapter 3 and **Figure 3-10**).
- Species habitat distribution (see Chapter 3 for a general description of these models and **Appendix D** for the model parameters for each species).
- Watersheds (see **Figure 3-6**).

The results of the conservation gap analyses are presented in **Table 5-4** for land cover types and **Table 5-6** for covered species. Data are presented by open space Types 1, 2, 3, and 4 (see Chapter 2 for a definition of open space types). Because of the importance of protecting substantial portions of occupied and suitable habitat for Bay checkerspot butterfly, **Table 5-7** presents the gap analysis for the individual populations recognized in the species account (**Appendix D**). Together, these results constituted a key input to the conservation strategy and the design of the Reserve System.

Gaps in Land Cover and Watershed Protection

Many natural land cover types have greater than 30% of their extent in open space Types 1, 2 or 3 (**Table 5-4**). Natural land cover types that are generally well represented in the study area in open space (>40%) are mixed oak woodland and forest, ponderosa pine woodland, coastal and valley freshwater marsh, willow riparian forest and scrub, blue oak woodland, seasonal wetland, reservoir, and central California sycamore alluvial woodland. Natural land cover types with the lowest proportion in open space overall and where the conservation gaps are most likely to occur are knobcone pine woodland, coast live oak forest and woodland, rock outcrop, serpentine rock outcrop, northern mixed chaparral/chamise chaparral, mixed riparian forest and woodland, and California annual grassland. Agricultural land cover types are poorly represented in open space in the study area.

Of the five major watersheds in the study area (Coyote, Pacheco, Llagas, Guadalupe, and Uvas), Type 1, 2, 3, or 4 open space is greatest in quantity and proportion in the Pacheco and Uvas watersheds (34 and 20%, respectively). The Alameda and Guadalupe watersheds have the least representation in open space Types 1, 2, 3, or 4 (1% each), followed by the Uvas and Llagas watersheds (15% each). In all five watersheds, the majority of land in open space is upstream of reservoirs. There is no Type 1, 2, 3, or 4 open space in the portion of the Santa Cruz Mountains watershed—which includes the headwaters of Pescadero Creek—within the study area (7,209 acres).

Of the 2,392 miles of mapped USGS blue line streams within the study area, approximately 34% are within Type 1, 2, or 3 open space. The Plan will also provide additional protection for ephemeral streams that are not mapped. The level of protection for these streams is generally high with approximately 16% in irrevocable protection and 34% of streams in Types 1, 2, or 3 open space.

Gaps in Species Protection

As shown in **Table 5-6**, most covered species with models have moderate levels of representation in open space Types 1, 2, and 3, between 25% and 50%. Exceptions to this are San Joaquin kit fox secondary habitat and secondary habitat (low use); western burrowing owl overwintering, occupied nesting, and potential nesting habitat; tricolored blackbird secondary habitat; least Bell's vireo primary habitat; Loma Prieta hoita secondary habitat, and most beautiful jewelflower secondary habitat. Potential breeding habitat for least Bell's vireo is particularly underrepresented in Type 1, 2, or 3 open space (11%). No species' habitat occurs in open space Types 1, 2, and 3 above 50%.

Table 5-7 presents more detail on the status of protection for all Bay checkerspot butterfly populations in the study area, because this species is one of the key species used to design the conservation strategy. As described in the biological goals and objectives for this species (**Table 5-1c**), some populations are targeted for conservation. Of these targeted populations, more than two-thirds are in need of long-term protection, and the level of occurrence in open space by population varies from zero to 100%.

Regional and State Gaps

Gap analyses conducted at scales larger than the study area were also considered to determine whether land cover types in the study area are underrepresented in Type 1, 2, or 3 open space compared to other regions or to regional conservation targets. For example, the conservation strategy in this Plan will contribute to regional conservation goals for land cover types found throughout the region.

Analysis at the regional scale entailed consulting a gap analysis conducted in the nine-county San Francisco Bay Area (Wild 2002). Although that study was conducted using an older and much coarser dataset[8], it provided a wider regional context and helped to inform conservation priorities for the Habitat Plan. This study utilized a system of open space classification (based on Davis et al. 1998) similar to the one used in this Plan. **Table 5-8** lists the vegetative communities that are found in the study area (equivalent to Habitat Plan land cover types) that were identified as being underrepresented in protected status in the San Francisco Bay Area. Data are also presented in **Table 5-8** on the level of protection of these vegetation communities at the state level (Davis et al. 1998).

Landscape Linkages

Landscape linkages were also used to design the Reserve System. For the purposes of this Plan, landscape linkages are defined as areas that allow for the movement of species from one area of suitable habitat to another. A linkage can vary from a narrow strip of habitat that only functions as a conduit for movement (i.e., a corridor) or a large area of intact habitat that is used for movement, dispersal, and other life functions such as foraging and breeding.

The NCCP Act explicitly requires NCCPs to address landscape or habitat linkages, as shown below.

> Establishing one or more reserves or other measures that provide equivalent conservation of covered species within the plan area and linkages between them and adjacent habitat areas outside of the plan area. (Section 2820[a][4][B].)
>
> Sustaining the effective movement and interchange of organisms between habitat areas in a manner that maintains the ecological integrity of the habitat areas within the plan area. (Section 2820[a][4][E].)

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[8] This analysis utilized land cover data from the California Gap Analysis Project (Davis et al. 1998), which used aerial photography from 1990 and minimum mapping units of 247 acres (100 hectares) for upland communities and 98.8 acres (40 hectares) for wetland communities. In addition, the open space data are from 2002.

Some species require linkages for periodic migrations among different habitat types used for breeding, feeding, or roosting. Wildlife movement from one important habitat area to another may vary from daily to seasonal migration depending on the species. Linkages may also be needed for the permanent immigration or emigration of individuals among habitat patches, allowing for gene flow and recolonization after local extinction (Beier and Noss 2000; Hilty et al. 2006; Groom et al. 2006).

Linkage requirements differ greatly from species to species. Specific characteristics of linkages, such as dimensions, location, and quality of habitat, can influence species use. Wider linkages tend to be more effective than narrower linkages (Merenlender and Crawford 1998; Hilty et al. 2006).

To incorporate landscape linkages in the reserve design process, all known or potential linkages within the study area and in the surrounding areas were compiled from the following sources, in no particular order.

- Statewide assessment of wildlife linkages needs developed by expert opinions of wildlife biologists (California Wilderness Coalition 2002).
- Ecoregional planning process conducted for the central coast region (The Nature Conservancy 2006b).
- A study of movement needs of mountain lions estimated by least-cost path analysis of regional land cover data (Thorne et al. 2002).
- A local workshop on wildlife linkages in the Sierra Azul region[9] held on October 11, 2006 (Coastal Training Program, Elkhorn Slough National Estuarine Research Reserve 2006).
- Wildlife movement data from the study area for American badgers (Diamond 2006; T. Diamond pers. comm.), Tule elk (Coletto 2006; H. Coletto pers. comm.), bobcat, and other species (T. Diamond pers. comm.).
- Locations of existing culverts, bridges, and other overpasses suitable for wildlife along U.S. 101 between Metcalf Road in San José and the Coyote Creek bridge crossing near Morgan Hill (California Department of Fish and Game 2006).
- Locations of median barriers and existing culverts, bridges, and other overpasses suitable for wildlife along SR 152 between the SR 156 interchange and the Santa Clara/Merced County line (data collected by Jones & Stokes in February 2007).
- *Coyote Valley Specific Plan Draft Environmental Impact Report* (City of San José 2007).

Potential dispersal routes for plants and wildlife covered by the Plan were also inferred from the land cover data, compiled occurrence data, and habitat distribution models developed for this Plan (see Chapter 3 and **Appendix D**).

[9] The Sierra Azul region was defined to encompass the southern portion of the Santa Cruz Mountains south of Highway 17, the Diablo Range, and the Gabilan Range. The workshop focused on issues of connectivity between the Santa Cruz Mountains and the Diablo and Santa Lucia mountain ranges to the east and south.

The results of the compilation of these sources are described in **Table 5-9** as 20 distinct and potential landscape linkages found either entirely within the study area or within the study area that lead to outside the study area. **Figure 5-6** illustrates these 20 potential linkages, which are discussed below for their relative importance to the Habitat Plan. These linkages are drawn at a regional level as broad swaths of natural land cover types rather than specific alignments or corridors. Often there are multiple ways to protect land to achieve the linkage design in **Figure 5-6** and the goals in **Table 5-9**.

Regional Connectivity

Maintaining linkages with areas outside the study area (i.e., regional habitat connectivity) is essential to retaining a high level of native biological diversity within the study area. For example, the southeast part of the study area may be an important linkage within the Diablo Range to the north and south (Linkage 15). The San Luis Reservoir in Merced County forms a significant barrier to terrestrial wildlife moving through the eastern Diablo Range, and the study area includes most of the Diablo Range west of the reservoir. Habitat continuity in this area likely benefits species such as San Joaquin kit fox. If kit foxes move from the Salinas Valley to the San Luis Reservoir area in Merced and Stanislaus Counties, they may use the southeastern part of the study area as a secondary route around the San Luis Reservoir.

The Santa Cruz Mountains on the western edge of the study area provide a connection for wide-ranging species between the Santa Cruz Mountains in Santa Cruz and San Mateo Counties and the Gabilan Range to the south. This connection is most apparent at the southern tip of the study area (Linkages 19 and 20) where there is a narrow linkage through the "Chittenden Gap" in Santa Cruz County to the Gabilan Range and the Santa Lucia Range to the south. If linkages like this are severed, populations of wide-ranging species (e.g., mountain lion) could be extirpated from the Santa Cruz Mountains because that range is likely insufficient in size to sustain a viable mountain lion population on its own (Thorne et al. 2002; Coastal Training Program 2006).

Connectivity within the Study Area

Within the study area, many landscape linkages are important to maintain connections among populations. For example, the major stream corridors of Coyote Creek, Guadalupe River, Pacheco Creek, Uvas Creek, Llagas Creek, Pajaro River (Linkages 1, 2, 11, 12, 17, 18), and Pescadero Creek all support native fish species. These corridors also provide critical connections for other aquatic and terrestrial species moving through urban or cultivated agricultural areas.

There is considerable existing open space in the Santa Cruz Mountains both inside and outside the study area (**Figure 2-3**). Additional linkages could be made between existing open space within the study area (Linkages 9 and 13).

Such connectivity would benefit covered species such as California tiger salamander, California red-legged frog, and foothill yellow-legged frog, and other native species such as Coast Range newt, bobcat, and mountain lion.

Protected areas adjacent to Henry W. Coe State Park form a large nucleus of open space within the study area. These protected areas already provide landscape linkages for species such as California red-legged frog, California tiger salamander, Tule elk, American badger, bobcat, mountain lion, and mule deer. Additional landscape linkages would connect this large core open space with smaller protected areas and with key features outside the study area (e.g., Linkages 5, 6, 7, 14, 15, and 16).

Linking the Santa Cruz Mountains and the Diablo Range

Historically, the Santa Cruz Mountains and the Diablo Range were linked across the Santa Clara Valley through a network of creeks, wetland complexes, and large stands of valley oak woodland (San Francisco Estuary Institute 2006). Over time this linkage has diminished with urban development, road barriers, and cultivated agriculture. Because some of the valley floor has remained in agricultural production and the creek corridors are largely intact, some connectivity remains (Linkages 8 and 10). There has been considerable debate recently about the best means to maintain this important connectivity between the Santa Cruz Mountains and the Diablo Range within the study area (Coastal Training Program 2006; City of San José 2007).

The connectivity between the Santa Cruz Mountains and the Diablo Range is expected to degrade further as covered activities are implemented. For example, development within Morgan Hill and Gilroy will make it more difficult for some wildlife species to cross the valley floor. While the Habitat Plan does not authorize incidental take associated with urban development in the Coyote Valley Urban Reserve at the southern end of San José, continued rural growth is expected to contribute to some long-term degradation (see Chapter 4). An important conservation objective of this Plan is to preserve and enhance the linkage between the two ranges (see Goal 2 in **Table 5-1a**). See landscape-level conservation actions in Section 5.3.2 *Landscape Conservation and Management* for more details.

The Use of Maps to Define the Reserve System

Regional conservation plans take a variety of approaches in the use of maps to display land acquisition requirements. At one end of the spectrum, a conservation plan may use maps to delineate exactly where reserves are to be created. In this type of plan, often called a *map-based plan*, map designations define the application of regulations, fees, land acquisition, restoration, or other elements of the plan. Because all landowners must agree to the designation placed on their lands, purely map-based plans (otherwise known as *hard boundary* or *hard line* plans) are difficult to develop on a large scale and are rare.

At the other end of the spectrum, a conservation plan may display no maps or only very general maps and instead include a *process-based* land acquisition strategy. A purely process-based plan (also known as a *policy-based* or *criteria-based* plan) has no maps of where reserves will be established or other mitigation accomplished. Instead, the conservation plan outlines a detailed process by which reserves are assembled according to a set of clear criteria. The amount of flexibility in a process-based plan depends on the flexibility of the reserve assembly criteria.

The Local Partners considered the full range of available approaches and chose to employ a combination of these strategies. This Plan uses a hybrid approach in which maps display conservation priorities on a regional scale. Land acquisition will be undertaken in accordance with a detailed set of requirements, while maintaining flexibility in how the Reserve System is ultimately assembled. Although the final boundaries of the system cannot be known, the general location, size, configuration, and protected resources of the reserves are described in the conservation actions below. The Local Partners considered this element of the Plan to be essential to its success.

Geographic Units of Conservation

The study area was subdivided into 34 discrete units called *conservation analysis zones* (**Figure 5-5**) to identify locations for conservation actions consistent with the hybrid approach to the use of maps described above. These zones define the areas in which conservation actions could occur outside existing protected areas. The primary purpose of these zones is to describe the specific areas in which conservation actions such as land acquisition will occur without identifying individual parcels. This focuses the conservation actions in a spatially explicit manner while maintaining the flexibility to conduct these actions on different parcels to meet the same conservation objectives (i.e., to respond to willing sellers where they arise). The arrangement of the zones also provides a mechanism to apply conservation actions at several spatial scales using consistent units (e.g., within a watershed, within a combination of zones, or within a single zone).

The conservation analysis zones were developed using subwatershed boundaries from the California Department of Water Resources (Calwater 221) that were aligned with the watershed boundaries used by the Habitat Plan. Existing open space (Types 1–3) was excluded from the zones. Subwatersheds smaller than 3,000 acres were merged with their adjacent larger subwatershed within the same watershed. Other adjustments were made to the zone boundaries to facilitate the conservation strategy; for example, the large Santa Clara Valley subwatershed that includes lower Llagas Creek was split into two subwatersheds for planning purposes[10]. Subwatersheds with mostly urbanized areas were also merged for convenience.

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[10] In addition, the subwatershed surrounding Anderson Reservoir was merged with the adjacent three subwatersheds to create a less fragmented conservation planning unit.

Conservation analysis zones were defined within the six primary watersheds of the study area: Guadalupe, Coyote, Llagas, Uvas, Pacheco, and Pescadero (**Figure 5-5**). The portions of the study area within the Calabazas and San Tomas watersheds were combined into a single conservation analysis zone. Conservation analysis zones were numbered sequentially within each watershed generally from headwaters to their exit from the study area. The size and land cover types found in each conservation analysis watershed is shown in **Table 5-10**.

Reserve Assembly Process

The Implementing Entity will establish the Reserve System through acquisition of land in fee title, conservation easement, or purchase of credits at an approved mitigation bank. Lands will only be acquired from willing sellers or donors and lands must meet one or more of the biological goals and objectives and the land acquisition requirements described below. The Implementing Entity will assemble the Reserve System in any of the following ways.

- Inclusion of land owned by a Permittee by conservation easement.
- Purchase of land in fee title from willing sellers.
- Purchase of conservation easements from willing sellers.
- Purchase of land or conservation easements in partnership with other organization(s) (not to be used as mitigation for another project that is not a covered activity).
- Acceptance of land or easement dedication in lieu of some development fees if the easement contributes to the goals and objectives of the Habitat Plan and is approved by the Implementing Entity and the Wildlife Agencies.
- Acceptance of credits sold in private mitigation banks approved by USFWS and CDFG if they meet the terms of the Plan (see Chapter 8, Section 8.6.2 *Land Acquired by Other Organizations or through Partnerships*, subheading, *Private Mitigation Banks*).
- Acceptance of land or easement dedication as a gift or charitable donation.

Acquisition of land in fee title or use of conservation easements will likely be the primary mechanisms used in most conservation analysis zones. Conservation easements will be used when the property owner wishes to enter that type of arrangement rather than sell land in fee title. The terms of each conservation easement may be tailored to each landowner and parcel, but will be consistent with goals of the conservation strategy, the general principles for easements outlined in this Plan (see Chapter 8), and the guidelines in the Implementing Agreement. The land and conservation easement acquisition process and the conditions under which the other four reserve assembly techniques may be used are discussed in detail in Chapter 8.

To achieve the Plan's biological goals and objectives, including contribution to the recovery of covered species, it is important to focus land acquisition where it will have the greatest conservation benefit. By concentrating land acquisition in certain areas, larger effective reserves can be assembled by augmenting and connecting existing protected lands. However, the Implementing Entity must have flexibility in deciding where to acquire land because the Plan depends on the availability of willing sellers. The Plan balances these needs by focusing acquisition of certain land cover types within certain conservation analysis zones, as described below.

Despite this flexibility, the Implementing Entity will prioritize land acquisition in order to buy parcels of greatest conservation value (e.g., see *Reserve Design and Assembly Principles*, above) under the greatest threat of development and whose cost is expected to rise fastest. These criteria are met in conservation areas that span the floor of the Santa Clara Valley (Coyote-7, Llagas-3, Llagas-4) and the foothills immediately adjacent to the valley floor (Guadalupe 1, 3; Coyote-7, 8; Llagas-2, 3, 4; Uvas-1, 2, 5, 6; Pescadero-1).

When possible, land will first be acquired adjacent to existing protected areas to ensure that, in the unlikely event that funding does not become available for full acquisition of the Reserve System (see Chapter 9 for details), the Reserve System is composed of contiguous units rather than isolated parcels.

Field Verification Prior to Acquisition

Land cover data, species occurrence data, and species habitat distribution models were developed for this Plan at a regional scale. The data and models were used to develop a sound conservation strategy for the study area at this regional scale. These data and models are not intended for site-specific planning because of the limitations described in Chapter 3.

To account for some of the uncertainty inherent in this conservation strategy, biological resources in potential conservation areas will, whenever possible, be verified in the field prior to land acquisition. The Implementing Entity will conduct *pre-acquisition assessments* on potential reserve lands to evaluate whether these lands are likely to meet Plan requirements. If a pre-acquisition assessment is not feasible, the Implementing Entity will conduct an assessment of the site based on air photo analysis and the best available regional data sets (e.g., Habitat Plan data, CNDDB).

The biological suitability of the site for the Reserve System will be determined on the basis of the information listed below.

- The results of past biological surveys, updated land cover mapping, assessments of habitat suitability for covered species, air photo interpretation, and the biological resources present or expected on site.
- An evaluation of the site's enhancement and restoration potential.
- An evaluation of how well the site achieves the reserve design principles listed above.

- An evaluation of the site's existing and potential biological value in the context of the remaining unmet biological goals and objectives and land acquisition requirements.

Types of information collected during these assessments will include an evaluation of location, quantity, quality, and type of covered species populations; covered species habitat; and natural communities present, as well as other site conditions or infrastructure that would benefit or conflict with the Plan's biological goals and objectives. The site's restoration and enhancement potential will also be evaluated. This information will help the Implementing Entity prioritize acquisition of reserve lands based on their relative contribution toward meeting the biological goals and objectives. More details on pre-acquisition assessments are found in Chapter 8.

5.2.4 Aquatic Habitat Protection and Enhancement

Protection and enhancement of aquatic habitat for covered species and other native species is an important goal of this Plan. Protection of off-stream aquatic habitats will be accomplished through the land acquisition process described below and through the stream and riparian setback requirement described in Chapter 6 (see Section 6.5, subheading *Condition 11 Stream and Riparian Setbacks*). In addition, the Plan requires restoration of aquatic land cover types to ensure no net loss in their extent and function within the study area.

The approach to stream and riparian woodland land cover protection and enhancement combines elements of land acquisition, restoration, and water management. The land acquisition strategy focuses on stream protection primarily in areas where large stands of riparian woodland are present, such as along Pacheco Creek, San Felipe Creek, and upper Uvas Creek. This focus has the dual benefit of protecting streams and riparian woodland habitats. Stream protection through land acquisition will also occur in areas most suitable for riparian woodland restoration to support covered birds, amphibians, reptiles, and native fish species.

Stream and riparian protection will also occur through the development review process when projects are proposed adjacent to streams. Through the stream and riparian setbacks condition (Condition 11 described in Chapter 6), applicants will be required to set aside stream frontage to protect stream and riparian functions. In some cases, high-value stream setback areas will be incorporated into the Reserve System to increase opportunities for riparian and stream restoration, and provide greater consistency in management and monitoring of these areas.

To enhance habitat for native fish species and covered amphibian and riparian bird species, broader strategies are needed than riparian woodland restoration in specific locations. To contribute to the recovery of covered amphibians and reptiles, the Plan will acquire and enhance upper watershed streams and associated upland riparian habitat throughout the study area. To enhance habitat for least Bell's vireo and other native songbirds, the Plan will provide riparian restoration opportunities along Llagas Creek, Pacheco Creek, Uvas Creek, and the Pajaro River.

5.2.5 Land Management

The primary means of mitigating impacts on and conserving covered species and natural communities is preservation of high-quality habitat in accordance with the reserve design criteria outlined above. In order to meet regulatory requirements and to contribute to the recovery of covered species, habitat enhancement, restoration, and creation are also important components of the conservation strategy. Some land cover types that are lost to covered activities will be replaced with the same or similar communities or land cover types within the Habitat Plan reserves. Habitat enhancement, restoration, and creation ensure that there will be no net loss of certain resources (e.g., wetlands, breeding habitat for specific covered species). In other cases, restoration and enhancement are used to supplement preservation to adequately conserve land cover types or covered species habitat.

Some habitat-restoration requirements exceed those typically required for individual mitigation in order to contribute to the recovery or prevent listing of covered species that these habitats support. (These greater restoration requirements are also proportional to the stronger regulatory assurances provided by CDFG to the Permittees and private developers within the participating jurisdictions.) Depending on the resource, creation, restoration, or enhancement is required as part of the conservation strategy. Habitat enhancement, restoration, and creation will occur in addition to, not as a substitute for, land preservation. Success criteria for habitat enhancement, restoration, and creation will be based in part on reference stands in the region. Reference stands will be selected based on their condition as representative of high-quality communities in the study area. Such use of reference stands will allow habitat enhancement, restoration, and creation plans to incorporate any unique regional characteristics of these habitats. Each of these terms is defined below.

Definitions

Appendix A *Glossary* has a complete list of definitions used in this Plan. The following are selected key definitions critical to the conservation strategy.

Habitat Enhancement

Habitat enhancement is the manipulation of the physical, chemical, or biological characteristics of a land cover type to heighten, intensify, or improve one or more specific existing ecological function(s). Enhancement results in the gain of selected existing ecological function(s), but may also lead to a decline in other ecological function(s). Habitat enhancement implemented in the Reserve System will result in an increase or improvement in specific ecological function without a change in the amount of land cover types. Examples of ecological functions include native species richness, species diversity, native vegetative cover, and wildlife habitat.

Examples of habitat enhancement include:

- Planting valley oak seedlings in an existing stand of valley oaks to increase oak cover and density and improve the age-class structure of the valley oak population.
- Manipulating the growth stage composition of vegetation on a site.
- The reduction or removal of one or more threats to covered species or natural communities, including:
- The treatment and removal of invasive species including bullfrog removal, weed abatement, and prescribed burning (see **Appendix D** for a discussion of threats to each covered species).
- Permanently protecting Reserve System lands to remove threats of development, overcollecting, overgrazing, lack of grazing, and others.
- Fencing installation and repair to support improved livestock grazing and prevent unauthorized access.
- Reducing hazards to animal movement by adding or resizing culverts or reducing traffic on private roads within the Reserve System.

Enhancement actions will differ according to each natural community and site. For example, some communities in the study area have inherently low productivity, low species richness, or low vegetation cover. Enhancement of these communities may be measured by an increase in relative cover of native plants or a decrease in inappropriate disturbance.

The appropriate type of habitat enhancement will be considered on a site-by-site basis by the Implementing Entity within the context of the entire Reserve System and Plan goals and objectives. Habitat enhancement will occur on all lands preserved in the Reserve System. The level of habitat enhancement will vary greatly within the Reserve System. For example, degraded communities will need a higher degree of enhancement than lands with little or no degradation. Some natural communities will need little to no management unless changed circumstances occur; in these cases, permanent protection of the land and the removal of key threats may be the only enhancement occurring on those sites.

Habitat enhancement will be informed by pre-acquisition assessments, targeted studies and by the monitoring and adaptive management program, to conserve the populations of all covered species and maintain or improve ecological processes.

Habitat Restoration

Habitat restoration is the manipulation of the physical, chemical, or biological characteristics of a site with the goal of returning natural or historic functions to a site that historically supported such functions, but no longer does because of the loss of one or more required ecological factors or as a result of past disturbance.

Restoration typically involves altering the soil or other substrate to improve a site's ability to support the historic land cover types, although it may also include physical manipulation to restore specific ecological function in a site where that function has been lost (e.g., removal of hardscape in a stream channel and re-vegetation with riparian plantings). In contrast to enhancement, restoration results in the re-establishment of ecological function, value, *and* acreage of a natural community or land cover types.

For example, riparian woodland could be restored to stream reaches that historically supported them. In this Plan, habitat restoration is only allowed in those land cover types for which techniques are generally successful, and where restoration would substantially enhance habitat for covered species and native biological diversity. Restoration actions must also incorporate the best available science.

Habitat restoration may not restore all functions of natural communities. For example, recent studies of wetland restoration projects indicate that many of them fail to meet success criteria or lack important functions of natural reference sites (National Research Council 2001). The conservation strategy takes this uncertainty into account by relying primarily on habitat preservation and by requiring habitat restoration in amounts exceeding typical mitigation ratios. Also, uncertainty is taken into account by the adaptive management strategy (see Chapter 7 *Monitoring and Adaptive Management Program*).

Habitat restoration will be focused in the Reserve System, including existing open space that may become part of the Reserve System. Riparian and stream restoration that is counted towards the total conservation benefit of the Plan (**Table 5-13**) is allowed on private or public lands outside the Reserve System (i.e., without a conservation easement) as long as the following conditions are met.

- Restoration is conducted by a Permittee, including the Implementing Entity, or a third party under contract with a Permittee.
- Restoration is done consistent with the *Reserve Design and Assembly Principles* described in Section 5.2.3[11].
- The site is restored to pre-project or ecologically improved conditions within 5 years of the end of the covered activity.
- A Wildlife Agency-approved site restoration plan is developed consistent with the requirements in Section 5.3.6 *Riverine and Riparian Forest and*

[11] Restoration efforts need to remain in compliance with the Plan's Stay-Ahead provision, described in Section 8.6.1.

Scrub Conservation and Management, subheading *Riparian Restoration*, subheading *Site Restoration Plan*.

- There are no suitable and feasible restoration sites within the Reserve System.
- The restoration project meets the riverine and riparian and requirements described below in Section 5.3.6 *Riverine and Riparian Forest and Scrub Conservation and Management.*
- The site is maintained in perpetuity according to the terms of the Plan by the Implementing Entity or a Permittee. If the site is maintained by a third party, the third party must enter into a contract with the Implementing Entity to ensure management according to the terms of the Plan.
- The Implementing Entity, or its designated third party, monitors the restoration site in accordance with Chapter 7.
- The Implementing Entity and Wildlife Agencies approve the project.

One exception to the requirement that the site be maintained in perpetuity is that restoration projects occurring on streams managed for flood control and human safety purposes may be adversely modified (i.e., modified such that the restoration no longer serves the functions for which it was designed) by future covered activities. In such cases, any adverse modification of a restoration site will be off-set by new restoration in an alternative location(s). New restoration actions must be initiated in advance of the new covered activity that would adversely modify the restoration site. All such arrangements will be discussed and approved by the Wildlife Agencies as soon as the Permittees or Implementing Entity become aware of such a need.

All restoration conducted outside of the Reserve System will be tracked by the Implementing Entity to ensure that the site is monitored and managed consistent with the requirements of the Plan for the Reserve System. These projects will also be identified in the annual report.

Stream and riparian restoration outside of the Reserve System (i.e., on lands not under a conservation easement) is likely to constitute a small proportion of the Plan's commitment to riparian and stream restoration (**Table 5-13**) because the Implementing Entity will prioritize all feasible sites within the Reserve System. In addition, restoration must comply with the Plan's reserve design and assembly principles which include, but are not limited to, preservation of the highest-quality communities, preservation of connectivity, and consideration of management needs. Furthermore, the Wildlife Agencies will also need to approve restoration outside of the Reserve System.

Habitat Creation

Habitat creation is the manipulation of the physical, chemical, or biological characteristics present to develop a land cover type in an area that did not previously support it. Similar to restoration, creation results in establishment of new ecological function, value, *and* acreage of a natural community or land cover types.

The only habitat creation proposed under this Plan is for ponds. Ponds will be created as breeding habitat for California red-legged frog or California tiger salamander in areas along streams that did not previously support ponds. This type of habitat creation must be balanced by the need to maintain and enhance stream functions. No on-stream ponds will be constructed in drainages that support, or could support, covered species under this Plan. Habitat creation will occur in damaged or disturbed areas to minimize the loss of existing habitats by the creation of new ones. Ponds may also be created in other appropriate areas as long as there is normally enough water, or a water source may be established (e.g., installation of a spring box or a well) to adequately maintain the necessary inundation schedule for the target species.

In-kind/like-function habitat creation is the establishment of the same land cover type as the land cover type lost to the covered activity, and that would establish the same type of ecological functions over time. For example, creating an artificial pond with species similar to those found in a natural pond would be in-kind/like-function creation.

Out-of-kind/like-function creation of habitat is the establishment of a different land cover type with some of the same ecological functions as the affected land cover type. Out-of-kind/like-function creation or restoration is not allowed under the Habitat Plan except in situations where historic physical conditions can be restored to recreate a community that has been lost historically. For example, sycamore alluvial woodland and alkali wetland may have been more common in the study area before human alterations of the landscape (San Francisco Estuary Institute 2006, 2008). If conditions supporting these communities could be restored, then the historic communities could be recreated out-of-kind.

Land Management on Reserves

Reserve management is designed to maintain and enhance natural communities, habitat for covered and other native species, native biological diversity, and ecosystem function. The location of reserves and condition of resources within these reserves will not be known until suitable sites are identified, surveyed, and acquired. Therefore, site-specific management objectives and techniques cannot be developed until reserve sites are known. The Implementing Entity will prepare a *reserve unit management plan.*

Reserve unit management plans will be developed for each reserve unit to identify, on the basis of site-specific conditions and reserve objectives, the management and maintenance actions necessary to ensure that desired ecosystem characteristics and functions are maintained and enhanced. Reserve units are defined as groups of contiguous or neighboring parcels that have similar natural communities, covered species, and infrastructure. Reserve unit management plans must address and minimize the conflicts that may arise when managing for multiple species and habitats. Reserve unit management plans will also describe reserve-specific actions to address invasive species, fire management, infrastructure maintenance, recreation, monitoring, agricultural activities, and mosquito abatement as applicable.

Separate reserve unit management plans will be prepared for a minimum of five reserve units. These reserve units are expected to support similar land cover types, covered species, and habitats, and will therefore face similar management issues. A list of likely reserve units is presented below based on the expected geographic distribution of the Reserve System.

- Upper Penitencia Creek,
- Coyote Ridge,
- Pacheco Watershed,
- Southern Santa Cruz Mountains, and
- Santa Teresa Hills.

The Implementing Entity may decide to prepare additional reserve unit management plans to address more specific geographic areas of the Reserve System.

All reserve unit management plans must be prepared in collaboration with the Wildlife Agencies and approved by the Implementing Entity and the Wildlife Agencies. In cases where reserve unit management plans include land that remain in private ownership (i.e., conservation easements but not fee title), plans will also be prepared in collaboration with applicable landowners. The Wildlife Agencies will review each draft reserve unit management plan and provide comments to the Implementing Entity within 60 days after receiving the draft plan. The Implementing Entity will revise the draft plan based on the Wildlife Agencies' comments, if any, and will provide a revised draft to the Wildlife Agencies, which will have an additional 60-day review period. If an initial draft reserve unit management plan or any subsequent revised draft reserve unit management plan adequately addresses a Wildlife Agency's comments, the Wildlife Agency will so notify the Implementing Entity within 60 days, and the reserve unit management plan will be deemed to be approved by that Wildlife Agency for purposes of this Plan, the Implementing Agreement, and the permits. In addition, if a Wildlife Agency does not provide comments within 60 days after receiving the revised draft reserve unit management plan, the Wildlife Agency will thereafter be deemed to have approved the revised draft plan for purposes of this Plan, the Implementing Agreement, and the permits. The Implementing Entity will incorporate comments submitted by the Wildlife Agency after the 60-day period in the revised draft reserve unit management plan to the extent that the Implementing Entity determines the comments can be incorporated.

Comments from the Wildlife Agencies will focus on implementation of the management techniques described in this chapter or introduction of new techniques associated with the adaptive management program and in response to monitoring results (see Chapter 7). The deadlines described above are established to ensure the timely review and comment on the reserve unit management plans by Wildlife Agency staff and to enable the Implementing Entity to implement conservation actions as soon as possible.

Reserve unit management plans will also be updated and revised as part of the adaptive management program (Chapter 7). Land management on new reserves must not wait until adoption of the first reserve unit management plan; until the first reserve unit management plan is approved, land management will occur according to the guidelines in this chapter and best scientific practices. The conservation actions below describe the objectives, principles, and general requirements of these reserve unit management plans.

Reserve Unit Management Plans

Reserve unit management plans will be prepared by the Implementing Entity for each reserve unit for natural land cover types (i.e., on land not cultivated or irrigated for crops or pasture; see the next section for management of other lands). Reserve unit management plans will describe reserve-specific management strategies for maintaining, and when necessary, improving existing habitat conditions for covered species. These plans will also facilitate the management of enhanced/created/restored habitats, to maintain or improve their functions over time through the adaptive management process. The Implementing Entity should consider developing decision trees or flow charts for certain types of management such as prescribed burning or invasive species management (e.g., Starfield and Bleloch 1991).

Reserve unit management plans will be prepared as soon as reasonably possible but not longer than 5 years following acquisition of the first parcel in a reserve unit or of placing a conservation easement on the parcel. This time period will provide an opportunity to conduct thorough inventories of the site's resources over several seasons. It will also provide the time necessary to seek review and approval from the Wildlife Agencies. Reserve unit management plans will be developed in partnership with adjacent land management agencies, resource agencies, and current grazing lessees, if any. In cases where reserve unit management plans include land that remain in private ownership (i.e., conservation easements but not fee title), plans will also be prepared in collaboration with applicable landowners. Input from interested citizens will be included in reserve unit management plan development through public outreach and education (see *Public Education and Outreach* below). When possible, new or updates to existing reserve unit management plans will be coordinated with concurrent open space planning processes of the agency that owns the site (e.g., County Parks Master Plan).

Until the first reserve unit management plan is developed and formally approved by the Wildlife Agencies, reserve lands will be managed in the interim to maintain and improve covered species habitats in accordance with the guidance in the Plan, best available information, and management methods currently being used in the study area. Subsequent reserve units will be managed in the interim based on reserve unit management plans for other units of the Reserve System.

Until a reserve unit management plan is prepared, management regimes that existed prior to acquisition will continue until it can be shown through management on other Habitat Plan reserves or elsewhere in the study area, pilot studies, experimentation, or other relevant studies that changing management will benefit natural communities or covered species. If the pre-existing management was damaging the resource or resources contained in that reserve, interim actions, based on best available information, will be implemented immediately and continued until the specific reserve unit management plan is completed. For example, if a parcel was previously overgrazed, the stocking rate could be reduced to the point where it can reasonably be assumed that the modified level of grazing will sustain natural resources. The reserve unit management plan will then define the appropriate standards to provide for reserve enhancement in perpetuity.

As described in Chapter 9, development fees are the primary source of funding for management actions and other operational activities in the Reserve System. Due to the slow pace of development in the study area as a result of the recent recession, it is unclear whether development fees will be adequate to fully fund management of the Reserve System in the early years of Plan implementation. In the event that development fees cannot fully fund management in reserve units according to the requirements and guidelines in this conservation strategy, the Implementing Entity may conduct only essential management tasks and defer non-essential management tasks for up to 5 years from the first acquisition for each reserve unit, or when development fees become available, whichever comes first. Essential management tasks are defined as those tasks necessary to ensure that the reserve unit does not degrade below the existing condition at the time it was incorporated into the Reserve System in terms of natural land cover and covered species habitat. Existing conditions will be documented by the Implementing Entity through the pre-acquisition assessment and the site inventory, described in Chapters 7 and 8. Management in response to changed circumstances (i.e., remedial actions described in Chapter 10) cannot be deferred.

Reserve unit management plans will be working documents; accordingly, they will not preclude the modification of management measures prior to Plan updates in cases where adaptive management or new research identifies more effective techniques. The Implementing Entity will review and, where biologically appropriate, systematically revise reserve unit management plans at least every 5 years. This review will be based on an evaluation of the success of management methods (i.e., knowledge gained through the monitoring and adaptive management program) in achieving objectives of the reserve, as well as on results of other outside research. As applicable to each reserve unit, reserve unit management plans will include the following types of information.

Objectives of the Conservation Area

Each reserve unit management plan will clearly identify the biological objectives for the reserve unit. Biological objectives for each reserve unit will be a subset of the biological goals and objectives of the Habitat Plan (**Table 5-1**). Each reserve unit management plan will also identify the conservation actions applicable to the reserve (**Table 5-2**).

Vegetation Management

Each reserve unit management plan will describe reserve-specific objectives for the following goals.

- Reducing the abundance and distribution of invasive plants.
- Increasing or maintaining the abundance and distribution of covered plants, and of compatible native plants in general.
- As indicated by pre-acquisition assessments and targeted studies and informed by the monitoring and adaptive management program, reducing the fuel load of the reserve so that the risk to biological resources of catastrophic wildfire is at an acceptable level and the risk to adjacent urban areas is minimized (meeting all state and local requirements). The methods and intensity of fuel management will vary depending on the location of the reserve relative to human populations and structures; emergency vehicle access; and the sensitivity of resources in the reserve to fuel load reduction techniques (e.g., fuel breaks, prescribed fire, mowing). Because fuel load reduction in chaparral habitats may be problematic (i.e., high-quality chaparral habitat is frequently characterized by periodic wildfire), it may be necessary to establish buffers in which to implement fuel load reduction.
- Minimizing the impacts of vegetation management techniques on native biological diversity and covered species (some impacts on covered species from vegetation management are expected and are included in the take allowances provided in this Plan).

Each reserve unit management plan will identify the types of management actions and the implementation schedule required to achieve the vegetation management objectives. Anticipated methods for managing vegetation include, but are not limited to, the following.

- Livestock grazing.
- Prescribed burning.
- Mechanical mowing (e.g., mowing fire breaks near the end of the growing season around the margins of reserves or as an alternative to grazing in areas where livestock cannot be used; large-scale use of heavy machinery to remove vegetation will not be allowed).
- Hand removal of vegetation (e.g., to remove infestations of invasive plants and to increase abundance of early successional vegetation along dense riparian corridors downstream of reservoirs).
- Biological control agents, where biologically appropriate and when shown to have minimal risk to non-target native species.
- Application of herbicides (e.g., spot spraying to remove infestations of invasive plants). There may be a need to apply herbicides on a large scale (e.g., to control yellow star-thistle). Note that use of herbicides is not proposed for coverage in the Section 10(a)(1)(B) permits. Herbicide use should consider the County of Santa Clara Integrated Pest Management Program and Pesticide Use Ordinance Section B28-10.

Reserve unit management plans will also describe the ongoing vegetation management actions that must be undertaken to implement community-level actions required on each of the reserves. This chapter includes detailed recommendations for management techniques and principles grouped by natural community that must be incorporated appropriately into each reserve unit management plan. These measures describe management requirements and guidelines that will be applied to natural communities to benefit covered and other native species.

- Section 5.3.2 *Landscape Conservation and Management*.
- Section 5.3.3 *Grassland Conservation and Management*.
- Section 5.3.4 *Chaparral and Northern Coastal Scrub Conservation and Management*.
- Section 5.3.5 *Oak and Conifer Woodland Conservation and Management*.
- Section 5.3.6 *Riverine and Riparian Forest and Scrub Conservation and Management*.
- Section 5.3.7 *Wetland and Pond Conservation and Management*.

Management of Invasive Species

Each reserve unit management plan will include a section on management of invasive species. This section will incorporate management tools for controlling and if possible eradicating invasive plants and animals. Actions to control invasive animals (bullfrogs, nonnative predatory fish and feral pigs) that are described in Section 5.3.2 will also be incorporated as relevant into individual reserve unit management plans. In addition, California tiger salamander hybrid management, discussed in **Appendix K**, will be addressed in relevant reserve unit management plans.

Fire Management

Each reserve unit management plan will include a section on fire management. The fire management section of each reserve unit management plan will include a description of minimum impact suppression techniques, which are described in more detail below. The plans will also include the following elements specific to each reserve:

- A map of fire access roads and gates.
- Identification of fuel-load management methods and criteria for their application.
- Criteria and procedures for use of prescribed fire for management purposes (burn plan).
- A description of fire-suppression criteria, procedures, resources, and responsibilities, including criteria for selecting fire-fighting water sources.
- A discussion of restoration/rehabilitation of vegetation following a fire.

Fire is an important natural component of local ecosystems. Therefore, some wildfires will be allowed to burn naturally to provide periodic disturbances that will benefit natural communities and covered species, within the larger land-use context. The fire management component of each reserve unit management plan must include a clear decision system to determine when a wildfire will be left to burn and when it must be partially or wholly contained to prevent damage to structures, prevent injuries, prevent impacts to neighboring properties (including loss of forage and livestock), or cause excessive disturbance to natural communities.

The fire management component of each reserve unit management plan must be consistent with achieving the biological objectives of the reserve, as well as associated regulatory requirements. Reserve fire management components will be coordinated with the California Department of Forestry and Fire Protection (Cal-Fire) and any other firefighting agency that has responsibility for Reserve System lands. Copies of all fire plans, including maps of access roads, gates, and biologically sensitive areas, will be provided to all firefighting units. Additionally, the plans may include prescribed burn guidelines for management of fire-dependent natural systems. This would include coordination with other land management entities to assure adequate availability of burn permits from the Bay Area Air Quality Management District.

The development of the fire management component of each reserve unit management plan will include, based on the location of existing access roads and gates, an assessment of the need to develop additional fire access roads sited to minimize impacts on sensitive species and communities and to minimize the need for new access roads (which could affect sensitive species and communities) to be constructed under emergency conditions (i.e., during fires). In addition, all access gates will include common locks, inventoried and regularly checked by the Implementing Entity, which will allow for ready access by firefighting agencies.

Maintenance of Infrastructure

Each reserve unit management plan will include a map showing the location of infrastructure, such as livestock grazing infrastructure, roads, firebreaks, fences, gates, pumps, wells, water control structures, ditches, canals, drains, powerlines, and buildings. The reserve unit management plan will include a schedule for inspecting infrastructure to determine the need for maintenance. Work needed to maintain infrastructure that is necessary for maintaining reserves (e.g., firebreaks, fences) will be conducted as soon as practicable after the need for maintenance has been identified. The reserve unit management plan will also identify periods during which maintenance activities will be conducted to avoid or minimize adverse effects on natural communities and covered species. Applicable avoidance and minimization measures described in Chapter 6 will also be applied. The Implementing Entity will include as a section in the reserve unit management plan a hazardous materials management/spill prevention plan to identify procedures that must be followed if hazardous materials are encountered or a spill occurs on the reserve.

Monitoring Requirements and Adaptive Management

Each reserve unit management plan will include monitoring and adaptive management for the species, threats, and management actions within the reserve.

All management actions described in the reserve unit management plan will take into account the adaptive management program described in Chapter 7. Reserve unit management plans will include a description of how the results of the effectiveness monitoring will be used to adjust management of the reserve unit within the decision-making structure of the adaptive management process.

Recreational Use

The participation of County Parks and the Open Space Authority in the conservation strategy requires that public access be permitted within the Reserve System. For Reserve System lands that permit public access, each reserve unit management plan will address recreational use that is compatible with the preservation and enhancement of natural communities, covered species, and biological diversity on the reserve. The recreation component of the reserve unit management plan will apply the allowances and restrictions described in Condition 9 to the management unit.

Agricultural Lands

The Habitat Plan does not require acquisition of cultivated agricultural lands (i.e., grain, row-crop, hay, disk/short-term fallowed land cover type or irrigated pastures). However, acquisition of a larger site could include some cultivated agricultural land. For reserves that include cultivated agriculture, each reserve unit management plan will describe the agricultural practices that will be undertaken to ensure the land's compatibility with the Habitat Plan. The reserve unit management plan will also include limitations on permitted practices to reduce adverse effects of some practices on covered and other native species. Ongoing agricultural practices will be allowed if they are compatible with the goals and objectives of this Plan. If these ongoing agricultural practices are not compatible with the goals and objectives of this Plan, the parcel will either not be incorporated into the Reserve System or portions of an individual parcel with incompatible uses will be excluded from the Reserve System. Agricultural lands receive credit and enrollment into the Reserve System only if the site supports the biological goals and objectives of the Plan.

The key elements of the agricultural component (e.g., conservation goals and standards) will be negotiated with the landowner and included in the conservation easement when this form of ownership interest is acquired. The agricultural component will include details on the techniques and tools that will be used to achieve these goals. See Chapter 8 for the required elements of these easements, including the prohibitions on uses that would degrade the conservation value of the easement land. Preparation of reserve unit management plans will include opportunities for public review and comments.

Mosquito Abatement

Any mosquito control activities to be performed on Reserve System land will be addressed in the reserve unit management plan in consultation with the Santa Clara County Vector Control District. The Implementing Entity will work with the Santa Clara County Vector Control District to create a unified mosquito control strategy that will apply to the entire Reserve System. All reporting requirements will be consistent with those required by the Santa Clara County Vector Control District and the U.S. Department of Agriculture. The reserve unit management plan will include specific detail related to that unit. It will also explain specific measures implemented to avoid and minimize impacts to covered species consistent with the Habitat Plan.

5.2.6 Alternative Conservation Strategies

To facilitate the decision-making process, three alternative conservation strategies were developed that served as the basis for the preferred conservation strategy described in this chapter. Before the alternatives were developed, the Permittees established the following criteria, all of which had to be met for an alternative conservation strategy to be considered.

- Meet all applicable regulatory standards of ESA and the NCCP Act.
- Be technically feasible.
- Provide real choices in action and cost.
- Reflect the range of preferences of local agencies and stakeholders.
- Be easily distinguishable (i.e., vary as few parameters as possible).
- Support the CEQA/NEPA process, if possible.

Affordability was considered as a criterion and the Permittees felt that, while the preferred alternative must be affordable, it may be useful to have an alternative that is potentially unaffordable. Such an alternative helps to establish the "maximum practicable" conservation strategy, as required by ESA.

The alternative strategies developed differed primarily in the amount and location of land acquisition required. The details of the three alternative conservation strategies were released in June 2007 in the preliminary working draft of Chapter 5. Land acquisition ranged from 30,000 acres in Alternative 1 to 40,000 acres in Alternative 2 to 58,000 acres in Alternative 3. The alternatives also differed in the amount of existing open space incorporated into the Reserve System. Alternative 1 relied heavily on existing open space while Alternative 3 did not rely on any existing open space; Alternative 2 relied on a moderate amount of existing open space for the Reserve System. The three alternative conservation strategies were considered by the Wildlife Agencies and the Stakeholder Group in a series of meetings between July 2007 and June 2008 and through written comments. The public was also given the opportunity to review the alternative conservation strategy at a public meeting on September 26, 2007.

To develop the preferred conservation strategy, elements were taken from each alternative to best meet the biological goals and objectives of the Plan with the least cost. Although Alternative 3 would result in the greatest benefit to the covered species and natural communities, it was determined that this alternative was unaffordable and would result in infeasible development fees. The preferred land acquisition strategy, as described below in Section 5.3.1 *Land Acquisition and Restoration Actions*, combines elements from all three alternatives but mostly falls between Alternatives 2 and 3 in scale and scope.

5.2.7 Data Sources

The primary sources of data for the conservation strategy were the ecological accounts of covered species (**Appendix D**), the species distribution models (**Appendix D**), and the inventory of existing conditions summarized in Chapter 3. Other sources consulted to develop the conservation strategy are cited throughout the chapters. Additional general sources are listed below.

- Species recovery plans, if available (California Red-Legged Frog [U.S. Fish and Wildlife Service 2002], Least Bell's Vireo [U.S. Fish and Wildlife Service 1998b], Serpentine Soil Species of the San Francisco Bay Area [U.S. Fish and Wildlife Service 1998c], Upland Species of the San Joaquin Valley [U.S. Fish and Wildlife Service 1998a]).
- Species and natural community experts, including the independent Science Advisors for the Plan.
- Approved or in-process HCPs for adjacent or nearby areas with similar natural communities and covered species (e.g., San Francisco Public Utilities Commission Alameda Watershed HCP (ICF International 2010a) [in process], Pacific Gas and Electric Company Bay Area Operations and Maintenance HCP (ICF International 2010b) [in process], East Contra Costa County HCP/NCCP (Jones & Stokes 2006) [approved]).
- Local land acquisition priorities of open space agencies and organizations, where they overlap with the biological goals and objectives of the Plan: County Parks (County of Santa Clara 1987), Open Space Authority, The Nature Conservancy (The Nature Conservancy 2004, 2006b), National Audubon Society (National Audubon Society 2008), and Peninsula Open Space Trust.
- Management or mitigation plans for large-scale projects in the study area that address biological goals and objectives similar to those of the Plan (e.g., Kirby Canyon landfill, SR 152/156 Interchange).

5.3 Conservation Actions

The conservation strategy is composed of a series of *conservation actions*. Conservation actions are tools, strategies, comprehensive programs, and actions to conserve natural communities, habitats, and landscape-level processes and to conserve and help recover covered species in the study area. Tiering off of the biological goals and objectives (Section 5.2.1 *Biological Goals and Objectives*), conservation actions also occur at the landscape-level, natural community-level, and species-level. Conservation actions are grouped into two major categories—land acquisition actions and management actions—and are given unique labels and numeric codes according to their topic area. All conservation actions are listed sequentially in **Tables 5-2a and 5-2b**. The relationship of these conservation actions with the biological goals and objectives is presented in at the landscape-level (**Table 5-1a**), the natural community-level (**Table 5-1b**) and species-level (**Tables 5-1c and 5-1d**). Included as management actions are studies that will address key management questions related to the covered species and natural communities (**Table 5-2b**). The results of these studies will be incorporated into the adaptive management process described in Chapter 7. Therefore, management actions will be adjusted in response to the results of these studies.

The following subsections describe in detail the landscape-level and natural community-level conservation actions. Section 5.4 *Benefits of and Additional Conservation Actions for Covered Species* relates the landscape-level and natural community level conservation actions to each covered species, while also discussing in detail the species-level conservation actions.

5.3.1 Land Acquisition and Restoration Actions

An important part of the conservation strategy is the creation of a Reserve System. Many parts of the Reserve System will link existing protected areas with newly protected lands. When completed, this Reserve System will protect substantial areas of high-quality habitat for covered species and will provide extensive new opportunities for habitat enhancement, restoration, and creation. The term “land acquisition” includes acquisition of all aquatic land cover types including wetlands, ponds, and streams.

All lands in the Reserve System will be enhanced, as indicated by pre-acquisition assessments and targeted studies and informed by the monitoring and adaptive management program, to improve habitat for covered species and natural communities. The details of habitat enhancement activities are described starting in Section 5.3.2 *Landscape Conservation and Management*. Habitat restoration and creation will occur in targeted sites for wetlands, streams, and ponds as described in Sections 5.3.6 *Riverine and Riparian Forest and Scrub Conservation and Management* and 5.3.7 *Wetland and Pond Conservation and Management*.

The land acquisition process is described in Chapter 8, Section 8.6 *Land Acquisition*. All land acquisition will be proposed to CDFG and USFWS for review and approval to ensure consistency with the biological goals and objectives.

Acquisition Requirements by Land Cover Type

Acquisition Requirements for Terrestrial Land Cover Types

The minimum land acquisition required under the Habitat Plan for terrestrial land cover types is 32,850 acres, as shown in **Table 5-11**. Additional minimum land acquisition requirements apply to some conservation analysis zones and for aquatic land cover types, as described below. Actual acquisition of some land cover types will likely be greater than the combined minimum requirements because parcel boundaries typically do not follow ecological boundaries, and the boundaries of acquired parcels will include land cover types that are not specified by acquisition requirements[12]. In addition, qualitative requirements for habitat connectivity or for preservation of plant occurrences could require additional acreage.

All terrestrial land acquisition must be accomplished by Year 45 of the permit term. This requirement is in place to ensure that all lands incorporated into the Reserve System have at least 5 years to be managed, enhanced, and monitored according to the terms of the Plan before the permits expire. This time period will enable the Wildlife Agencies to closely monitor the final land acquisitions to ensure the Implementing Entity will complete the land acquisition strategy and achieve the final biological goals and objectives. Management of these lands however, will occur in perpetuity.

To estimate the actual extent of the Reserve System, the amount of land that would need to be acquired to meet all the requirements of this Plan was estimated. The actual size of the Reserve System will be different than the estimated amount because of the uncertainty in which parcels are acquired. Regardless of the final Reserve System size, all land acquisition requirements described in this chapter must be met by Year 45 of the permit term.

Acquisition and Restoration Requirements for Aquatic Land Cover Types

As described above, the primary approach to conservation of terrestrial land cover types is through preservation and enhancement of lands based on regional estimates of impacts and the conservation needs of the covered species and natural communities. The approach to mitigating and conserving aquatic land cover types (wetlands, ponds, streams, and riparian woodland and scrub) differs from the approach to other land cover types. As described in Chapter 4, there is greater uncertainty in the degree of impact on aquatic features than on other land cover types. This is due, in part, to the uncertainty in some of the land cover mapping (particularly regarding wetlands; see **Table 3-4**). It is also due to the coarse scale of development designations within the local jurisdictions relative to the scale of these aquatic features. For example, even though an area may be designated for residential development, it is anticipated that residential projects will, for the most part, avoid riparian woodland and streams within their boundaries. Because it is difficult to predict the level of onsite avoidance, the Habitat Plan utilizes conservation ratios that are tied to actual impacts during Plan implementation to determine the necessary level of conservation.

All wetlands, ponds, and streams to be affected or preserved will be delineated in the field prior to impacts or acquisition as described in Section 6.8.4. Delineations may not always be feasible prior to acquisition for the Reserve System. Since land will be acquired on a willing seller basis, the Implementing

[12] For example, a 1,000-acre parcel may have required land cover types on 950 acres. Therefore, the remaining 50 acres of the parcel would not count towards Plan requirements.

Entity will need to respond quickly and may not always have the opportunity to conduct a pre-acquisition delineation. If infeasible, a delineation would occur within one year of acquisition. To offset impacts on these aquatic land cover types, the Implementing Entity will acquire these land cover types in-kind within reserves according to the ratios in **Table 5-12**. As with terrestrial land cover types, all aquatic land cover types must be acquired by Year 45. This requirement is in place to ensure that all lands incorporated into the Reserve System have at least 5 years to be managed, enhanced, and monitored according to the terms of the Plan before the permits expire. This time period will enable the Wildlife Agencies to closely monitor the final land acquisitions to ensure they will complete the land acquisition strategy and achieve the final biological goals and objectives.

To ensure a minimum level of protection of wetlands and other aquatic land cover types and ensure contribution to recovery for the covered species, regardless of the level of impact, the Implementing Entity must acquire at least 250 acres of riparian forest and scrub, 40 acres of central California sycamore alluvial woodland, 10 acres of coast and valley freshwater marsh (perennial wetland), 5 acres of seasonal wetland, 50 acres of ponds, and 100 miles of streams as shown in **Table 5-13**. Because there is a finite amount of these relatively rare land cover types in the study area not already protected in open space, the minimum protection levels can be met through preservation needed for mitigation. In addition, the preservation ratios for aquatic land cover types include a recovery component. For example, if all 25 acres of impacts occur to coastal and valley freshwater marsh, then 50 acres of this land cover type must be preserved in the Reserve System. Because of the limited availability of this land cover type, the minimum preservation of 10 acres will be fulfilled by the preservation of 50 acres (i.e., it may be infeasible to make the mitigation and minimums additive). In another example, if only 2 acres of impacts occur to coastal and valley freshwater march, then the minimum of 10 acres of preservation must occur (applying the mitigation ratio of 2:1 only reaches 4 acres of preservation).

Aquatic land cover types will also be restored or created according to the ratios in **Table 5-13**. Guidelines for restoration and creation for each natural community are described in the sections below on each natural community. All restoration and creation construction must be completed by Year 40 of the permit term. This requirement is in place to ensure that there is at least 10 years before the end of the term in which to monitor success criteria and take remedial actions in the event that success criteria are not being met.

To ensure a minimum level of restoration or creation that will contribute to species recovery, the Implementing Entity will restore or create 50 acres of riparian woodland, 20 acres of freshwater marsh, 20 acres of ponds, and 1 mile of streams (**Table 5-21**). These restoration and creation requirements are in addition to those required to offset impacts to these land cover types. To ensure that the Implementing Entity makes steady progress towards the final minimum creation and restoration goals, interim deadlines are established for each of the five applicable land cover types (**Table 5-14**). Interim deadlines are established for Years 15, 30, and 40.

Wetlands and streams exhibit a high degree of biological, physical, and hydrologic diversity in the study area. Consequently, it is important to preserve, enhance, restore, or create the full diversity of these land cover types as they occur in the area. Wetland delineations conducted prior to wetland impacts will be used, in part, to classify wetland types lost to ensure that the same types are being acquired and restored or created within Habitat Plan reserves. In addition, vegetation in wetlands and streams will be classified at the association or alliance level (rather than as a single land cover type) in order to help ensure that a diversity of communities is preserved.

Limits on impacts on aquatic land cover types are described in **Table 4-2** and preservation will occur in accordance with the preservation ratios in **Table 5-13**. Preservation ratios were determined on the basis of the following factors.

- The rarity and irreplaceability[13] of the land cover type within the inventory area (rarer and more irreplaceable land cover types have higher ratios).
- The biological value of the land cover type (e.g., overall biological diversity, function as habitat for covered species, ecosystem function).
- Mitigation ratios previously accepted by state and federal regulatory agencies (these ratios were used as starting points for this Plan).

Avoidance and minimization of impacts on aquatic land cover types (see Chapter 6) at project sites may reduce the amount of preservation area required if preserved aquatic land cover types meet minimum distance requirements from dense urban development (see *Buffer Zones within the Reserve System* below). Note that project proponents who receive take authorization under this Plan and who wish to fill jurisdictional wetlands and waters must obtain separate permits and certification from USACE and the Regional Board, respectively, to comply with CWA Sections 404 and 401, and may also need permits from the Regional Board under the Porter-Cologne Water Quality Control Act and a streambed alteration agreement with CDFG under California Fish and Game Code Sections 1600 et seq.

Buffer Zones within the Reserve System

Fuel Buffers

When the Implementing Entity acquires land adjacent to existing or planned urban development[14] that has no buffer zone, or an inadequate buffer zone, one may be created on the reserve according to the terms described in Chapter 6, Section 6.4.6, subheading *Condition 10 Fuel Buffer*. The buffer zone will experience a reduction in habitat function due to the indirect effects of urban development (see Chapter 4). To account for this loss of habitat function, any area adjacent to development that is disked, mowed, and/or sprayed with herbicides for fuel management will not be credited toward land acquisition

[13] A habitat or land cover type is irreplaceable if it cannot be restored or created elsewhere due to unique soil requirements, topography, or other conditions.
[14] Defined as the planning limit of urban growth (see Chapter 2) or the Urban Service Area, whichever is greater.

requirements (see Chapter 6 for required fuel buffers). The remainder of any buffer zone may be credited toward terrestrial land cover because it will provide habitat for some species and serve an important function. However, aquatic land cover types and aquatic covered species breeding habitat without sufficient buffer zones will not be credited toward meeting preservation requirements because their proximity to intensive urban development can greatly reduce their habitat value. See **Table 5-15** for minimum setback distances required for aquatic land cover types to be counted toward Plan requirements for preservation and restoration or creation (**Table 5-12**).

Plant Occurrence Buffers

In order for a plant occurrence to count as protected under the Plan, there will be a buffer of at least 500 feet between the occurrence and adverse land uses. Adverse land uses include permanent land uses that could endanger the long-term viability of the plant occurrence; including urban development, landfill, and other intensive land uses. A 500-foot buffer was recommended in the *Recovery Plan for Serpentine Soil Species of the San Francisco Bay Area* (U.S. Fish and Wildlife Service 1998c), and this same buffer has been extended to the only covered plant not restricted to serpentine soils, the Loma Prieta hoita.

This buffer may be reduced under specific circumstances where, based on documented site conditions, plant occurrences are protected from adverse land uses by another means. For example, a reduced buffer may protect the viability of a plant occurrence if a major physical barrier separates the occurrence from adjacent land use. Conversely, the buffer may need to be increased in specific circumstances where, based on documented site conditions, plant occurrences are not afforded adequate protection from adjacent land uses. For example, to minimize hydrologic effects of adjacent land use on an occurrence located down-gradient, a buffer exceeding 500 feet may be necessary. Adequacy of the 500-foot buffer will be determined by the Implementing Entity, in coordination with the Wildlife Agencies. Buffers surrounding protected plants will also expand as plant occurrences expand, assuming space is available after covered activities are completed. In other words, occurrence expansion will not result in a reduced buffer.

Incorporating Covered Plant Species

The locations of all covered plants within the study area are not known due to survey and mapping limitations. Habitat distribution models were developed for 6 of the 9 covered plant species (see Chapter 3 and **Appendix D**), but the conservation value of these models is limited because of the paucity of known occurrences of most species in the study area. The habitat requirements of the remaining species are not well known enough to develop a credible model at this time. Many covered plants likely have unique microhabitat requirements such as soil types or plant associations that cannot be mapped at the regional scale used in this Plan.

Despite model limitations, for compliance purposes, impacts on all covered plants will be limited by known *occurrences* (**Table 4-6**) and modeled habitat for the 6 covered plants for which habitat models were developed (**Table 4-4**) if additional occurrences are not discovered during the permit term. Similarly, mitigation and conservation will be based on known occurrences (**Tables 5-16**) and modeled habitat (**Table 5-17**). Additional known occurrences and new occurrences not yet discovered at the time of permit issuance can be impacted up to the limits described in **Table 5-16** and in accordance with the criteria described below. For all but one covered species, a plant occurrence is defined as a group of individuals that are separated by at least 0.25 mile from other groups of individuals of the same species or subspecies. This definition was used to be consistent with how plants are tracked by the CNDDB, and to facilitate compliance monitoring by the Plan (see Chapter 7). For Santa Clara Valley dudleya, a distinct occurrence is ecologically a group of individuals on a rock outcrop. These rock outcrops often occur less than 0.25 mile from each other. A different definition of an occurrence was used for this species because of its unique clumped distribution on rock outcrops.

In some cases, an occurrence may be equivalent to a population; in other cases, multiple occurrences may form a single population. A biological population is defined differently for each of the covered plants and is often unknown due to a lack of population data. Therefore, an occurrence provides a single standard by which to measure impacts and conservation for all covered plants. During implementation, the Implementing Entity may conduct monitoring or management actions based on populations, which is a more biologically meaningful unit.

The Implementing Entity must ensure that adequate numbers of occurrences of covered plants are protected in the Reserve System. The conservation strategy for each plant species includes the acquisition (preservation) and/or creation of covered plant occurrences. Both acquired and created occurrences will be permanently protected in the Reserve System. Land containing occurrences of covered plants will be acquired from willing sellers in fee title or through establishment of conservation easements.

Almost all known occurrences of covered plants in the study area are found outside the planning limit of urban growth and away from the footprint of covered activities. Therefore, many occurrences are expected to be included in the Reserve System as it is established. However in order to ensure that covered plant occurrences are protected, the land acquisition actions listed below include specific requirements for covered plants.

Preservation of covered plant occurrences must occur ahead of the impacts to each plant species, as described in the Stay-Ahead provision in Section 8.6.1 *Stay-Ahead Provision*. Impacts to all plants, with the exception of the Coyote ceanothus (see Section 5.4.11) will be offset by the acquisition of occurrences of the same species that is at least equivalent in size[15] and of the same or better "condition" than the impacted occurrence. The number of occurrences that must

[15] Measured as either plant cover or number of individuals, whichever is most appropriate for the species and site. The occurrence size that must be matched or exceeded is the occurrence size at the time of impact, which may be different from the known occurrence size during the development of this document.

be acquired prior to impacts will be in accordance with the Plan's species-specific mitigation ratios (**Table 5-16**). For example, although the Plan proposes to preserve 55 occurrences of Santa Clara dudleya if additional occurrences were not discovered during the permit term, four occurrences of equal or greater size and same or better condition must be acquired prior to each impact. In other words, all 55 occurrences of Santa Clara dudleya do not need to be acquired prior to the first impact. Acquisition ratios were not developed for the Tiburon Indian paintbrush, Coyote ceanothus, and Metcalf Canyon jewelflower, the three plant species for which additional impacts are not covered by the Plan even if additional occurrences are discovered during the permit term. For more details, refer to species-specific acquisition timing requirements in Section 5.4 *Benefits of and Additional Conservation Actions for Covered Species.*

If the Implementing Entity cannot protect the necessary plant occurrences, then proponents of projects that will have impacts on covered plants will be required to protect the covered plant occurrences in order to receive take authorization under this Plan for any covered species.

To ensure that the Plan adequately protects covered plants, site-specific surveys in impact areas (described in Chapter 6), and site inventories conducted in new reserves, will document the presence, absence, and condition (as defined below) of occurrences of covered plants. When known, this information will also inform the land acquisition process. Field assessments will consist of one season of surveys for all species, except when there is evidence that a single season may not provide adequate information to make a reliable assessment of condition as defined below. Reasons for a second season of surveys could include:

- Extreme weather (e.g., unusually low or high rainfall), fire, or other natural condition or disaster during the survey year that creates unusual negative or positive growing conditions.
- Disease appears to be affecting greater than 50% of an occurrence, especially of woody species.

For the purposes of this Plan, "good condition" of a covered plant occurrence is defined as a high potential to increase in size with improved management. The condition of a plant occurrence will be assessed in the field by a qualified botanist on the basis of the characteristics listed below.

- **Physical health.** Individuals in good or excellent physical health (e.g., little or no signs of disease, viruses, severe herbivory, nutrient deficiencies) are more likely to survive, achieve an average or above-average lifespan, and reproduce successfully than individuals in poor physical condition. Plants in good physical health generally also indicate a highly suitable site.
- **Age structure.** Occurrences of perennial species with an age distribution that includes many seedlings or juvenile plants relative to adults suggests a stable or positive rate of occurrence growth. Additionally, for annual and perennial species, seeds or bulbs in the soil (i.e., the seed bank) are also part of a plant occurrence's age structure, but this component is generally very difficult to assess.

- **Reproductive success.** Occurrences with evidence of average or above-average reproductive success for the species (e.g., production of flowers per plant, seed production per flower or per plant, proportion of seeds that appear to be viable based on visual observations) are more likely to be increasing than occurrences with below-average reproductive success, because this is often a key component of occurrence growth rate. If reproductive success cannot be measured, plant size or other physical features may be an appropriate surrogate in some covered species.
- **Availability of suitable habitat.** In order for a plant occurrence to remain stable or grow, enough suitable habitat must be present. Occurrences near unoccupied suitable habitat or without evidence of shrinking suitable habitat areas (e.g., nonnative plant populations that may be expanding, native shrubs that may be advancing) will be considered in better condition than occurrences without these indicators.
- **Diversity of suitable habitat.** Occurrences that occupy a wide range of microhabitats for the species may exhibit relatively high genetic diversity and therefore occurrence condition. Occurrences that occupy unusual microhabitats for the species may indicate unusual genetic composition or adaptations that should be protected.
- **Threats.** Threats to occurrences within the Reserve System will be assessed to ensure that protection and improved management will not be undermined by external factors such as disease, severe herbivory, recreational uses, or adjacent land uses. Occurrences in danger from threats that can be addressed should be considered in better condition than those that cannot be addressed.

The location of affected plant occurrences and the location of the preserved or created plant occurrences will also be taken into consideration by a qualified botanist. In some cases, it may be beneficial to preserve occurrences that would expand the current range of a species. In other cases, preservation of genetic integrity in a specific locality may have more conservation value. The Implementing Entity will consult the Wildlife Agencies on the location of preserved and created occurrences to ensure that the biological goals and objectives of each species are met.

Sites selected for preservation of plant occurrences in good condition will be incorporated into the Reserve System to ensure long-term viability of these occurrences. Reserves will contain sufficient suitable habitat for the covered plant to support occurrence expansion and fluctuation and to apply beneficial management techniques such as appropriate disturbance regimes.

When practicable, all lands protecting covered plant occurrences will be connected to existing protected areas or Habitat Plan reserves. When not practicable, the minimum reserve size to protect covered plant occurrences will be determined on the basis of site-specific conditions but will not be less than 40 acres unless acquiring a smaller site is the only way to meet a land-acquisition requirement in this Conservation Action (i.e., all other options have been exhausted). The minimum reserve size required for the long-term viability of covered plant occurrences will vary depending on species, site conditions, occurrence status, and surrounding land uses but will generally be unknown. A 40-acre minimum has been established because it is a common parcel size in the study area (1/16 of a section) and because this is the estimated minimum size needed to properly manage a site in the study area. Because land acquired for the Reserve System must be linked to other Habitat Plan reserves or existing public lands whenever possible, few, if any, isolated, 40-acre reserves will be established. Additionally, reserves must be configured to minimize the extent of edge (e.g., rectangles, squares, or circles instead of strips or fragments).

Created occurrences will not count toward the Stay-Ahead provision for plants and will not be used to mitigate adverse effects, with the exception of the Coyote ceanothus. Created plant occurrences will therefore only contribute to species recovery due to the highly experimental nature of this technique.

Land Acquisition Requirements by Conservation Analysis Zone

To ensure that acquisition occurs in locations that will maximize the benefits to natural communities and covered species, acquisition requirements are also defined by conservation analysis zone (**Figure 5-5**) or by a combination of zones. In addition to numeric land acquisition requirements by land cover and zone, qualitative land acquisition requirements are provided for some zones. For instance, linkage of existing public lands or preservation of covered plant occurrences could be required. The requirements for land acquisition within the zones or groups of zones are described below, generally from north to south in the study area. The relevant acquisition actions from **Table 5-2a** are also referenced.

The proposed land conservation strategy is shown in **Figure 5-7**. **Table 5-18** describes land acquisition and enhancement requirements for select conservation analysis zones where geographic specificity was required to ensure that Plan goals and objectives were met. This figure illustrates the relative level of land acquisition effort that would occur in each of the conservation analysis zone (high, moderate, or low) based on the specific land acquisition requirements described below. The landscape linkages protected or partially protected by the land conservation strategy are shown in **Figure 5-8** (linkages correspond to those in **Table 5-9** and **Figure 5-6**).

Alameda-1 and Coyote-7

The Alameda-1 conservation analysis zone lies at the northern edge of the study area in the Alameda watershed. This zone is combined with the adjacent Coyote-7 zone for the purposes of the land acquisition strategy because together they create an important linkage outside the study area. In addition, land cover types and species habitat in the two zones are similar. The primary purposes of the land acquisition strategy in these conservation analysis zones are listed below.

- Enhance connectivity and linkage between large blocks of existing open space in the northeast corner of the study area and the large network of existing open space adjacent to the study area to the north (Linkage 4 in **Table 5-9** and **Figure 5-8**) (LAND-L7).
- Protect large stands of valley oak woodland (LAND-OC3).
- Protect stands of northern coastal scrub/Diablan sage scrub (LAND-C3).
- Protect upper watershed tributaries of Upper Penitencia Creek (important breeding habitat for foothill yellow-legged frog) and Cherry Flat Reservoir (LAND-L1, LAND-R5).
- Protect an area with a high density of ponds and likely breeding habitat for California red-legged frog, California tiger salamander, and western pond turtle (LAND-G2, LAND-OC1, LAND-OC2, LAND-OC3, LAND-OC4, LAND-OC5, LAND-WP3a, LAND-WP3b, LAND-WP6a, LAND-WP6b).
- Protect designated critical habitat for California red-legged frog and California tiger salamander (LAND-WP4).
- Protect elevation gradients in the north of the study area under threat from rural residential development (LAND-L2a, LAND-L2b, LAND-L-2c, LAND-L2d).

Land acquisition in these conservation analysis zones will expand the existing open space in the northeast corner of the study area and provide an important linkage to more than 75,000 acres of contiguous protected areas to the north in Santa Clara and Alameda Counties. Acquisition in this area also provides a unique opportunity to protect extensive stands of valley oak woodland, critical habitat for three covered species, and elevation gradients, all with moderate amounts of acquisition. Acquired lands are expected to have excellent potential for freshwater marsh restoration and pond creation.

The specific land acquisition requirements for these conservation analysis zones are shown below.

- Acquire natural land cover types in the two conservation analysis zones as shown in **Table 5-18**.
- Land must be acquired to connect existing open space adjacent to the conservation analysis zones to the north and south.
- The landscape linkage between the study area and SFPUC lands to the northwest must be widened to at least 1.0 mile.

Guadalupe-1 and -3

Guadalupe-3 is one of the largest conservation analysis zones in the study area. However, this zone is largely composed of urban development in San José. The southern edge of Guadalupe-3 supports small but important patches of serpentine grassland, including the north side of Tulare Hill. Guadalupe-1 is combined with Guadalupe-3 for the purposes of the land acquisition strategy because of the similar land cover types found along their borders. The primary purposes of the land acquisition strategy in these conservation analysis zones are listed below.

- Link large block of protected lands south of Calero Reservoir with Almaden Quicksilver County Park and extensive protected lands outside the study area to the west in the Santa Cruz Mountains (Linkage 9 in **Table 5-9** and **Figure 5-8**) (LAND-L8).
- Complete the linkage between the Diablo Range and the Santa Cruz Mountains across Tulare Hill (Linkage 8 in **Table 5-9** and **Figure 5-8**) (LAND-L4, LAND-WP7).
- Protect and enhance important stands of serpentine grassland and serpentine chaparral (LAND-C2).
- Protect and enhance watershed functions in the Guadalupe Watershed (LAND-L3).
- Protect stands of northern coastal scrub/Diablan sage scrub (LAND-C3).
- Protect freshwater perennial marsh and seasonal wetlands (LAND-WP1a, LAND-WP1b, LAND-WP2a, LAND-WP2b).
- Protect important occurrences and suitable habitat of covered plants, including Mt. Hamilton thistle, Metcalf Canyon jewelflower, most beautiful jewelflower, smooth lessingia, and Santa Clara Valley dudleya (LAND-P2, LAND-P3, LAND-P4, LAND-P5, LAND-P6, LAND-P7, LAND-P10).
- Protect important habitat and designated critical habitat for Bay checkerspot butterfly (LAND-G3).
- Partner with various public agencies in north San José (e.g., San José Water Pollution Control Plant, VTA) to protect and maintain the second largest population of western burrowing owls in the study area (LAND-G6).
- Protect the watershed of Alamitos Creek and its tributaries (LAND-R5).

Land acquisition in these conservation analysis zones achieve multiple goals and objectives with relatively low levels of land acquisition. First, many occurrences of covered plants can be protected and possibly enhanced with strategic acquisitions. Second, important potential habitat for Bay checkerspot butterfly would be acquired so that improved management can attract butterflies and expand their range locally.

Finally, key acquisitions can also provide important linkages among the existing network of open space in and adjacent to the study area. These acquisitions can also serve as important buffers between existing and future urban areas and extensive open space in the Santa Teresa Hills and Santa Cruz Mountains.

The land acquisition requirements for these conservation analysis zones are listed below.

- Acquire serpentine grassland within the conservation analysis zones as shown in **Table 5-19**.

- Protect and enhance occupied and potential nesting habitat for western burrowing owl consistent with the burrowing owl conservation strategy described in Section 5.4.6 *Western Burrowing Owl*.
- Acquire at least 1,600 acres in the Guadalupe Watershed as a whole.
- Link Santa Teresa and Calero County Parks.

Coyote-4

Conservation analysis zone Coyote-4 comprises much of the upper watershed of Coyote Creek above Anderson Reservoir (**Figure 5-5**), including some of San Felipe Creek and its tributaries, as well as a portion of Coyote Ridge. The primary purposes of the land acquisition strategy in this conservation analysis zone are listed below.

- Provide landscape linkage between Coyote Ridge and mid- to high-elevation natural communities in the Diablo Range (Linkage 7 in **Table 5-9** and **Figure 5-8**).
- Protect linkage between J. Grant Park and Henry Coe (Linkage 5 in **Table 5-9** and **Figure 5-8**)
- Protect and enhance important stands of valley oak and blue oak woodland (LAND-OC3), mixed oak woodland and forest (LAND-OC1), and annual grassland (LAND-G2).
- Protect and enhance watershed functions in the Coyote Watershed (LAND-L3).
- Protect stands of northern coastal scrub/Diablan sage scrub (LAND-C3).
- Protect and enhance riparian forest along lower San Felipe Creek and its tributaries (LAND-R2, LAND-R5).
- Protect and enhance potential nesting and overwintering habitat for western burrowing owl, and potential breeding and foraging habitat for tricolored blackbird.
- Protect and enhance potential breeding habitat and extensive upland habitat for covered amphibians and western pond turtle (LAND-G2, LAND-OC1, LAND-OC2, LAND-OC3, LAND-OC4, LAND-OC5, LAND-WP3a, LAND-WP3b, LAND-WP5, LAND-WP6a, LAND-WP6b).
- Protect and enhance annual grasslands that support or could support California ground squirrels to provide food and shelter for covered and native species (LAND-G8).
- Protect freshwater perennial marsh and seasonal wetlands (LAND-WP1a, LAND-WP1b, LAND-WP2a, LAND-WP2b).
- Protect designated critical habitat for California tiger salamander.

This conservation analysis zone is noteworthy because of its relatively high concentration of desirable land cover types: blue oak woodland, valley oak woodland, riparian woodland (including high quality sycamore alluvial woodland) and forest, and ponds. Moreover, these areas are largely unsurveyed and may contain important undocumented occurrences of covered plants. Covered wildlife species known or with potential to occur in this area are California red-legged frog, California tiger salamander, western pond turtle, and foothill yellow-legged frog; extensive habitat for these species occurs in this conservation analysis zone. Acquisition in this zone would also support a large proportion of the annual grassland in the Reserve System. These lands may also support secluded rock outcrops or large trees overlooking open grassland that would protect suitable nesting sites for golden eagle and other raptors.

The land acquisition requirements for this conservation analysis zone are listed below.

- Acquire natural land cover types in conservation analysis zone as shown in **Table 5-18**.
- Acquire serpentine grassland within the conservation analysis zones as shown in **Table 5-19**.
- Provide landscape linkage along Coyote Ridge between Anderson Lake County Park and the Silver Creek Hills (Linkage 6 in **Table 5-9** and **Figure 5-8**).
- Connect Coyote Ridge with the San Felipe Ranch Conservation Easement.

In 2008, creation of the San Felipe Ranch Conservation Easement protected all of the remaining unprotected ponderosa pine woodland in the study area. Therefore, no ponderosa pine woodland is available to protect in the Reserve System. There is also no impact expected to this land cover type.

Coyote-5 and 6

Conservation analysis zone Coyote-5 encompasses the southern end of the Coyote watershed and the southern half of Coyote Ridge (**Figure 5-5**). Because this subwatershed spans Coyote Valley, it also includes the eastern extent of the Santa Teresa Hills and the lower foothills of the Santa Cruz Mountains west of Coyote Valley. Coyote-6 encompasses the northern half of Coyote Ridge and the immediate watershed of Silver Creek. The main stem of Coyote Creek below Anderson Dam is excluded from the conservation analysis zone because it occurs within several County parks. These conservation analysis zones were combined for the purposes of the land acquisition strategy because together they include all of Coyote Ridge and support most of the unprotected serpentine grassland in the study area. The primary purposes of the land acquisition strategy in these conservation analysis zones are listed below.

- Provide landscape linkage across Coyote Ridge (Linkage 6 in **Table 5-9** and **Figure 5-8**).
- Enhance the landscape linkage from Coyote Ridge to Coyote Creek, facilitating connections across the Santa Clara Valley (Linkages 8 and 10 in **Table 5-9** and **Figure 5-8**).

- Protect and enhance watershed functions in the Coyote Watershed (LAND-L3).
- Provide a connection from Santa Teresa County Park to Calero County Park.
- Protect and enhance extensive serpentine grassland and serpentine chaparral along Coyote Ridge (LAND-L5, LAND-C2).
- Protect and enhance extensive occupied habitat for Bay checkerspot butterfly and designated critical habitat (LAND-G3).
- Protect freshwater perennial marsh and seasonal wetlands (LAND-WP1a, LAND-WP1b, LAND-WP2a, LAND-WP2b).
- Protect and enhance occurrences of and suitable habitat for covered plants including Mt. Hamilton thistle, Metcalf Canyon jewelflower, most beautiful jewelflower, smooth lessingia, fragrant fritillary, Loma Prieta hoita, Coyote ceanothus, and Santa Clara Valley dudleya (LAND-P1, LAND-P2, LAND-P3, LAND-P5, LAND-P6, LAND-P7, LAND-P8, LAND-P11).
- Protect and enhance annual grasslands that support or could support California ground squirrels to provide food and shelter for covered and native species (LAND-G8), including overwintering habitat for western burrowing owl.
- Protect and enhance upland habitat near and adjacent to Laguna Seca, a future wetland restoration site, for covered species that breed in coastal and valley freshwater marsh (e.g., tricolored blackbird, California tiger salamander, California red-legged frog, and western pond turtle).
- Protect upland habitat connections to Coyote Creek below Anderson Dam, an important regional wildlife linkage (Linkage 10 in **Table 5-9** and **Figure 5-8**).

Land acquisition in these two conservation analysis zones will protect and provide the opportunity to enhance 73% of the remaining suitable and occupied habitat for Bay checkerspot butterfly in Coyote-5 and Coyote-6. Land acquisition in these zones is essential to meeting the conservation objectives for this species. Serpentine grassland and chaparral in these zones also support at least eight covered plant species, sometimes in multiple occurrences; accordingly, conservation in these zones is essential to meeting the plant conservation requirements. To meet the plant conservation targets, serpentine grassland will be acquired on both sides of the Santa Clara Valley, protecting occurrences that may be disjunct from one another. Much of the serpentine chaparral in the Reserve System would be acquired in these zones.

Land acquisition in these conservation analysis zones would also protect and provide opportunities to enhance upland habitat near Laguna Seca. Historically, this large wetland complex was unique in the Santa Clara Valley, supporting a large freshwater marsh and large willow groves (San Francisco Estuary Institute 2006). This wetland complex will be restored by SCVWD to some of its historic condition in conjunction with the approved Coyote Valley Research Park development.

The valley floor between Tulare Hill and Anderson Reservoir is one of the narrowest points in the Santa Clara Valley between the Santa Cruz Mountains and the Diablo Range (Linkages 8, and 10 in **Table 5-9** and **Figure 5-8**). The land acquisition strategy in Coyote-5 focuses on protecting lands east and west of Coyote Creek to allow terrestrial and aquatic wildlife to continue to access and use that creek as a movement corridor (portions of both sides of the creek are already protected by County Parks). Additional land acquisition in the Coyote Valley could occur, but it is not required. As development intensifies on the valley floor in this zone west of the creek, Coyote Creek will increasingly become the primary corridor for terrestrial wildlife moving through the valley.

At least 24 undercrossings or culverts have been documented along this stretch of U.S. 101, most of which are small culverts associated with drainages from Coyote Ridge (though at least one is approximately 6 feet in diameter) (California Department of Fish and Game 2006). There are also two large underpasses that allow wildlife passage under U.S. 101. Many species of wildlife have been documented using these culverts recently, and most of the culverts are utilized by multiple species (T. Diamond pers. comm.). Of the 24 culverts along this stretch of U.S. 101, 19 have Type 1, 2, or 3 open space on both sides of the highway; the remaining five culverts have Type 1, 2, or 3 open space only on the west side of the highway (Coyote Creek Parkway, a County park). The land acquisition strategy in Coyote-5 targets protection of land that provides access to most of the remaining culverts. Management actions within the Reserve System could then focus on enhancing these corridors, as indicated by pre-acquisition assessments and targeted studies. The conservation strategy also includes actions to assess and improve wildlife connectivity in these conservation analysis zones; see Section 5.3.2 *Landscape Conservation and Management* subheading *Connectivity and Permeability*.

The land acquisition requirements for these conservation analysis zones are listed below.

- Acquire serpentine grassland within the conservation analysis zones as shown in **Table 5-19**. Serpentine grassland acquisition must occur on both sides of the Santa Clara Valley.
- Provide linkage between Santa Teresa County Park and Calero County Park.
- Protect at least 50 acres of serpentine grassland east of Santa Teresa County Park.
- Acquire the unprotected portions of the three unprotected occurrences of Coyote ceanothus within Coyote-5.
- Acquire either Kalana 1 or Kalana 2, 3, and 4 populations of Bay checkerspot butterfly (see **Table 5-7** and the species account in **Appendix D**) to protect and enhance habitat for Bay checkerspot butterfly.
- Acquire at least 75% of the currently unprotected portions of mapped habitat for Bay checkerspot butterfly at the Hale and Falcon Crest sites within Coyote-5 and Llagas-3 (see habitat map in species account in **Appendix D**).

Llagas-3

Conservation analysis zone Llagas-3 comprises the northern half of the Llagas Basin subwatershed downstream of Chesbro Reservoir, mostly on the floor of the Santa Clara Valley. This zone includes the city of Morgan Hill and extensive agricultural areas of the valley. It also includes small but important patches of serpentine grassland and riparian woodland. The primary purposes of the land acquisition strategy in this conservation analysis zone are listed below.

- Protect and enhance habitat for Bay checkerspot butterfly on the west side of the Santa Clara Valley (LAND-G3).
- Protect and enhance potential breeding and overwintering habitat for western burrowing owl.
- Protect and enhance the largest population of Coyote ceanothus on the west side of the Santa Clara Valley (LAND-P1).
- Protect designated critical habitat for California tiger salamander (LAND-WP6b, LAND-WP1a, LAND-WP1b, LAND-WP2a, LAND-WP2b).
- Protect occurrences of and suitable habitat for covered plants, including most beautiful jewelflower, Santa Clara Valley dudleya, and smooth lessingia (LAND-P2, LAND-P5, LAND-P7, LAND-P10).
- Provide riparian restoration opportunities along Llagas Creek for least Bell's vireo and other native songbirds (LAND-R2).

Land acquisition on the west side of the Santa Clara Valley within Llagas-3 is essential to meeting the biological objectives for protection of known populations of Bay checkerspot butterfly and Coyote ceanothus. Land acquisition in this area is also important to meeting several plant acquisition targets. Llagas-3 shares conservation targets with Llagas-4 and Uvas-2 for acquisition of critical habitat for California tiger salamander northwest of Gilroy. This area also supports extensive seasonal wetlands and has been proposed as a conservation and wetland mitigation bank (WRA Environmental Consultants 2008).

Land acquisition and riparian/stream restoration along middle Llagas Creek and Little Llagas Creek within Llagas-3 and 4 were considered but rejected. Much of the narrow Llagas Creek is already owned by SCVWD, but the restoration potential is limited by several factors. First, the creek is highly channelized and would therefore require extensive physical modification that may not be feasible in consideration of surrounding lands uses and small parcels. Second, as urban development in Gilroy expands to the east, the habitat value of Llagas and Little Llagas Creeks will diminish. Finally, one of the covered activities in this Plan is a flood protection project along Llagas Creek. While that project will be built to minimize adverse effects on wildlife and habitat, its increasing use as a flood conveyance facility limits its dual use as habitat for covered species. For these reasons, land acquisition and stream and riparian restoration was instead directed to stream reaches with greater potential for enhancement of stream and riparian functions such as Uvas Creek, Carnadero Creek, Lower Llagas Creek, the Pajaro River, and Pacheco Creek.

The land acquisition requirements for this conservation analysis zone are listed below.

- Acquire land in Llagas-3 to fully protect the occurrence of Coyote ceanothus found in this zone.
- Acquire serpentine grassland within the conservation analysis zones as shown in **Table 5-19**.
- Acquire at least 75% of the currently unprotected portions of mapped habitat for Bay checkerspot butterfly at the Hale and Falcon Crest sites within Llagas-3 and Coyote-7 (see habitat map in species account in **Appendix D**).

Llagas-4

Conservation analysis zone Llagas-4 encompasses the southern half of the Llagas Basin, mostly on the floor of the Santa Clara Valley. For convenience, this zone also includes the northern edge of the adjacent watershed that extends into San Benito County (**Figure 5-5**). The primary purpose of the land acquisition strategy in this conservation analysis zone is to protect designated critical habitat for California tiger salamander (LAND-WP6b, LAND-WP1a, LAND-WP1b, LAND-WP2a, LAND-WP2b).

Llagas-4 shares conservation targets with Llagas-3 and Uvas-2 for acquisition of critical habitat for California tiger salamander northwest of Gilroy. This area also supports extensive seasonal wetlands and has been proposed as a conservation and wetland mitigation bank (WRA Environmental Consultants 2008). See Llagas-3 for a discussion of why land acquisition along Llagas and Little Llagas Creek was not a priority within Llagas-3 and 4. There are no specific land acquisition requirements in Llagas-4.

Pescadero-1

Conservation analysis zone Pescadero-1 is located at the southwest corner of the study area and encompasses all of the Pescadero watershed within the study area. This conservation analysis zone includes most of the headwaters of Pescadero Creek. The primary purposes of the land acquisition strategy in this conservation analysis zone are listed below.

- Protect the headwaters and streams of the Pescadero Creek watershed (LAND-L1, LAND-L3, LAND-R5).
- Protect and maintain high-quality redwood forest (LAND-OC6).
- Protect large stands of northern coastal scrub/Diablan sage scrub (LAND-C3) and annual grassland (LAND-G2).
- Protect and maintain high-quality riparian woodland in Pescadero Creek (LAND-R2).

- Facilitate the landscape linkage from the study area to the Lomerias Muertas Range (Linkage 19 in **Table 5-9** and **Figure 5-8**) and to the Gabilan Range (Linkage 20) (LAND-L19).
- Protect a portion of the linkage along the ridgeline of the Santa Cruz Mountains (Linkage 13).
- Protect and enhance habitat for California red-legged frog and western pond turtle in the Santa Cruz Mountains (LAND-WP5, LAND-WP6a, LAND-WP6b).
- Protect strong environmental gradients within the Santa Cruz Mountains (LAND-L2a, LAND-L2b, LAND-L2c, LAND-L2d).

In most years stream flow in Pescadero Creek is low, and some reaches are likely to be intermittent or dry. In wet years, most reaches along Pescadero Creek are flowing and are bordered by dense riparian forest that provides ample shade and in-stream woody debris that create pools for rearing and sheltering native fish, including juvenile steelhead. In-stream ponds and off-stream seasonal wetlands and ponds in this watershed likely provide habitat for California red-legged frog, California tiger salamander, and western pond turtle (H.T. Harvey & Associates 2006). The Pescadero watershed also supports stands of redwood forest, some of which may be unlogged.

Land acquisition in this watershed will protect large stands of riparian woodland and potential breeding habitat for least Bell's vireo, along with diverse land cover types in the southern Santa Cruz Mountains that range from California annual grassland to redwood forest to valley oak woodland. These lands may also support secluded rock outcrops or large trees overlooking extensive stands of annual grassland that would provide suitable nesting sites for raptors.

Uvas-1, 2, 5, and 6

All the conservation analysis zones in the Uvas watershed are combined for the purposes of the land acquisition strategy. The primary purposes of the land acquisition strategy in these conservation analysis zones are listed below.

- Protect headwaters of tributaries of Uvas Creek (LAND-L1, LAND-R5).
- Protect stands of northern coastal scrub/Diablan sage scrub (LAND-C3).
- Protect freshwater perennial marsh (LAND-WP3, LAND-WP1a, LAND-WP1b).
- Protect and enhance breeding habitat for California red-legged frog and western pond turtle in the Santa Cruz Mountains (LAND-WP5, LAND-WP6a, LAND-WP6b).
- Facilitate the landscape linkage from the study area to the Lomerias Muertas Range (Linkage 19 in **Table 5-9** and **Figure 5-8**) and to the Gabilan Range (Linkage 20) (LAND-L9).

- Protect a portion of the linkage along the ridgeline of the Santa Cruz Mountains (Linkage 13 in **Table 5-9** and **Figure 5-8**).
- Protect strong environmental gradients within the Santa Cruz Mountains (LAND-L2a, LAND-L2b, LAND-L2c, LAND-L2d).
- Protect and enhance watershed functions in the Uvas Watershed (LAND-L3).
- Protect stands of northern mixed chaparral (LAND-C1) and annual grassland (LAND-G2).
- Protect riparian woodland and opportunities for riparian woodland restoration along Uvas/Carnadero Creek and the linkage along the creek (Linkage 12) (LAND-R2, LAND-R5).

Land acquisition is planned above Uvas Reservoir to protect high-quality habitat for foothill yellow-legged frog, riparian woodland, and a relatively high diversity of natural communities with a relatively low intensity of rural development in the watershed. Land cover types above Uvas Reservoir include serpentine chaparral, blue oak woodland, foothill pine-oak woodland, and valley oak woodland. Land acquisition above Uvas Reservoir has the potential to create an unbroken landscape linkage from Uvas Reservoir to Santa Teresa County Park. Land acquisition in the Uvas watershed conservation analysis zones will also support populations of California red-legged frog and California tiger salamander in the Santa Cruz Mountains to ensure that populations on either side of the Santa Clara Valley are protected and managed.

The land acquisition requirements for these conservation analysis zones are listed below.

- Protect natural land cover types within the conservation analysis zones as shown in **Table 5-18**.
- Extend the Uvas Creek Park Preserve 1.6 miles upstream to Hecker Pass Highway (LAND-R1) and setback expected development adjacent to this stream segment consistent with the stream setback condition (see Chapter 6) to protect the Uvas Creek Corridor[16].
- Protect at least 1.0 mile of Uvas Creek above Uvas Reservoir to protect and enhance habitat for foothill yellow-legged frog and California red-legged frog.

Llagas-2

Conservation analysis zone Llagas-2 occurs around and upstream of Chesbro Reservoir and borders the eastern edge of the Cañada del Oro Open Space Preserve. The primary purposes of the land acquisition strategy in this conservation analysis zone are listed below.

- Protect riparian woodland in upper Llagas Creek (LAND-R5).

[16] This conservation action is consistent with Goals 5-5, 5-7, and 5-8 of the approved City of Gilroy Hecker Pass Specific Plan (City of Gilroy 2005).

- Protect occupied habitat for foothill yellow-legged frog in upper Llagas Creek.
- Protect and enhance serpentine grassland and serpentine chaparral (LAND-G1, LAND-C2).
- Protect stands of northern coastal scrub/Diablan sage scrub (LAND-C3).
- Protect and enhance breeding habitat for California red-legged frog and California tiger salamander in the Santa Cruz Mountains (LAND-WP1a, LAND-WP1b, LAND-WP2a, LAND-WP2b).
- Protect riparian habitat along upper Llagas Creek for least Bell's vireo and other native songbirds and provide riparian restoration opportunities (LAND-R2).
- Protect potential habitat for Bay checkerspot butterfly (LAND-G3).

Land acquisition in this conservation analysis zone serves multiple purposes. Some of the only known occupied habitat for foothill yellow-legged frog in the Santa Cruz Mountains in the study area is present upstream of Chesbro Reservoir (H.T. Harvey & Associates 1999). The conservation strategy includes stream protection along upper Llagas Creek to protect this habitat and provide opportunities for habitat enhancement, as indicated by pre-acquisition assessments and targeted studies and informed by the monitoring and adaptive management program. Furthermore, potential habitat for Bay checkerspot butterfly (Cañada Garcia site) and serpentine covered plants are also found in this conservation analysis zone. Because surveys have not been conducted in this area, the occurrence of serpentine covered species is largely unknown. This conservation analysis zone also supports small patches of serpentine chaparral.

The land acquisition requirements for this conservation analysis zone are listed below.

- Acquire serpentine grassland within the conservation analysis zones as shown in **Table 5-19**.
- Acquired land that will connect with either protected lands around Chesbro Reservoir or the Open Space Authority lands within the analysis zone.
- Acquire at least 1.0 mile of Llagas Creek above Chesbro Dam to protect and enhance habitat for foothill yellow-legged frog, California red-legged frog, and least Bell's vireo.

Pacheco-1, 2, 3, 4, 5, and 6

Conservation analysis zones Pacheco 1–6 encompass the upper and middle reaches of Pacheco Creek and its tributaries (e.g., south and north forks of Pacheco Creek). These conservation analysis zones are characterized by large, remote ranches with grassland, oak woodland, and chaparral at a variety of elevations and terrain. Extensive tracts of riparian woodlands are found in several zones along Pacheco Creek and its major tributaries. These zones are combined for the purposes of the land acquisition strategy because of their similar land cover types and species habitat, and the overlapping land ownership patterns among the zones. The primary purposes of the land acquisition strategy in these conservation analysis zones are listed below.

- Protect and enhance riparian woodland, including large stands of sycamore alluvial woodland, along the main stem and tributaries of Pacheco Creek, and provide restoration opportunities in this area (LAND-R2).
- Protect potential breeding habitat for least Bell's vireo (LAND-R5).
- Protect portions of landscape linkage along Pacheco Creek (Linkage 17 in **Table 5-9** and **Figure 5-8**) (LAND-L1).
- Maintain landscape linkages across SR 152 at key undercrossings or gaps in the highway median barrier (Linkage 15 in **Table 5-9** and **Figure 5-8**) for San Joaquin kit fox and other native species.
- Protect and enhance watershed functions in the Coyote and Pacheco Watersheds (LAND-L3).
- Protect movement and potential breeding habitat for San Joaquin kit fox (LAND-G9).
- Protect and enhance extensive stands of annual and potential native grasslands (LAND-G2, LAND-G3) that support or could support California ground squirrels to provide food and shelter for covered and other native species (LAND-G5, LAND-G8).
- Protect strong environmental and elevation gradients (LAND-L2a, LAND-L2b, LAND-L2c, LAND-L2d).
- Protect large stands of northern mixed chaparral (LAND-C1), mixed oak woodland and forest (LAND-OC1), and valley oak woodland (LAND-OC3).
- Protect and enhance breeding and upland habitat for covered amphibians and reptiles (LAND-G2, LAND-OC1, LAND-OC2, LAND-OC3, LAND-OC4, LAND-OC5, LAND-WP5, LAND-WP6a, LAND-WP6b).

Land acquisition in these conservation analysis zones will protect important stands of riparian woodland and scrub, valley oak woodland, and northern mixed chaparral. Riparian woodland along Pacheco Creek may provide suitable breeding habitat for least Bell's vireo. These lands may also support secluded rock outcrops or large trees overlooking open grassland that would provide suitable nesting sites for golden eagle and other raptors. In addition, the low-elevation annual grassland and some oak woodland types are suitable for movement of San Joaquin kit fox through the study area to known breeding sites at the fringes of the inner Coast Ranges to the east and south of the county. Acquisition of low-slope grassland in this area may also provide suitable breeding habitat for San Joaquin kit fox, although such events are expected to be rare.

Land acquisition in these conservation analysis zones will also protect a landscape linkage within the Diablo Range (Linkage 15) that will benefit several covered and other native species such San Joaquin kit fox, Tule elk, and mountain lion. Because the threat of development in these zones is low, land acquisition in these zones is targeted, in part, at key points along SR 152 where kit fox and other native wildlife are most likely to cross the busy road. SR 152 between Gilroy and the Santa Clara/Merced county line poses a major hazard and a partial barrier to wildlife movement. In addition to the large and increasing volume of traffic, a 6-mile-long median barrier stretches from Bell Station to the Santa Clara/Merced County line. There are only three breaks in this barrier, each about 50 feet wide. Because these breaks are so narrow and few, and because of the high volume of traffic on the road, undercrossings are very important to maintain a landscape linkage across the road.

There are six bridges that span creeks along SR 152 and offer connectivity along the stretch with the median barrier (**Figure 5-8**). The riparian corridors are well vegetated, and the bridge spans offer adequate clearance for all species to move underneath. There are no data of wildlife use of these undercrossings, but the habitat model for San Joaquin kit fox (**Appendix D**) suggests this area as a potential regional linkage. The land acquisition strategy in these zones will preserve key undercrossings along SR 152. The conservation strategy also includes actions to assess and improve wildlife connectivity in these conservation analysis zones; see Section 5.3.2 *Landscape Conservation and Management* subheading *Connectivity and Permeability*.

The land acquisition requirements for these conservation analysis zones are listed below.

- Land acquisitions in these conservation analysis zones will occur as shown in **Table 5-18**.
- Land will be acquired on either side of SR 152 at two key crossing points to protect and provide opportunities to enhance wildlife movement across the road.
- Protect at least 1.0 mile of the main stem of Pacheco Creek, North Fork of Pacheco Creek below Pacheco Dam, or South Fork Pacheco Creek.
- Protect land in the Pacheco Creek Watershed giving higher priority to lands with gentler slopes that provide suitable habitat for San Joaquin kit fox.

Pacheco-7 and -8, Coyote-2

Although they are in different watersheds, Pacheco-7, Pacheco-8, and Coyote-2 serve a similar function because they represent the closest connection between Henry W. Coe State Park and the extensive wetland complex across the county line in San Benito County (San Felipe and Soap Lakes). These conservation analysis zones are also combined for the purposes of the land acquisition strategy because of their similar patterns of land ownership and parcel configuration. The primary purposes of the land acquisition strategy in these conservation analysis zones are listed below.

- Link Henry W. Coe State Park with the San Felipe Lake (Soap Lake) region in San Benito County (Linkage 14 in **Table 5-9** and **Figure 5-8**) (LAND-L6).

- Protect immediate watershed of San Felipe Lake.
- Protect riparian woodland and streams in upper Coyote Creek and Pacheco Creek (LAND-L1, LAND-R2), including large stands of sycamore alluvial woodland.
- Protect freshwater perennial marsh (LAND-WP1a, LAND-WP1b).
- Protect and enhance high density of ponds to support covered amphibians and reptiles and other native species, and possibly tricolored blackbird (LAND-G2, LAND-OC1, LAND-OC2, LAND-OC3, LAND-OC4, LAND-OC5, LAND-WP5, WP3a, LAND-WP3b, LAND-WP5, LAND-WP6a, LAND-WP6b).
- Protect designated critical habitat for California tiger salamander.
- Protect movement and potential breeding habitat for San Joaquin kit fox (LAND-G9).
- Protect and enhance annual grasslands (LAND-G2) that support or could support California ground squirrels to provide food and shelter for covered and other native species (LAND-G5, LAND-G8).
- Protect foraging habitat for birds using the large wetland complex surrounding San Felipe Lake, including tricolored blackbird.
- Protect strong environmental gradients in the study area (LAND-L2a, LAND-L2b, LAND-L2c, LAND-L2d).
- Protect and enhance valley oak woodland (LAND-OC3).

The land acquisition strategy in these conservation analysis zones focuses on protection of environmental gradients, habitat for covered amphibians, and an important landscape linkage. This area has an unusually high density of ponds compared to the rest of the study area; accordingly, it provides excellent potential breeding sites for California red-legged frog, California tiger salamander, western pond turtle, and possibly tricolored blackbird. With enhancement, this dense network of ponds could support a large population of these covered species. These conservation analysis zones, particularly Pacheco-8, also provide an important connection over a wide range of environmental gradients between Henry W. Coe State Park and the large wetland complex in Soap Lake, including San Felipe Lake. Land within Pacheco-8 provides the most direct connection between this wetland complex and the vast area of annual grassland and oak woodland in the Diablo Range foothills; consequently, Pacheco-8 may be important for terrestrial wildlife moving from the Santa Clara Valley to the Diablo Range. In addition, aquatic species breeding at San Felipe Lake (e.g., tricolored blackbird) likely forage in upland habitats nearby; land within these conservation analysis zones provides the closest upland foraging habitat to San Felipe Lake. This area also provides the “gateway” from the Diablo Range to Linkage 18 along the Pajaro River. Large stands of valley oak woodland and riparian sycamore alluvial woodland are also found within these conservation analysis zones.

The land acquisition requirements for these conservation analysis zones are listed below.

- Land acquisitions in these conservation analysis zones will occur as shown in **Table 5-18**.
- Protect land that connects Henry W. Coe State Park to SR 152 (and San Felipe Lake in adjacent San Benito County).
- Protect at least 1.0 mile of the main stem of Pacheco Creek.

Conservation Analysis Zones without Requirements

There are no specific land acquisition requirements in the following conservation analysis zones.

- San Tomas-1. This zone is highly urbanized at the western edge of the study area, entirely within San José. There is almost no natural vegetation left in this zone, and the creeks running through it do not provide habitat for any of the covered species.
- Guadalupe-2. This zone is also highly urbanized (84%) and provides only small, fragmented habitat for the covered species. Much of what remains is already in open space designations.
- Coyote-1 and 3. These remote and rugged conservation analysis zones are adjacent to the north and west side of Henry W. Coe State Park. There are limited acquisition opportunities in the zone due to the low number of large parcels. Development potential in this zone is very low due to steep topography, little or no access, and a lack of surface water. The few parcels occurring in these zones are expected to be acquired by State Parks as part of the expansion of Henry W. Coe State Park. Because State Parks is not a permittee in this Plan, land acquisition targets were not established in these zones.
- Coyote-8, 9, and 10. These conservation analysis zones have a relatively high degree of parcelization and urban and rural development, making conservation in these zones challenging. Coyote-10 is almost entirely within the urban service area for San José and is highly urbanized. Coyote-8 and 9 have limited conservation opportunities because of the high degree of rural development. Land acquisition or long-term management agreements within Coyote-10 (and possibly Coyote-8 and 9) will occur to protect and enhance breeding habitat for western burrowing owl consistent with the burrowing owl conservation strategy described in Section 5.4.6 *Western Burrowing Owl*.
- Llagas-1 and 5. These zones are small (Llagas-1 = 3,092 acres; Llagas-5 = 4,129 acres), support only small amounts of high-priority land cover types, and have a high proportion of small parcel sizes, making land acquisition in these zones inefficient.

- Uvas-3 and 4. Similar to Llagas-1 and 5, these zones are small (Uvas-3 = 5,061 acres; Uvas-4 = 4,422 acres). They support only small amounts of high-priority land cover types.

Despite the lack of specific land acquisition requirements in these zones, there are still portions of some of these zones that can contribute to the goals of the Plan. Any land acquired within zones Coyote-3, Coyote-8, or Coyote-9 will count towards the overall land cover requirements for the study area (**Table 5-11**). Acquisition of streams in Coyote-10 may also count towards overall stream acquisition requirements and acquisition of habitat for western burrowing owl in this zone will contribute to goals for this species.

Acquisition of Habitat for Covered Wildlife Species

The land acquisition requirements for land cover types, by geographic locations (e.g., by Conservation Analysis Zones), and for landscape linkages, combined with the reserve assembly principles will allow the Implementing Entity to create a Reserve System that will conserve the covered species. This will occur through preservation, management, and enhancement, and in some cases, restoration, of suitable habitat for the covered species. Although the Plan is not based on field verification of suitable habitat, we have inferred the location of suitable habitat through a combination of the species models (**Appendix D**), locations of designated critical habitat (for some species), extensive data on species observations, and the expert opinion of field biologists familiar with the covered species and the study area. As a result, we are confident that the Reserve System as designed will adequately conserve the covered species.

Requirements to permanently protect plant occurrences will ensure that the covered plants will be conserved by the Plan. The Wildlife Agencies require additional assurances to guarantee that the Implementing Entity will protect habitat for the covered wildlife species and not just land cover types that are assumed to support their habitat. Furthermore, assurances are needed that the Reserve System will support habitat that is occupied by the covered wildlife species. The following requirements are included in the Plan to address these regulatory needs. All of the additional requirements below are additive to the other land acquisition requirements in the Plan.

Acquisition of Modeled Habitat for Covered Species

To address the need to acquire habitat for the covered species and not just land cover types, the Implementing Entity will acquire land with modeled habitat for each covered species for which models were developed in the minimum amounts specified in **Table 5-17**. Commitments are provided both for new land acquired for the Reserve System and land incorporated into the Reserve System from existing open space. The commitments are to acquire minimum amounts of *modeled habitat* based on the species models in **Appendix D**.

Species models will be updated during implementation based on new information. Modeled habitat requirements will be tracked based on the most recent model update. The Implementing Entity will be conducting field inventories of new reserve lands to locate, quantify, and assess the quality of suitable habitat for all covered species. The results of this inventory are important for habitat and land acquisition requirement tracking and long-term management and monitoring (see Chapter 7).

Acquisition of Occupied Habitat for Select Wildlife Species

The Wildlife Agencies require additional assurances that land will be acquired for the Reserve System that will support occupied habitat for five covered wildlife species:

- Bay checkerspot butterfly,
- California red-legged frog,
- California tiger salamander,
- Western pond turtle, and
- Foothill yellow-legged frog.

These species were selected because they are known to consistently breed in multiple locations in the study area or because they are so rare that it is necessary to be assured that occupied lands are protected. It is critical that the Reserve System protect some of this occupied habitat to ensure the conservation of the species in the study area.

Occupancy requirements for the purposes of this Plan do not need to be met at the time of land acquisition. This flexibility provides the opportunity to acquire unoccupied habitat that is later occupied as a result of improved management, habitat restoration (e.g., streams), or habitat creation (e.g., ponds) (see Chapter 5, Section 5.2.3 *Reserve System* and Chapter 8, Section 8.2.5 *Wildlife Agencies*). The metapopulation dynamics of the Bay checkerspot butterfly warranted a specific temporal component of the occupancy requirements, which are described in detail below.

It is important to note that these occupancy requirements are designed to aid the Wildlife Agencies in making their regulatory findings. The Implementing Entity will provide habitat management, habitat enhancement, habitat restoration, and/or habitat creation, in addition to these basic occupancy requirements, because these requirements are not the minimum species targets for the Reserve System. To meet the biological goals and objectives for these species (and all covered species), the Plan includes additional restoration/creation, and monitoring beyond those noted in the following basic occupancy requirements. The abundance and condition of the covered species in the Reserve System will be monitored to determine the effectiveness of the conservation actions.

Bay Checkerspot Butterfly

For the Bay checkerspot butterfly, occupancy will be demonstrated in both core and satellite habitat units (see **Table 5-7** and the species account in **Appendix D** for definitions of core and satellite habitat units). The occupancy requirement will be met by demonstrating the presence of larvae and adults (not just adults, in case individuals fly through a site but are not reproducing).

The Implementing Entity will acquire and manage enough habitat for Bay checkerspot butterfly to ensure occupancy of each of the four core habitat units identified in Figure 5-A of the 1998 Serpentine Recovery Plan (Kirby, Metcalf, San Felipe, and Silver Creek Hills). Occupancy in these four core habitat units must be demonstrated at least four out of every 10 consecutive years of the permit term. This occurrence frequency is based on population data reported for the Kirby, Metcalf, and Silver Creek core habitat units, which are fairly robust (e.g., Kirby population data dates back to 1991).

The Implementing Entity will also acquire and manage land to ensure occupancy of at least three of the six (50%) satellite habitat units identified in the 1998 Serpentine Recovery Plan (W. Hills of Santa Clara Valley, Tulare Hill, Santa Teresa Hills, Calero, Communication Hill[17], or North of Llagas Avenue) (**Table 5-7**) by Year 45. Occupancy is less certain in satellite habitat units because of their smaller size than and greater distance from core habitat units. Because of their isolation, they are colonized only periodically by long-distance dispersal events. Because of their small size, populations that become established go extinct quickly due to small population sizes (Harrison et al. 1988). For these reasons, occupancy of a total of 50% of satellite habitat units must only be demonstrated once by Year 45. For example, occupancy of Tulare Hill in Year 5, North of Llagas Avenue in Year 10, and Calero in Year 15 would fulfill the satellite component of the occupancy criteria. The satellite units with the greatest chance of occupancy due to size, proximity to core units, and expected improvements in habitat management are:

- Santa Teresa Hills
- Tulare Hill
- Calero

There is a potential that less than 50% of the satellite populations will be occupied by Year 45. If this occurs, the Implementing Entity will remain in compliance with the satellite occupancy criteria if it demonstrates to the Wildlife Agencies that it has managed satellites incorporated in the Reserve System in accordance with the Plan and Bay checkerspot butterfly has not colonized these sites for reasons beyond its control (e.g., climate change).

[17] Communication Hill is considered a historic/unoccupied site. Therefore, the three occupied satellite units could occur in any of the five remaining satellite units that are described by this Plan as occupied, potential, or occupancy unknown.

California Red-legged Frog, California Tiger Salamander, and Western Pond Turtle

California red-legged frog, California tiger salamander, and western pond turtle have been grouped for the purposes of the species occupancy requirement because of their co-reliance and frequent co-occurrence in ponds and perennial wetlands in the study area. To simplify this requirement, the species occupancy requirement for these three species is defined as a minimum percent occupancy of the number of freshwater wetlands and ponds in the Reserve System (not wetland or pond acreage).

- California red-legged frog = 40% of ponds and wetlands in each of the federal Recovery Units 4 and 6 in the Reserve System (which correspond to the two major watersheds in the study area).
- California tiger salamander = 30% of ponds and wetlands in the entire Reserve System.
- Western pond turtle = 25% of ponds and wetlands in the entire Reserve System.

The occupancy requirements for these species must be demonstrated when the Reserve System is fully acquired, which will be at or before Year 45. Occupancy is demonstrated the first time that a pond or wetland is occupied by the species, as defined above. Once occupied, a pond or wetland is counted as occupied for this requirement for the rest of the permit term, even if it becomes unoccupied later[18]. As is the case for all covered species habitat, habitat for these species contained within the Reserve System will be protected, enhanced, restored, and monitored. As such, once presence is documented, there is a high probability that these species will persist within the Reserve System.

To ensure that the Implementing Entity is making progress towards these requirements during the permit term, these occupancy requirements must also be met for the Reserve System at Year 30, minus 5% for each one (i.e., 35% for California red-legged frog, 25% for California tiger salamander, and 20% for western pond turtle). The measurement will be made based on the total Reserve System at Year 30.

For the frog and salamander, an entire wetland or pond is considered occupied if the species is reproducing successfully, which is defined as evidence of metamorphosis. This metric ensures that ponds have the correct hydroperiod to support the full life-cycle of California red-legged frog and California tiger salamanders. A site is considered occupied by western pond turtle if basking is observed by adults and juveniles at the same site. Observations of juveniles and adults provide evidence of successful reproduction, and therefore is an indication of population viability. The presence of multiple age-classes is important given that adult turtle populations can persist in highly modified environments

[18] If a pond or wetland becomes unoccupied later, the Implementing Entity will consider altering management at that site to encourage recolonization through the adaptive management process, but that outcome will not affect the occupancy requirement for that site. See Chapter 7 for more details on the monitoring and adaptive management program.

providing the illusion that the population is stable when in fact reproduction is unable to take place, likely due to degraded upland nesting habitat (**Appendix D**).

Ponds created or wetlands restored in the Reserve System that meet the occupancy criteria will count towards the occupancy requirement. Although unoccupied created ponds or restored wetlands would not contribute to the occupancy requirements of this Plan, they would be credited toward the aquatic land cover requirements described in **Table 5-12**. In other words, these created and restored sites do not count as part of the total ponds and wetlands assessed in the Reserve System for this requirement, if these sites are unoccupied. This approach creates an incentive to create ponds and restore wetlands that are occupied by one or more of the covered species.

The occupancy requirements were derived from three data sources, East Bay Regional Park District (Bobzien and DiDonato 2007), and the Central Valley of California (Germano and Bury 2001). Henry W. Coe State Park has the largest data set in the study area on ponds and wetlands and their occupancy by these three species. Surveys of 136 ponds and wetlands were conducted from 2001–2007 in the park (Belli 2007), most of which were in the study area (the remaining sites were just outside the study area in Santa Clara and Stanislaus Counties). The land cover types in Henry W. Coe State Park are similar to those in the rest of the study area. However, there is less grassland in the park than in the rest of the study area because of its higher elevation.

East Bay Regional Park District conducted surveys of 271 ponds 1996, 2000, and 2004. All ponds were surveyed at least once and many ponds were surveyed more than once (Bobzien and DiDonato 2007). Although not in the study area, the habitats, landscapes, and topography of the park lands within the East Bay Regional Park system are similar to that of the study area. The survey in the Central Valley of California was conducted in 1999 at 55 aquatic sites in the Sacramento and San Joaquin Valleys; 27 of these sites were ponds or lakes (Germano and Bury 2001). Only the data from ponds and lakes was considered for this analysis.

Surveys in Henry W. Coe State Park found California red-legged frog in 41 ponds (30.1%), California tiger salamander in 9 ponds (6.7%), and western pond turtle in 18 ponds (13.2%). The ponds and wetlands in Henry W. Coe State Park are representative of the ponds and wetlands expected to be found in the Reserve System, with two exceptions. First, Henry Coe is at higher elevations than the expected Reserve System. This means that California tiger salamander will likely be more common in the Reserve System than in Henry Coe, all else being equal. Second, there is no active predator removal program in Henry W. Coe State Park to remove bullfrogs, bass, and other nonnative predators. Therefore, California red-legged frog and California tiger salamander are expected to be more abundant in the Reserve System than in Henry W. Coe State Park due to the aggressive predator control planned for the Reserve System.

Surveys of ponds in the East Bay Regional Park District system found California red-legged frog in 75 of 271 ponds (27.7%) and California tiger salamander in 75 of 170 ponds within the range of that species (44.1%) (Bobzien and DiDonato 2007). Western pond turtle occurrences were not reported. The East Bay Regional Park District has an active predator-control program in ponds and other wetlands. Therefore, the abundance of the two amphibians within their ponds is likely more representative of what the Reserve System should expect, with one exception. California tiger salamander distribution within the East Bay Regional Park District may be higher than what will be seen in the Reserve System because the Reserve System will include ponds and wetlands in the Santa Cruz Mountains (not just the Diablo Range, where the East Bay Regional Park District is found). California tiger salamander is likely less abundant in the Santa Cruz Mountains than in the Diablo Range.

The aquatic surveys of the Central Valley ponds and lakes found western pond turtle at 10 of the 27 ponds and lakes surveyed (37%). Amphibians were not surveyed. In this study, sites were selected based on known historic or suspected occurrences of western pond turtle (Germano and Bury 2001). Therefore, the sample was likely biased towards occupied sites and may overestimate the occurrence of this species in all ponds and lakes in the Central Valley.

The species occupancy target for California red-legged frog (40%) was set for the study area as a rounded number greater than the results of these two applicable studies, considering the factors outlined above. The minimum occupancy targets for California tiger salamander and western pond turtle (30% and 25% respectively) were set at or above the midpoint between the two applicable study results. In all three cases, targets take into account the assumed success in attracting these species to created ponds. Nonnative barred tiger salamander alleles will be assumed present in wetlands and ponds containing paedamorphic tiger salamanders[19]; therefore, such ponds and wetlands will not count towards the California tiger salamander species occupancy requirement (see **Appendix K** for details).

Species occupancy for California red-legged frog must be met equally in both of the major watersheds in the study area, which match the two federal recovery units identified in Figure 5-B of the Species Recovery Plan (Units 4 and 6; U.S. Fish and Wildlife Service 2002). In other words, 40% of the ponds and/or wetlands in the Coyote Creek/Guadalupe River portion of the Reserve System will be occupied and 40% of the ponds and/or wetlands in the Pajaro River watershed portion of the Reserve System will be occupied.

Both California red-legged frog and western pond turtle also occur in streams throughout the study area. However, accounting for occupancy in streams, which do not have discrete boundaries as do ponds and wetlands, will complicate compliance monitoring. Furthermore, both species are known to travel significant distances from breeding sites, which would make it more difficult to identify the extent of "occupied" stream length. For these reasons, and because the majority of the conservation benefits afforded to these two species will be

[19] Paedamorphic tiger salamanders are sexually mature adult tiger salamander that retain juvenile characteristics (e.g., maintain larval form). Paedamorphisis is a characteristic of non-native barred tiger salamanders, whereas, California tiger salamanders always metamorphize prior to sexually maturity.

through the preservation and enhancement, restoration, and/or creation of ponds and wetlands (**Table 5-12**), occupancy requirements will be measured by pond and wetland habitat within the Reserve System, not streams.

The species occupancy target for western pond turtle is based on the best available data and the need to meet the regulatory standard to contribute to recovery. If future monitoring data or other information suggests that this target is biologically unattainable, the Implementing Entity will confer with the Wildlife Agencies to revise the target (including how it is measured) to better meet the regulatory standards and the biological goals and objectives of this Plan. Additional conservation actions (e.g., translocation) may be necessary to achieve conservation for this species. All translocation activities will be reviewed and approved by the Wildlife Agencies in advance of translocation activities occurring.

Foothill Yellow-legged Frog

Foothill yellow-legged frog is known or suspected to occur in at least five major rivers and creeks in the study area based on occurrence records and the presence of suitable habitat:

- Upper Penitencia Creek, below Cherry Flat Reservoir
- San Felipe Creek
- Upper Coyote Creek and its tributaries, above Coyote Reservoir
- Llagas Creek above Chesbro Reservoir
- Upper tributaries to Uvas Creek, including Little Arthur and Bodfish Creeks

Additional populations may be present in the many unsurveyed streams of the study area. The population in Upper Coyote Creek is located in Henry W. Coe State Park and the Palassou Ridge Open Space Preserve. The populations in Upper Penitencia Creek and San Felipe Creek are partially contained in Alum Rock Park and the San Felipe Ranch Conservation Easement, respectively. Known populations occur in three of the major watersheds in the study area shown in **Figure 3-6** (Coyote, Llagas, and Uvas). Additional populations may occur in two more watersheds (Pacheco and Pescadero).

For the purposes of demonstrating occupancy of foothill yellow-legged frog in this Plan, occupied habitat within the Reserve System is defined as perennial streams with an observation of egg masses by Year 45. Although there are some reports of foothill yellow-legged frogs breeding in perennial tributaries in the study area, the species typically breeds in perennial portions of main-stem channels (E. Gonsolin pers. comm.; Kupferberg et al. 2009). This is likely because main stem channels provide habitat that is more conducive to successful breeding in the study area (i.e., areas of shallow, low velocity flows during the spring months) as opposed to perennial portions of tributaries that often have turbulent conditions (E. Gonsolin pers. comm.). The presence of egg masses will adequately demonstrate occupancy because spring breeding and summer tadpole rearing represent critical life stages for this species (Kupferberg et al. 2009).

Foothill yellow-legged frogs are known to travel significant distances and are highly stream dependent (**Appendix D**). For these reasons, correlating occupied stream segments (i.e., miles of stream) to observed egg masses will be difficult. Therefore, the foothill yellow-legged frog occupancy requirement for this Plan will be met when the Implementing Entity protects occupied habitat in the Reserve System in at least four of the watersheds in **Figure 3-6**. This target was set based on the probability of occupancy in the Reserve System in each of the watersheds in **Figure 3-6**: very high in the Reserve System within the Llagas watershed, high in the Coyote watershed, moderate-high in the Uvas watershed, and moderate in the Pacheco and Pescadero watersheds. These rough probabilities were based on the location of known occurrences, highly suitable habitat, and Reserve System acquisitions.

Occupied habitat in the Reserve System must be in both the Diablo Range and in the Santa Cruz Mountains. Historic populations of this species have likely been lost from the Santa Clara Valley floor (H.T. Harvey & Associates 1999), so it is important to protect occupied habitat in both mountain ranges in case there is no connectivity between the two ranges.

Furthermore, occupancy will be demonstrated upstream of dams that present permanent barriers to the species or on streams unaffected by dam operations. Although foothill yellow-legged frogs could occur downstream of dams within the study area, remnant populations are likely to be adversely affected by continued dam operations. Foothill yellow-legged frog populations in regulated rivers are likely at greater risk of extinction by virtue of their low abundance, even before the effects of hydrologic stressors are considered (Kupferberg et al. 2009). For these reasons, the best opportunities for maintaining and increasing foothill yellow legged frog populations exists upstream of dams, or in streams unaffected by dam operations, and will be the focus of the conservation strategy for this species (e.g., see Goal 16 for this Plan).

Stay-Ahead Provision and Rough Proportionality

The timing and sequence of reserve assembly relative to impacts of covered activities is critical to the success of the Habitat Plan. Progress toward assembling the Reserve System must *stay ahead* of progress toward total impacts allowed under the permit. This sequence ensures that reserve assembly is keeping pace with development and that the Implementing Entity is making steady progress toward the complete Reserve System.

Such progress toward assembly of the Reserve System is a requirement under the NCCP Act. The NCCP Act requires that implementation of mitigation and conservation actions be "roughly proportional in time and extent to the impact on habitat or covered species authorized under the plan" (California Fish and Game Code Section 2820[b][9]). To meet the requirements of this section, CDFG requires that NCCPs make progress towards the final conservation goals (i.e., the ultimate size and configuration of the Reserve System) in proportion to the impacts of covered activities. The Stay-Ahead provision applies to both preservation/enhancement and restoration commitments in this Plan and is further described in Chapter 8 (Section 8.6.1 *Stay-Ahead Provision*) addresses this requirement.

If impacts occur more slowly than expected, strict adherence to the Stay-Ahead provision would result in relatively slow growth of the Reserve System initially, followed by a rapid expansion of the Reserve System in order to meet the final acquisition targets. To ensure that the Implementing Entity makes steady progress towards the final land acquisition targets, in Year 20 of implementation, the Implementing Entity will work with the Wildlife Agencies to conduct a formal and complete review of progress toward building the Reserve System. To ensure that the Implementing Entity makes steady progress towards final restoration/creation goals, interim deadlines are established in **Table 5-14** for each watershed in the study area. Section 5.3.6 *Riverine and Riparian Forest and Scrub Conservation and Management* also includes deadlines for riverine acquisition and restoration. The Stay-Ahead provision described above must always be followed.

Land Acquisition Outside the Permit Area

In order to meet the requirements of this conservation strategy, all land acquisition must occur within the Habitat Plan permit area, including the *Expanded Study Area for Burrowing Owl Conservation*[20] (**Figure 1-2**). Parcels extending beyond the County and/or Habitat Plan permit area could be counted toward land acquisition commitments of this Plan if more than half of the parcel is located within the permit area. For example, land acquisition along the ridgeline of the Santa Cruz Mountains may include some land in Santa Cruz County. If parcels are acquired that include land outside the permit area, land cover types on that parcel will be credited toward applicable Plan requirements as long as less than half the parcel is outside the permit area and the total land area credited outside the permit area is less than 250 acres.

As described in the land acquisition strategy, regional linkages are important to some covered and other native species (**Table 5-9** and **Figure 5-6**). The Implementing Entity is encouraged to partner with other organizations to secure these regional linkages inside and outside the study area. For example, the linkage from the Santa Cruz Mountains to the Gabilan Range will not function unless suitable habitat is present in four counties: Santa Clara, Santa Cruz, Monterey, and San Benito. Securing this linkage will require strong partnerships.

Conservation in the Study Area beyond Habitat Plan Requirements

The land acquisition requirements above are not designed to provide the blueprint for all conservation in the study area. Open space acquisition will

[20] Land acquisition in the *Expanded Permit Area for Burrowing Owl Conservation* will only be done to satisfy requirements for the burrowing owl conservation strategy, not other species covered under this Plan.

continue separate from the Habitat Plan during and after the permit term, and projects not covered by the Plan will need to implement their own mitigation. However, conservation that occurs separate from this Plan will benefit the Plan and the biological resources of the study area if these acquisitions occur in coordination with the Plan. The following general priorities were developed to help guide conservation that occurs separate from the Habitat Plan. These priorities can also guide conservation actions under the Habitat Plan in the event that separate conservation or other actions prevent land from being acquired under the Habitat Plan in the areas listed above. These priorities build on the Habitat Plan Reserve System to create a larger system of conservation and open space in the study area.

- **Conservation Analysis Zones with High Acquisition Priority.** More land acquired in the conservation analysis zones already designated at a high priority for conservation will strengthen the Reserve System by creating larger, more contiguous conservation areas that are better able to preserve covered species habitat and landscape linkages.
- **Uvas-4, 5, Pescadero-1.** Additional land acquisition in these zones will increase protection in the Uvas and Pescadero watersheds to benefit native fish, California red-legged frog, California tiger salamander, and western pond turtle, among others. Land acquisition in this area could complete Landscape Linkage 13 between Mount Madonna County Park and the Reserve System in the southwestern corner of the study area.
- **Uvas-2 and 3.** Additional land acquisition in these zones will increase watershed protection in the Uvas watershed, protecting water quality and habitat for California red-legged frog, California tiger salamander, and western pond turtle along Uvas Creek, above and below Uvas Reservoir. Land acquisition will also support Landscape Linkage 13 and help to connect Mount Madonna County Park with open space surrounding Uvas Reservoir and the Reserve System to the north.
- **Coyote-9.** Land acquisition in this zone will increase protection of annual grassland and blue oak woodland near Alum Rock Park and the Reserve System in Coyote-7 and Alameda-1. Additional protection in this area will preserve more habitat for California red-legged frog, California tiger salamander, and western pond turtle and create a stronger linkage to outside the study area to the north (Landscape Linkage 4).
- **Coyote Ridge.** While most of Coyote Ridge is targeted for land acquisition (see Coyote-4, 5, and 6), parcels with no or lower-quality habitat for Bay checkerspot butterfly and serpentine covered plants would not be included in the Reserve System. Additional land acquisition in Coyote Ridge, particularly in the northwest, would provide additional covered species habitat and important buffers between the Reserve System and existing urban development.
- **Pacheco Watershed.** Additional land acquisition in the Pacheco watershed would strengthen and expand the Reserve System and could provide better linkages to Henry W. Coe State Park and Pacheco State Park. Although development threats in this watershed are low, increased open space could

provide much greater opportunities for habitat enhancement and long-term monitoring.

- **Uvas-1.** Additional land acquisition in the upper Uvas Creek watershed could expand the existing open space and the Reserve System that protects some of the only stands of knobcone pine woodland in the study area. Additional land acquisition could protect the remaining stands of this land cover type and enhance watershed and water quality protection.

5.3.2 Landscape Conservation and Management

This section discusses conservation and management in the permit area at the landscape level. The following sections describe conservation and management guidelines and principles for each natural community. Conservation and management guidelines specific to individual covered species are presented in the discussion of the relevant natural community. Additional conservation and management discussions are also included in the species-specific sections (see Section 5.4 *Benefits of and Additional Conservation Actions for Covered Species)*.

Each section is organized as shown below.

- **Biological Goals and Objectives:** A summary of the biological goals and objectives for that community presented in **Table 5-1b**.
- **Acquisition, Restoration, and Enhancement:** A summary of the acquisition, restoration, and enhancement requirements as they apply to that landscape or natural community, referencing the biologically appropriate conservation action from **Table 5-2a or 5-2b**.
- **Management Techniques and Tools:** Guidelines and specific techniques and tools that are recommended to achieve the biological goals and objectives. This section provides details on the conservation actions in **Table 5-2b**.
- **Threats and Uncertainties:** Describes the uncertainties associated with the conservation actions and external threats that may make their successful application more difficult.

Biological Goals and Objectives

A primary goal of this Plan is to protect and maintain natural and semi-natural landscapes within the study area that are large enough to accommodate natural processes beneficial to populations of covered and other native species. The Plan will accomplish this by establishing a Reserve System within the permit area that will preserve a minimum of 33,205 acres (**Table 5-13**). Up to an additional 13,291 acres of existing open space will be incorporated into the Reserve System to enhance their long-term management. The total size of the Reserve System will therefore be a minimum of 46,496 acres.

This Reserve System will support a range of environmental gradients (such as slope, elevation, aspect, rainfall) and a representative diversity of natural communities. In addition to protecting riverine systems and hydrologic function through fee title and conservation easement, the Plan will benefit stream and riparian habitats through the stream setback (described in Chapter 6, Section 6.5, subheading *Condition 11 Stream and Riparian Setbacks*) and by implementing stream and riparian restoration projects.

The Reserve System will be assembled to reduce habitat fragmentation and to sustain and enhance the effective movement and genetic exchange of native organisms within and between natural communities. Habitat connectivity and important movement and dispersal routes will be protected and, when necessary, enhanced inside the study area. Further, the Implementing Entity will increase the permeability for species movement in targeted areas.

The Plan will also enhance or restore representative natural and semi-natural landscapes to maintain or increase the diversity and distribution of native species. Enhancement and restoration activities within the Reserve System will increase the total area of high-quality habitat for covered and other native species and promote those natural processes that define each natural community (e.g., succession, competition). The Reserve System will be large enough to accommodate management for conflicting life history requirements between species. The Reserve System will also be large enough to allow natural disturbance regimes such as fire and flooding to occur. When these natural disturbances cannot be allowed, other management actions will be implemented that mimic those disturbances and yield similar results. Finally, the Plan will eradicate, where possible, or at least reduce the cover, biomass, and distribution of target nonnative invasive plants and reduce the number and distribution of nonnative invasive animals within the Reserve System.

Acquisition, Restoration, Enhancement, Creation

Acquisition

During the course of Plan implementation, a minimum of 33,205 acres of natural land cover types will be acquired through fee title or conservation easement to create the Reserve System (**Table 5-13**).

This Plan does not require protection of agriculture land cover types, although the Implementing Entity may acquire and manage agricultural lands if it determines such acquisition would support the goals and objectives of the Plan. All else being equal, the Implementing Entity will acquire parcels with natural land cover types over cultivate agriculture to fulfill the goals and objectives of this Plan.

Enhancement and Restoration of Natural Communities

All land and aquatic habitats in the Reserve System, including streams, will be enhanced to benefit covered and other native species as indicated by pre-acquisition assessments and targeted studies and informed by the monitoring and adaptive management program (LM-6, LM-7a, LM-7b). Existing open space included in the Reserve System would add up to 13,291 acres of natural land cover that would also be enhanced (**Table 5-5**). In total, the Reserve System would encompass 46,496 acres to 46,920 acres.

A required compensation ratio for specific land cover types, plus a minimum compensation requirement regardless of the level of impact, will result in restoration or creation of an estimated 339 acres of riparian forest and scrub, 75 acres of wetland, 72 acres of pond and 10,4 miles of streams in the Reserve System if all anticipated impacts occur (LM-6, LM-7a, LM-7b; see sections below on each land cover type for further information) (**Table 5-13**). The minimum compensation requirement will allow the Plan to contribute to the recovery of these resources within the study area during the permit term.

Restoration and enhancement of natural communities involves the recovery of ecosystem function that has been lost or degraded, respectively. Implementation of restoration or enhancement activities will initiate or accelerate ecosystem recovery with respect to functional processes, species composition, and community structure. Typically, the aim of restoration and enhancement is to return an ecosystem to a historic state or within the bound of its historic trajectory. In other words, the goal would be to recreate an ecological state that existed prior to the degradation of the system (Clewell et al. 2005). However, the level of restoration and the final result of these activities will be constrained by current conditions and feasibility. For the purposes of this Plan, restoration and enhancement activities will be guided by the biological goals and objectives of the Plan, with the overarching goal of enhancing ecological values in protected landscapes.

There are generally four broad steps to determine a restoration or enhancement program (Hobbs and Norton 1996).

- Identify the processes that have led to or are leading to degradation.
- Develop methods to slow or reverse the decline.
- Determine realistic goals and clear measures of success.
- Develop techniques for implementing these goals.

In this Plan, the techniques for enhancement and restoration are articulated as conservation actions and are summarized in each natural community section below. Guidelines are also presented in each section, where applicable, for selecting restoration sites. However, the following broad recommendations apply to all restoration activities.

- **Manage at multiple levels.** Biological processes occur at a wide variety of scales across the landscape. Restoration and enhancement activities will therefore be planned and executed with these multiple levels in mind. For example, the enhancement of covered plant occurrences will likely occur at a relatively small species level due to the small size of many occurrences. Microhabitats for covered plants such as soil texture, soil depth, rockiness, and nearest neighbor plants will be considered. However, other processes operating at larger levels—such as the spread of invasive species, hillside erosion or deposition, and the patterns of wildfires—will also affect plant habitat enhancement. To be successful, management actions will consider and anticipate processes operating at multiple levels.

- **Balance conflicting species needs.** The effects of an enhancement or restoration action must be evaluated for all covered species before management decisions are finalized. For instance, grazing generally benefits Bay checkerspot butterfly and many of the covered plant species. In contrast, Mt. Hamilton thistle may require grazing exclusions to prevent livestock from trampling its habitat. Similarly, some pond-dependent covered species can require conflicting habitat conditions. Dense emergent vegetation around pond margins can provide good habitat for tricolored blackbird and California red-legged frog but may not provide adequate habitat for California tiger salamander or western pond turtle. The large size of the Reserve System will allow disparate actions to occur in different places and benefit all of the covered species.
- **Account for inherent variability.** It is important to acknowledge that chance events can often exert strong effects on species and natural systems. The most common of these chance events are weather-related factors such as rainfall, temperature, timing of seasons, drought, and the unknown ramifications of global climate change. Other chance events are associated with species populations themselves; these may include reproductive success and dispersal. Such inherently uncontrollable variables and their effects on covered species are best offset by maintaining within the Reserve System a variety of microsites, environmental gradients, and management treatments. This ensures that covered species can take advantage of suitable habitat during good seasons and find refugia in bad seasons.
- **Mimic natural processes.** This is a management technique that recognizes that natural processes (e.g., hydrologic regimes, wildfire) are the fundamental forces that shape natural systems and create and maintain habitat for covered species. Therefore, management actions will focus on defining, maintaining or restoring and, as indicated by pre-acquisition assessments and targeted studies and informed by the monitoring and adaptive management program, enhancing these natural processes. If not feasible, then the effects of those processes can be duplicated by alternative management actions.
- **Use adaptive management principles.** Flexibility and adaptation will be embraced in making management decisions and improving restoration and enhancement activities within natural communities. Adaptive management principles (described in Chapter 7) will apply across the range of general principles as well as to the specific management techniques and tools described below.

Management Techniques and Tools

Most management techniques and tools are discussed under each natural community. Some techniques, however, apply to several natural communities or to the Reserve System as a whole. These landscape-level management actions are described below.

Connectivity and Permeability

One important measure of the Reserve System's success will be the degree to which it allows native wildlife species to move freely within and between the reserve units and to other habitat outside the Reserve System. In addition to wildlife, it is also important that plant occurrences be able to disperse with minimal limitations in order to facilitate occurrence expansion and ensure long-time viability within the context of global climate change. To achieve this, the permeability and connectivity of the study area will be increased by the actions listed below. In landscape ecology, connectivity refers to corridors between core habitat patches that allow for species movement. Protecting species habitat between two existing large protected areas of species habitat to link the two areas is an example of increasing landscape connectivity. Permeability, on the other hand, refers to the relative potential for a species to move across a landscape (Singleton et al. 2002). For example, removal of a fence or other barriers to species movement would increase landscape permeability. While these measures are targeted toward wildlife movement, it is assumed that they will also enhance opportunities for plant dispersal and occurrence expansion.

- Retrofitting or removing fences that serve as barriers or hazards to wildlife movement.
- Improving culverts and other crossing points under roads to make them more attractive and safer for wildlife.
- Perforating or modifying median barriers within the constraints of public safety to make road crossings more available in locations safe for wildlife.
- Collecting consistent data on wildlife movement throughout the study area to better inform the location and type of structures to facilitate movement.

Most fences in the Reserve System will remain and will be utilized for grazing management. Those that are unnecessary will be removed to increase the continuity of the Reserve System (LM-1). Additional fences may be installed to increase flexibility in grazing management or to exclude feral pigs from sensitive natural communities. Most existing private roads within the Reserve System will be utilized for management or monitoring purposes, but those that are unnecessary will be removed and decommissioned (i.e., returned to a natural condition) or stabilized and abandoned both to reduce hazards to wildlife and to reduce the erosion potential associated with dirt and gravel roads. Additional roads may be added to access parts of the Reserve System for management or monitoring purposes. These access routes will conform to the natural contours of the surrounding landscape and will only be maintained to the extent necessary for access and to reduce the spread of nonnative plant species.

In general, roadways can be made safer for wildlife and for motorists by increasing the number and quality of opportunities for animals to cross them. Median barriers pose a serious hazard to wildlife; when animals try to cross such roads, they often become trapped at the barrier. Median barriers on several major roadways in the study area (e.g., SR 152, Monterey Road) prevent wildlife from crossing except at limited undercrossings. Strategically perforating these medians will both increase the safety of the roadways and increase the connectivity of the study area (LM-5) (see Chapter 6, Condition 6 *Design and Construction Requirements for Covered Transportation Projects*).

Culverts that create a one-way barrier[21] along waterways will be removed or retrofitted to allow movement of fish and aquatic amphibians both upstream and downstream (LM-2). In most cases, retrofitting involves replacing small obstructive culverts with larger, straight culverts to allow species to move through more readily. In some instances culverts may be replaced with clear-span bridges to increase the habitat quality of the waterway where it flows under the roadway (LM-3). This approach enhances the habitat (both aquatic and terrestrial) under the roadway for animal movement. In addition, existing culverts or bridges may be enhanced to increase wildlife movement through or under these permanent barriers. Fencing could be installed along the roadway to guide wildlife species away from the roadway and through undercrossings (LM-4) (see Chapter 6, Section 6.4.4, subheading *Condition 6 Design and Construction Requirements for Covered Transportation Projects*).

Areas of Focus

Three primary areas of focus are suggested to improve landscape linkages in the study area using the techniques described above: Tulare Hill to Anderson Reservoir, Pacheco Creek (SR 152), and Pajaro River.

Tulare Hill to Anderson Reservoir

The section of valley floor between Tulare Hill and Anderson Reservoir is one of the narrowest points in the Santa Clara Valley. For wildlife moving between the Santa Cruz foothills and the Diablo foothills, this topographic pinch point is the closest connection, limiting the distance traveled across the valley floor (Linkages 6, 8, and 10 in **Table 5-9** and **Figure 5-8**) (see *Coyote-7 and -8* in Section 5.3.1 *Land Acquisition and Restoration Actions*).

U.S. 101 is a major barrier influencing wildlife movement across the valley between Tulare Hill and Anderson Reservoir. At least 24 undercrossings or culverts have been documented by CDFG along this stretch of U.S. 101 (**Figure 5-9a**). Most of the culverts would allow safe passage to many species of wildlife, although some are navigable only by the most agile species (e.g., bobcats). Many species of wildlife (e.g., bobcats, skunks, raccoons) have been

[21] One-way barriers occur when species can move in one direction, but not the other; for example, fish moving downstream but not upstream.

documented using these culverts, and most of the culverts are utilized by multiple species (T. Diamond pers. comm.).

All the culverts that adjoin open space Types 1, 2, and 3 on the west side of the highway provide a connection to the Coyote Creek Parkway. These culverts could be improved to better facilitate wildlife movement into and through the culverts. In addition, measures could be implemented to improve wildlife access to the few bridge underpasses along Coyote Creek. Increasing wildlife access to Coyote Creek will help to maintain this important landscape linkage between the Diablo Range and the Santa Cruz Mountains.

Pacheco Creek (SR 152)

Retaining a habitat linkage within the Diablo Range will benefit several covered and other native species (e.g., San Joaquin kit fox, Tule elk, mountain lion) within the study area. Along the 6 miles of SR 152 there are only three breaks in the highway median barrier, each about 50 feet wide (**Figure 5-9b**). These three breaks provide some opportunities for wildlife to cross the highway, but given the high volume of traffic, the likelihood of wildlife successfully using these breaks is low. Increasing the number and quality of crossing opportunities along this stretch will create connections for wildlife across SR 152.

Conservation options that would increase the permeability of SR 152 are limited. There is the possibility of increasing the function of existing linkages by enhancing the few undercrossings on both sides of the highway (bridges and culverts) to make them more biologically appropriate for wildlife use (see *Pacheco 1–6* in Section 5.3.1 *Land Acquisition and Restoration Actions*).

In order to maximize connectivity in this area, enhancements will be prioritized by focusing on the features shown below in descending order.

- Bridges with naturally vegetated riparian corridors on both sides of the highway.
- Bridges with degraded or otherwise limited riparian corridors on one or both sides of the highway.
- Culverts or other small passageways.

Pajaro River

In addition to providing local and regional habitat linkages to native species such as bobcat, and mountain lion, the Pajaro River riparian corridor supports many covered species within the study area. It also provides connectivity to areas outside the study area—specifically the Gabilan Range and Monterey Bay (Pacific Ocean). The river itself provides movement habitat for native fish and linkages to breeding and rearing habitat in the upper reaches of its tributaries (Linkages 11, 12, and 17 in **Table 5-9 and Figure 5-6**). The riparian corridor associated with the river supports California red-legged frog and likely supports least Bell's vireo, though this species has not been documented along the Pajaro in recent years.

Monitoring Wildlife Movement

The Implementing Entity will institute a data collection program to better understand how wildlife moves within and through the study area. While the areas listed above will likely be the focus of monitoring efforts, at least initially, this program will help determine linkage and connectivity throughout the study area. It will also help to define the role of the study area in the overall connectivity of the region. The data collected through this effort will be available for design and implementation of covered road projects. This program will remove the burden of data collection from each participating agency and ensure that all the data collected during the permit term is collected and collated consistently, is maintained in a central location, and is accessible. The program is described in Chapter 7, Section 7.3 *Monitoring and Management Actions*.

Feasibility Study

A feasibility study will be initiated by the Implementing Entity when adequate monitoring data exist on wildlife movement in the three focal areas described above or by year 10 of implementation, whichever comes first (STUDIES-1). The Implementing Entity will commit $500,000 to fund this study, which will evaluate the following questions for each of the three focal areas.

- Based on existing monitoring data, what feasible engineering options are available, small and large, to improve connectivity for the covered species and for native wildlife in general?
- What is the relative feasibility of these options based on factors such as regulatory permitting, cost, environmental impacts, and land use and safety compatibility?

Fire Management

In addition to protection by city fire departments, the study area is served by the Santa Clara County Fire Department and Cal Fire. Cal Fire is often the primary responder to wildfires in natural areas[22] (California Department of Forestry and Fire Protection 2005) and will likely be the primary firefighting agency within Reserve System.

Local wildfire responses may not always benefit covered natural communities and species in the Reserve System. Aggressive response to wildfires can damage topsoil or cause excessive erosion, particularly if heavy machinery or chemical treatments are used to create firebreaks or suppress flames. Most of the natural communities in the study area are adapted to fire and respond positively after a burn. Some communities (e.g., chaparral, foothill pine-oak woodland) and species (e.g., Coyote ceanothus) require fire for regeneration and may require some level of burning to continue to persist. However, fire also often threatens human lives and property. These differing perspectives on fire need to be balanced during Plan implementation.

[22] Three battalions in the Santa Clara Unit of Cal Fire serve the study area: Battalion 1 (Morgan Hill), Battalion 2 (San José), and Battalion 7 (South Santa Clara County) (California Department of Forestry and Fire Protection 2005).

Fire management will be a component of each reserve unit management plan developed as the reserve units are acquired and incorporated into the Reserve System. The fire management component will include discussions with Cal Fire and other local fire-fighting agencies on the use of biologically appropriate management response measures for fire events and fire-dependent ecosystems (LM-8). This general fire management component for the Reserve System should be based, in part and as applicable, on agreement between USFWS, CDFG, and the U.S. Forest Service on fire-fighting techniques. Fire management will be incorporated into the reserve unit management plans prepared for each reserve unit within 5 years of the first acquisition of the land for the reserve unit. The reserve unit management plans will include a range of fire response, from full suppression when wildfires compromise public safety and personal property, to less than full suppression in predetermined areas of the reserve unit where public safety and personal property is not compromised, and fire-dependent natural communities are present. The plans may include controlled burn and let-burn components. The goal of such components would be to reduce fuel loads and decrease fire intensity while promoting fire-dependent natural community regeneration and a natural successional process where feasible. This approach would protect public safety, personal property, and sensitive natural communities while allowing for persistence of natural processes in fire-dependent natural communities. The reserve unit management plan will also include coordination with other land management agencies regarding allocation of prescribed burn permits from the Bay Area Air Quality Management District (BAAQMD).

The reserve unit management plans will describe minimum impact suppression tactics (also known as MIST[23]). Many plans utilizing these techniques and plans with low-impact rehabilitation (restoration) techniques have been developed in recent years. The goal of minimum impact suppression tactics is to safely suppress wildfire using environmentally sensitive suppression methods. Examples of minimum impact suppression tactics guidelines and actions that will be implemented include the following.

- Give preference to using methods and equipment that have the least adverse environmental effects.
- Give serious consideration to the use of water as a firelining tactic.
- Establish mobilization and demobilization areas to minimize spread of noxious weeds or diseases.
- Consider use of helibucket with water or foam before calling for airtankers and retardant.

In order to assure that the reserve unit management plans are followed during fires, the Implementing Entity will develop a wildfire local operating agreement for the Reserve System with Cal Fire and with any other firefighting agency that has responsibility for Reserve System lands. The operating agreement will ensure that the fire management components are implemented, that minimum

[23] For example, see <http://www.wildfirelessons.net/documents/GB_MIST_Guidelines.pdf> or the National Wildfire Coordinating Group at www.nwcg.gov.

impact suppression tactics are utilized, and that post-fire restoration is carried out. An example of a local operating agreement that has been developed and utilized successfully is the Henry W. Coe State Park agreement with Cal Fire (California State Parks 2007). The wildfire local operating agreement will be in place within four years of permit issuance. This will allow time for the fire management component of reserve unit management plans to be developed and for the Implementing Entity to work closely with Cal Fire to develop the operating agreement.

Specifically, the wildfire local operating agreement for the Reserve System will, at a minimum:

- inform the firefighting agencies of Reserve System fire policies and sensitive resources[24],
- inform the Implementing Entity of functions within the Incident Command System (Cal Fire) with respect to wildland fire,
- be the local working agreement between the Implementing Entity and firefighting agencies for all activities related to wildland fires in the Reserve System,
- designate responsibilities and guidelines for all activities related to wildland fires,
- allow the Implementing Entity to be a Resource Advisor in the Incident Command System in the event of a wildfire,
- identify minimum impact suppression tactics during and after wildland fires to ensure the minimum possible environmental impacts, and
- identify biologically appropriate and complete post-fire restoration and rehabilitation responsibilities.

Following a fire, the Implementing Entity shall initiate remedial measures as described in Chapter 10, Section 10.2.1 *Changed and Unforeseen Circumstances* subheading *Fire*.

To ensure the success of prescribed burns and minimum impact fire suppression techniques described in this Plan, the Implementing Entity will hire staff with expertise in controlled burns and fire fighting using these techniques. Staff with this expertise will also help to ensure clear and frequent communication with Cal Fire, which is essential to proper implementation of these techniques during a wildfire (D. Rocha pers. comm.). Staff with this expertise will also help to ensure immediate assessment and possible responses following detection of wildfires in the Reserve System.

[24] The Implementing Entity will update the appropriate local firefighting agencies of sensitive resources in the Reserve System as the Reserve System grows.

Control Invasive Plants

Exotic plants (i.e., nonnative plants) pose a serious threat to ecosystem function, native biological diversity, and many covered plant species. However, many exotic plants cannot be effectively controlled due to their great abundance, high reproduction rate, and proficient dispersal ability; the high cost of control measures; or unacceptable environmental impacts of control measures. Therefore, the focus of control efforts in the Reserve System will be on the most invasive nonnative plants.

The spread of invasive plants may be exacerbated by covered activities. For example, increased human and pet populations can serve as dispersal vectors at the urban-wildland interface or through increased recreation in the Reserve System. Covered roads or other linear facilities can serve as dispersal corridors for these species. Accordingly, an aggressive control program is needed to minimize the adverse impacts of invasive plants and to enhance natural communities. Moreover, improved management within the reserves is expected to increase the resilience of natural communities to invasion by new invasive plants.

The Implementing Entity will address the control of invasive plants as a component of each reserve unit management plan. The appropriate management technique will be selected based on the invasive species present (**Table 5-20**). Control of invasive plants on reserve lands should begin immediately after acquisition if infestations are serious (e.g., yellow star-thistle), even if the reserve unit management plan is not finalized. Efforts to control invasive plans will be evaluated and revised as needed. Formal evaluations and revisions will take place at least every 5 years[25].

The goals of the each reserve unit management plan will be to control the spread of noxious weeds (as defined by the California Department of Food and Agriculture) and invasive exotic plants listed by the California Invasive Plant Council (California Invasive Plant Council 2007 or latest list) into new areas and to control infestations of noxious and serious weeds. Another important goal will be to distinguish those species for which eradication or control will be the objective and those species that will be addressed through landscape-level management. The major elements listed below will be included in each reserve unit management plan.

- An assessment of the exotic plants likely to be invasive within the reserve unit that includes the following components.
    - Maps and descriptions of their distribution and abundance.
    - Their known or potential effects on ecosystem function, native biological diversity, sensitive natural communities, and covered species.
    - The means and risk of their spread to other areas within and outside the reserves.

[25] This is the approximate interval at which the list of invasive plants in California is updated by the California Invasive Plant Council.

- The cost, feasibility, and effectiveness of available control measures for each species.

- An assessment of invasive plants not currently found in the reserves but that are found nearby or in similar habitats and that might invade the reserves in the future. The assessment will include a description of known or potential effects on ecosystem function, native biological diversity, sensitive natural communities, and covered species.
- Development and application of criteria for establishing invasive plant control priorities.
- Integration and coordination of exotic plant control efforts in the Reserve System with efforts of other ongoing invasive plant control efforts such as those listed below.
    - Efforts to reduce the spread of barbed goat grass on Coyote Ridge (conducted by Dr. Stuart Weiss)
    - Efforts by SCVWD and County Parks to eradicate giant reed from Coyote Creek below Anderson Dam (County of Santa Clara Parks and Recreation Department 2007).
    - The integrated pest management program for yellow star-thistle in Santa Clara County that has been experimenting with biological control agents (coordinated by the County of Santa Clara Agriculture Commissioner).
    - Plans by County Parks to control invasive plants in various sites to be added to the Reserve System (conducted by County Parks and various consultants).
- A description of methods to control and prevent the establishment of invasive plants and criteria for evaluating the suitability of application of these methods based on site-specific conditions.
- A description of a process by which future invasive plants can be evaluated quickly to determine the best course of action for their effective removal or control.

Development of the invasive plant component of the reserve unit management plans will be coordinated with the Santa Clara County Division of Agriculture, the Santa Clara County Weed Management Area, and other major resource management agencies in the study area including SCVWD, the Open Space Authority, State Parks, and County Parks. Neighboring land management agencies such as Midpeninsula Regional Open Space District and Peninsula Open Space Trust will also be consulted. Because control of many invasive plants in the study area is a regional issue, coordination with these agencies is essential. Coordination could include sharing costs, staff, and equipment and conducting joint management programs to address the regional problem of invasive plants. Management to control invasive plants will be prioritized such that the invasive plants with the greatest impacts on covered species are addressed first.

Herbicide Application

The selective use of herbicides is a conservation action proposed to control or eradicate invasive plants that may be used judiciously and occasionally within the Reserve System in specific locations (LM-14). Herbicide application may be necessary in particularly heavy infestations of exotic plants (e.g., Transline herbicide is effective in controlling yellow star-thistle). Certified personnel will conduct any herbicide application. Herbicides will be used with great caution, especially near seeps, creeks, wetlands, and other water resources. Herbicide use will be reserved for instances where no other eradication techniques are found to be effective. SCVWD is currently using this technique, among others, in the implementation of the Stream Maintenance Program within riparian zones (Santa Clara Valley Water District 2010). Herbicide restrictions within the Pajaro River watershed would also be applied, consistent with the guidelines of the Stream Maintenance Program (Santa Clara Valley Water District 2010).

Control Nonnative Animals

Bullfrogs and Nonnative Predatory Fish

The Implementing Entity will work to eradicate or reduce nonnative predators (e.g., bullfrogs, nonnative predatory fish) through habitat manipulation (e.g., periodic draining of ponds), trapping, hand capturing, electroshocking, or other control methods. Removal of bullfrogs and nonnative predatory fish will be a high priority in existing ponds or wetlands within the Reserve System (LM-13). The creation of new ponds or restoration of wetlands will only be conducted in areas where there are no known bullfrogs or where bullfrog control programs are underway or can be established.

Newly created ponds will be designed to periodically dry up naturally. In addition, where feasible, all new ponds will have drains installed to allow for occasional draining of the pond to control bullfrogs and nonnative predatory fish in case natural drying does not occur (POND-5). Some existing ponds might be retrofitted with drains if the nonnative species populations cannot be controlled by other means. Existing ponds without drains and that do not drain naturally may need to be drained periodically using pumps. During any maintenance or heightening of stock pond dams to increase capacity, the Implementing Entity-maintained rebuilt structures will be fitted with drains.

Draining ponds, sterilizing or removing subsoil, and removing bullfrogs can be effective at reducing predation by bullfrogs and other invasive species on covered amphibians and reptiles (Doubledee et al. 2003). Drainage of stock ponds and other wetlands will be carried out during the summer or fall dry season. Population models predict that draining ponds every 2 years will increase the likelihood that California red-legged frogs will persist in ponds with bullfrogs (Doubledee et al. 2003). SCVWD will evaluate water inputs from outside the study area to control nonnative fish and other exotic species from entering and establishing populations in waters inside the study area.

The SCVWD routinely distributes local and imported water supplies. Water distribution and release to stream channels may introduce and spread exotic, predatory, competitive, and habitat-altering species. To contain exotic species within off-channel recharge basins, current and future outflow systems will be screened.

Feral Pigs

Feral pig impacts on natural communities are well documented within the study area. In Henry W. Coe State Park, adverse affects were documented on grassland, oak woodland, and aquatic natural communities (Sweitzer and Loggins 2001). Rooting disturbance by feral pigs allows nonnative invasive plants to establish in grassland and aquatic communities, and fall acorn foraging likely has a detrimental effect on oak regeneration (Sweitzer and Van Vuren 2002). An aggressive feral pig control program will be implemented on the Reserve System using trapping, hunting, or other effective control methods (LM-12).

The impact of rooting activities in pond and wetland natural communities may be reduced by fencing, although fencing to exclude feral pigs will need to be built for that purpose and maintained frequently in order to be effective. If fencing is used, it must be constructed so as not to restrict wildlife movement routes or corridors. In cases where livestock access to ponds and surrounding uplands is desired but feral pigs are degrading habitat, a feral pig control program could be initiated to improve pond habitats (POND-6). Feral pig control has been effective on San Francisco Public Utility Commission land in the adjacent Alameda Creek watershed (T. Koopman pers. comm.) and in Henry W. Coe State Park within the study area (Sweitzer and Loggins 2001; program is on-going). Feral pig control will be focused on parts of the permit area where the concentrations of feral pigs are high and impacts on native communities have been observed. It would be difficult to census the exact number of feral pigs within the Reserve System without an extensive effort. However, rooting disturbance can be monitored. Pig populations will be controlled during the permit term as long as their disturbance (i.e., rooting disturbance) adversely affects the Implementing Entity's ability to successfully implement the conservation strategy for this Plan.

Public Education and Outreach

Public education and outreach will be an integral component of reserve management. The Implementing Entity will conduct outreach to local private and public landowners and residents that will include education on the Plan's management goals and objectives as well as implementation techniques. The focus of public education and outreach activities will be to raise landowner and public awareness of reserve management goals, actions and methods, and how the public can support and help implement them. For example, through the public outreach program, the Implementing Entity will obtain input from interested citizens on the preparation and implementation of reserve unit management plans. Activities may include education about

- not planting invasive plant species or releasing invasive animals such as bullfrogs,
- land uses to allow wildlife passage through streams and upland areas, or
- best management practices in agricultural and urban areas to minimize impacts to streams and other sensitive habitats.

The public education and outreach staff of the Implementing Entity will serve as a conduit for technical information and expertise available to landowners and the public. The Implementing Entity will develop and publish guidelines for local landowners and provide education programs to assist in the implementation of such guidelines. Public education and outreach will be coordinated with other local agencies providing similar services in the study area (e.g., County Parks, SCVWD, Open Space Authority).

To support the stream conservation actions (e.g., STREAM-1, STREAM-2, STREAM-3) and the stream and riparian setback condition (Chapter 6, Section 6.5, subheading *Condition 11 Stream and Riparian Setbacks*), the Implementing Entity will develop Stream Management (Riparian Land Use). Guidelines for private landowners, including an educational program to assist in the implementation of the guidelines, within five years of permit issuance. The guidelines and educational program will be based on SCVWD's *Guidelines & Standards for Land Use Near Streams* (Santa Clara Valley Water Resources Protection Collaborative 2006) developed for local permitting agencies, homeowners, and developers. The focus of the program and guidelines will be to raise landowner awareness of riparian conservation actions and methods that can be employed to protect riparian habitats and streams.

Threats and Uncertainties

Threats to covered species and natural communities at the landscape level include those threats that this Habitat Plan seeks to minimize and offset, such as habitat loss, habitat fragmentation, and other forms of habitat degradation (see Chapter 4). The expected increase in vehicle traffic in the study area during the permit term will increase the threat to species that move across roads. Increases in population and transportation corridors will also increase the risk of the spread of invasive plants subject to the invasive plant component of the reserve unit management plan. Consequently, more invasive plants and exotic wildlife are expected to warrant eradication or control in the future.

While it is important to provide habitat linkages for native fish, wildlife, and plants, it is also important that those linkages do not facilitate an increase in nonnative species within the study area. The implication of management actions on the distribution of nonnative species will be weighed before these actions are implemented. In some cases, increasing habitat connectivity within the study area may introduce nonnative predators to areas that had been insulated from such introduction. For example, installing or improving culverts may increase access by covered amphibians to sites that expose them to new hazards. By creating the Reserve System and applying substantial long-term management and monitoring through the Plan, some of these threats will be reduced and offset. However, many of these threats will remain outside the Reserve System.

Fire in the Reserve System is both an opportunity and a threat. Wildfires at moderate frequencies can maintain a healthy mosaic of natural communities without the buildup of too much fuel. If fires occur too infrequently, there is the threat that fires will burn too hot, damaging native ecosystems while promoting nonnative vegetation establishment. Fires that are too frequent could have similar effects. A combination of a let-burn policy, prescribed burns where and as needed, and restrictions on human access or uses in areas of the Reserve System with high fire risk should address this threat.

Climate change is one of the largest threats and uncertainties that the Plan confronts in the management of natural landscapes. Creating climate predictions for an area as small as the study area is not possible with current modeling technology and unlikely for an extended time. At the micro-scale, change in temperature, along with precipitation patterns (either wetter or dryer) could adversely affect covered species and natural communities in the Plan area. Accordingly, several ecological responses are possible during the permit term.

- **Phenological changes resulting in phenological mismatches**. Timing of seasonal events, such as migration, flowering, and egg laying, may shift earlier or later (Walther et al. 2002; Forister and Shapiro 2003; Root et al. 2003; Root et al. 2005). Such shifts may affect the timing and synchrony of events that must occur together, such as butterfly emergence and nectar availability.
- **Reduction in species and natural community range and distribution**. Narrowly distributed species and natural communities that already have restricted ranges due to urban growth, altitudinal gradients, or within narrow environmental gradients are particularly vulnerable (e.g., Bay checkerspot butterfly, Mount Hamilton thistle) because they likely have nowhere to move if their habitat becomes less suitable (Parmesan et al. 1999; Pimm 2001; Walther et al. 2002; Easterling et al. 2000; Shainsky and Radosevich 1986; Murphy and Weiss 1992; J. Hillman pers. comm. 2007).
- **Shifts in natural community distribution and composition**. Increases in disturbance events, such as fire or flooding, could increase the distribution of disturbance-dependent land cover type and plant species, such as redwood forest annual grassland, within the study area (Brown and Hebda 1998; Lenihan et al. 2003; Fried et al. 2004; California Climate Change Center 2006; Rogers and Westfall 2007).
- **Changes in species abundance**. The number or density of individuals found in a particular location may change triggered by changes in resource availability associated with an increase or decrease in precipitation (Walther et al. 2002; Lenihan et al. 2003; Millar et al. 2006; Pounds et al. 2006). Changes such as these may benefit one species at the expense of another.

The conservation strategy, reserve design, and monitoring and adaptive management program address the threat of climate change using a multi-level approach: landscape level, natural community level, and species level. This approach focuses on protecting and enhancing a range of natural communities, habitat types, and environmental gradients (e.g., altitude, aspect, slope), as well as other features that are important, as availability of resources and habitat types in the study area changes with climate change. More details on the effects of climate change to the study area and covered species, and the Plan's anticipation of these effects, are found in **Appendix F**.

5.3.3 Grassland Conservation and Management

Biological Goals and Objectives

The overarching biological goal for grasslands is to maintain and enhance functional grassland communities that benefit covered species and promote native biodiversity. Specific objectives within the Reserve System entail protection of serpentine grassland, other native grasslands, and other endemic features of the community such as serpentine seeps and serpentine rock outcrops. An additional objective is to ensure that a diversity of soil types and other environmental gradients are acquired in areas suitable for enhancing native species. Grasslands will be enhanced by reducing cover and biomass of nonnative invasive species and by increasing the diversity of native plants. A final objective that will enhance the grassland natural community is to increase distribution of California ground squirrels to increase the prey base and burrow availability for covered species.

Grassland conservation and management is anticipated to benefit 18 covered species. Covered species use of the grassland natural community is varied. Wildlife use includes movement, foraging, breeding, and year-round habitat. The grassland natural community is known to provide primary and secondary habitat for plants. Bay checkerspot butterfly uses serpentine bunchgrass grassland as year-round habitat and may use other grassland types for movement habitat to move between serpentine grassland habitat patches (see Section 5.4.1 *Bay Checkerspot Butterfly*). California tiger salamander and California red-legged frog use grassland for upland and movement habitat (see Section 5.4.2 *California Tiger Salamander* and Section 5.4.3 *California Red-legged Frog*). Western pond turtle uses grassland as movement (see Section 5.4.5 *Western Pond Turtle*). Western burrowing owl uses grassland for foraging and breeding (see Section 5.4.6 *Western Burrowing Owl*). Tricolored blackbird uses grassland as year-round habitat (see Section 5.4.8 *Tricolored Blackbird*). San Joaquin kit fox uses grassland for movement and foraging (see Section 5.4.9 *San Joaquin Kit Fox*).

Serpentine bunchgrass grasslands and serpentine rock outcrop provides primary habitat for Tiburon Indian paintbrush, Santa Clara Valley dudleya, smooth lessingia, and Metcalf Canyon jewelflower (see Section 5.4.10 *Tiburon Indian Paintbrush,* Section 5.4.13 *Santa Clara Valley Dudleya*, Section 5.4.16 *Smooth Lessingia*, and Section 5.4.17 *Metcalf Canyon Jewelflower*). Serpentine bunchgrass grassland provides primary habitat for Coyote ceanothus and fragrant fritillary (see Section 5.4.11 *Coyote Ceanothus* and Section 5.4.14 *Fragrant*

Fritillary). Serpentine bunchgrass grassland and serpentine seeps provide primary habitat for Mount Hamilton thistle (see Section 5.4.12 *Mt. Hamilton Thistle*). Finally, serpentine bunchgrass grasslands and serpentine rock outcrops provides primary habitat and non-serpentine rock outcrops provides secondary habitat for most beautiful jewelflower (see Section 5.4. 18 *Most Beautiful Jewelflower*). The grassland acquisition and enhancement conservation actions identified in the following sections are intended to benefit these species as well as the natural community.

Acquisition and Enhancement

The Plan requires that the Implementing Entity acquire at least 17,300 acres of grassland through fee title or conservation easement (**Tables 5-11 and 5-18**).

Grassland Acquisition

The Implementing Entity will protect, through fee title purchase or easement, at least 4,000 acres of serpentine bunchgrass grassland, 120 acres of serpentine rock outcrops/barrens, 10 acres of serpentine seeps (LAND-G1, **Tables 5-11 and 5-18**), 10 acres of rock outcrops, and 13,300 acres of annual grassland (LAND-G2, **Table 5-11**). Specific acquisition targets are not established for native grasslands because native stands intergrade with nonnative grasses and are generally not well documented or mapped in the study area. Land acquisition will prioritize those parcels with stands of native grasses. Perennial bunchgrass grassland will be prioritized for acquisition where it occurs (LAND-G2). The Implementing Entity will manage these lands as part of the Reserve System. These areas will be representative of the diversity of vegetation alliances, soil types, topography, elevation, and other environmental gradients in the study area.

The Implementing Entity will acquire all land by Year 45 according to the Stay-Ahead provision described in Chapter 8, Section 8.6.1 *Stay-Ahead Provision*. This provision requires that grassland preservation requirements be met prior to impacts occurring to each grassland land cover type, with a 10% allowable deviation.

Acquisition of serpentine grassland will occur primarily on Coyote Ridge from Silver Creek south to Anderson Reservoir. Large stands of serpentine grassland will also be acquired in the Santa Teresa Hills, near Chesbro Reservoir (Llagas-2), and north of Morgan Hill (Coyote-5 and Llagas-3). Land acquisition targets for serpentine grassland that are geographically specific (see **Table 5-19**) will ensure that the most valuable stands are acquired to support the covered species. Portions of several County parks expected to be incorporated into the Reserve System support large and important stands of serpentine grassland that will be managed more effectively: Santa Teresa, Calero, and Coyote Lake-Harvey Bear Ranch (**Table 5-5**).

Annual grassland will be acquired for the Reserve System on and near Coyote Ridge, near San Felipe Creek, in Upper Penitencia Creek watershed, in the Pacheco Creek watershed, north of Gilroy, and in the southwest corner of the study area (Uvas-5, Uvas-6, Pescadero-1). County parks with significant stands of annual grassland that will be incorporated into the Reserve System include Joseph Grant and Coyote Lake-Harvey Bear Ranch (**Table 5-5**).

Grassland Enhancement

All grasslands in the Reserve System will be enhanced. Grassland enhancement will begin immediately after reserve unit management plans are completed or updated for each reserve unit. Native grasslands will be enhanced in the reserves using techniques tailored to the grassland type (i.e., the vegetation alliance) and the site. Each grassland stand will be classified to the alliance level according to the CNDDB vegetation classification scheme (California Department of Fish and Game 2003).

Enhancement techniques and frequencies and intensities of application will be informed by pre-acquisition assessments, baseline surveys, and targeted studies (see Chapter 7). Grassland communities in the study area are mosaics of many vegetation alliances, as described in Chapter 3, and will occur throughout the Reserve System. The proper management regime necessary to maintain this mosaic of grassland types and enhance each grassland vegetation alliance will be determined through a combination of proven techniques such as moderate livestock grazing and small-scale experimental treatments, or pilot studies. Pilot studies will be initiated on small species levels to determine the feasibility of enhancement activities that, if successful, can be applied on a larger level. The pilot studies will test approaches to promote native grassland species and will be conducted as part of the monitoring and adaptive management program.

If monitoring demonstrates that the treatments are effective at increasing the relative cover of native grasses and forbs, the reserve manager will evaluate whether these treatments can be applied to the entire stand of the grassland vegetation alliance to achieve enhancement objectives of grassland on a larger scale. In some cases, management regimes could be shifted in time, location, or intensity to achieve these objectives. This evaluation must be conducted on a case-by-case basis in which the expected benefits to grassland are weighed against the environmental impact, hazard risk, and increased cost of applying the technique on a larger scale.

Management Techniques and Tools

General Principles for Grassland Management

Enhancing grasslands within Habitat Plan reserves will likely require applying many of the management techniques described below concurrently at different sites and on different scales to create a mosaic of grassland conditions. Applying different management techniques across different spatial and temporal scales will maximize habitat heterogeneity across the landscape and will tend to increase native biological and structural diversity (Fuhlendorf and Engle 2001). For example, the buildup of dead plant material, or thatch, has been implicated in the suppression of native annual forbs in unmanaged wet grasslands in California (Hayes and Holl 2003). Techniques to reduce thatch (e.g., livestock grazing, prescribed burning, raking) will be applied only where the treatment is expected to benefit native grassland species. Techniques to reduce thatch should be discontinued if they are demonstrated to promote expansion of invasive species or encroachment of nonnative grassland into native grassland areas. These management techniques can also be effective at reducing the overall biomass of nonnative, invasive species and brush and increasing the annual success of native grassland species (LM-11).

Managers must consider the impacts of management treatments on other covered species. For example, if burns occur within grassland habitat, treatments may affect covered plants in both positive and negative ways (Gillespie and Allen 2004); accordingly, it is important to monitor several life stages to determine the net effect of management actions.

Site conditions (both physical and biological) and land use history are important in developing biologically appropriate management techniques to attempt to enhance native grassland alliances (Stromberg and Griffin 1996; Hamilton et al. 2002; Harrison et al. 2003). For example, some species of native grasses may occur primarily on steep north- or east-facing slopes where soil moisture tends to be higher (Jones & Stokes Associates 1989). Management strategies at these sites will differ from sites on more level topography and drier, south-facing slopes.

Livestock Grazing

The flora of the study area evolved under the influence of prehistoric herbivores, including large herds of deer, elk, antelope, and other grazing animals, and without the competition from nonnative annuals which dominate much of the study area today. At present, appropriate livestock grazing utilizing cattle, sheep, and goats can be useful for range management, as a vegetation management tool to promote native plants and animals, and to reduce fuel loads for wildfires. In the study area, grazing has been shown to benefit most covered plant species and Bay checkerspot butterfly by reducing cover of invasive plants and increasing habitat for dwarf plantain, the butterfly's host plant (Weiss and Wright 2005, 2006; Santa Clara Valley Transportation Authority 2006; also see **Appendix D**). In addition, grazing and rangeland management practice have been demonstrated to benefit California tiger salamander and California red-legged frog. For these species, the USFWS issued a special Section 4(d) rule exempting ranch practices from a possible take because the benefit of these practices was deemed far greater than any potential individual loss.

Grazing may also benefit some ground-nesting or ground-foraging songbird species by providing variations in vegetative cover (Santa Clara Valley

Transportation Authority 2006). However, effects on all covered species are not quantified or fully understood, and it is possible that in some cases the effects of grazing on some covered plants may be detrimental (J. Hillman pers. comm.). Initially, vegetation management that is implemented will reduce the height of all vegetation to less than 12 inches (through grazing and mowing) (GRASS-8).

Grazing by livestock and native herbivores is a conservation action proposed for implementation in the Reserve System to enhance grasslands by creating structural diversity and increasing the abundance of native grassland species (GRASS-1). Several factors, including timing, stocking rate, rotation type, and grazing species, may affect the success of a grazing program (Sotoyome Resource Conservation District 2007). Tule elk may not be ideal native grazers on a large scale. Large herds of Tule elk may damage fences and disrupt livestock grazing programs (J. Fields pers. comm.). Fencing required to manage herds of Tule elk or other large herbivores may create barriers to wildlife movement.

Varying the timing (i.e., seasonal timing, annual timing) of grazing generally produces different effects across the landscape (Weiss 1999; Santa Clara Valley Transportation Authority 2006). A grazing treatment should be defined by the kinds and classes of livestock, their spatial distribution, their temporal distribution, and their density, and determines the effects of grazing on plants in the grazing area (Huntsinger, Bartolome, and D'Antonio 2007). For instance, researchers have observed that in serpentine grasslands, winter/spring grazing reduces annual grass cover more effectively than other grazing regimes (S. Weiss pers. comm.). While winter/spring grazing increases opportunities for dwarf plantain and other serpentine-adapted forbs, it can crush butterfly larvae, eggs, and pupae (Weiss 1999; Santa Clara Valley Transportation Authority 2006). Alternatively, summer/fall grazing may avoid butterfly larvae, eggs, and pupae; however the habitat created is not as high quality as that produced by the winter/spring regime (Santa Clara Valley Transportation Authority 2006; S. Weiss pers. comm.) Short-term winter grazing following burning may help to control exotic grasses as they germinate after winter rains, while mid-summer grazing may promote native perennial grasses because they are dormant at that time and not substantially damaged by grazing. These tradeoffs will need to be considered as reserve unit management plans are developed. For serpentine grassland, typical stocking rates and seasonality include 1 cow-calf per 10–15 acres for winter-spring (rainy season) or summer-fall (dry season), with small modifications according to short-term seasonal variations.

The stocking rate is the number of cattle grazing a given site for a given period of time. The stocking rate will be consistent with known or experimentally derived rates that promote native plants without adversely affecting covered species or causing long-term rangeland degradation. For example, excessive numbers of cattle in an area may trample Mt. Hamilton thistle, which occurs in serpentine soils in wet habitats such as serpentine seeps and springs, (J. Hillman pers. comm.) and Santa Clara dudleya, which occurs on serpentine rock outcrops (S. Weiss pers. comm.; J. Hillman pers. comm.).

Rotation of cattle on different pastures within and between years can influence the success of a grazing program. Grazing patterns and their effects on serpentine plants and insects are being tested on several sites in the study area, including Coyote Ridge and Tulare Hill. Current BMPs (Santa Clara Valley Transportation Authority 2006; S. Weiss pers. comm.; J. Fields pers. comm.) and research in various systems (Zervas 1998; Cousins et al. 2003) suggest that timing regimes should be consistent over long periods because frequent variation may increase nonnative cover and reduce habitat for native species. In view of this finding, consideration of historical patterns of currently grazed lands will direct decisions about grazing in the Reserve System. Current rotations will be monitored and only shifted if monitoring results indicate that the lands or covered species are adversely affected under the existing timing.

Different herbivorous species have different preferences and abilities to be selective grazers and therefore have different impacts on vegetation. Reserve unit management plans will take these differences into consideration.

Grazers will be excluded from some sensitive riparian areas (see Section 5.3.6 *Riverine and Riparian Forest and Scrub Conservation and Management*). In addition, targeted studies examining grazing exclusion from specific terrestrial areas may be considered for sensitive plant species. However small-scale exclusion fences in potentially remote areas are expensive and labor intensive to install and maintain. Therefore, exclusionary fencing will only be considered in areas where monitoring indicates that conservation targets are not being met or detrimental effects of grazing may actually hinder the survival of the species.

Reintroduction of livestock grazing into areas where it has been excluded is an important conservation action of the Plan, particularly on serpentine grasslands. For example, livestock grazing will be reintroduced onto serpentine grassland sites in Santa Teresa County Park (**Table 5-5**) to reduce the biomass and diversity of nonnative grasses and herbs. Reintroduction of grazing is expected to substantially enhance habitat for Bay checkerspot butterfly and several covered plants. Recovery with the reintroduction of grazing may take many years, however, as evidenced in the Silver Creek Hills (Wetlands Research Associates 2008). On Tulare Hill, Weiss and colleagues have noted that seedbanks from the final large cohort of native forbs in 2004 (3 years after the cessation of grazing) provided for dense native forb cover following a June 2004 fire on Tulare Hill (Metcalf Energy Center 2006). Once the native seedbank is depleted, restoration of high-quality serpentine grassland requires recolonization from forb-rich patches of thin soils, which is a much slower process.

In view of the uncertainty of relevant research results, it would be prudent to use grazing management at sites with high potential to improve existing stands of native grasses and other targeted species, and to focus on reduction of the non-native species competition in a heterogeneous pattern—some patches grazed more and some less. Such grazing would favor a diversity of conditions, including those more favorable to expansion and persistence of the natives (Fuhlendorf and Engle 2001). Extensive grazing of large pastures with the livestock dispersed for the entire grazing period will be more effective at producing such heterogeneity than would higher intensity rotational grazing of smaller pastures. Recent research by Bartolome (2011) shows that undisturbed annual grassland patches with abundant native grasses are low in phosphorous, and the opposite is found at adjacent sites where no native grasses occur. Determining the potential of grassland sites for improvement in native grass abundance may be accomplished by correlating site conditions where native grasses are abundant, soil patches have low productivity, and soils have not been disturbed. Such determinations may be confirmed by analyses of phytolith evidence of prehistoric grasslands and perennial grasses (Bartolome and Evett 2010). Management treatments to improve native grass abundance should be focused only at grassland sites that have the indicators of potential, but do not already support abundant native grasses.

Prescribed Burning

Prescribed burning as a strategy to manage grasslands has been studied extensively in California and elsewhere (Harrison et al. 2003; Rice 2005). A review of existing literature in 2004 found that burning has mixed results depending on the starting condition of the ecosystem and on the timing and frequency of the burns (Rice 2005). Research indicates that in order for fire to successfully reduce nonnative and increase native plant cover, burns must be targeted toward the specific system and species conditions.

Prescribed burning is a conservation action to enhance natural communities, to control or eradicate invasive plants, and prevent natural community type conversion (GRASS-2). If burns are implemented in the Reserve System as a management tool, considerations will include the blooming and seeding times of the targeted nonnative species, the history of site use, and the likely condition of the native soil seed bank. Fires will be conducted at a time when the seeds of the targeted invasive plants will be destroyed. Single burns are generally unsuccessful at restoring native diversity and cover to grasslands; multiple burns are usually required. Burning can be used in conjunction with grazing or mowing to control infestations of invasive species and brush. If native vegetation on a site has been particularly denuded, supplementary seeding of native species may be required.

In particular, prescribed burning within the Reserve System may be an effective tool to eradicate exotic invasive species that are selectively avoided by grazing livestock. An example of this is barbed goatgrass (*Aegilops triuncialis*), a species that recently invaded Coyote Ridge and seriously threatens serpentine grasslands in the study area (S. Weiss pers. comm.). Barbed goatgrass is avoided by livestock but can be controlled with prescribed burns that are appropriately timed (just after plants senesce but while seeds are still maturing) and repeated (probably at least 2 or 3 years in succession) (DiTomaso et al. 2001). A pilot project to eradicate barbed goatgrass through burning that was initiated in 2006 on Coyote Ridge has shown mixed results (S. Weiss pers. comm.). Additional burns occurred in 2007.

Prescribed burns have been conducted by State Parks in Henry W. Coe State Park and by the Open Space Authority on several parcels. Prescribed burns have been conducted by County Parks at Joseph Grant, Motorcycle, Mount Madonna and Santa Teresa County Parks (D. Rocha pers. comm.). County Parks plans to conduct prescribed burns in Coyote Lake–Harvey Bear Ranch County Park in the future (Rana Creek Habitat Restoration 2004). Prescribed burns in the Reserve System will be planned and conducted using the techniques and lessons learned from these agencies on actual burns.

In areas that are deemed *No-Burn* areas, the Implementing Entity will utilize management strategies that mimic the affects of burning on grassland species (e.g., mowing, hand pulling, targeted herbicide application) (LM-9).

Mowing

In some instances, mowing is a reasonable alternative to prescribed burns; mowing is a conservation action for selected areas when grazing is infeasible (LM-11, GRASS-3). Mowing can often be safer and easier to implement on small scales than fire. Like prescribed burning, mowing needs to be timed to target the blooming/seeding cycle of nonnative species. Mowing may be particularly useful and effective as a small-scale treatment in areas that cattle cannot or should not access or for other site-specific logistical reasons (for example, when removal of vegetation is required at a time other than when livestock are available). Discing as a management tool in grasslands is not recommended because it often destroys burrows for covered and other native species (e.g., western burrowing owl, San Joaquin kit fox), increases soil erosion, and creates invasion sites for noxious weeds.

Seeding Native Forbs and Grasses

In order to protect genetic integrity of the local landscape and ecosystems it is recommended that natural revegetation of local ecotypes should be encouraged first by controlling weeds and non-native species and seeding of native species should only occur in areas where natural revegetation is unlikely to occur (California Native Plant Society 2001). Highly degraded grasslands; however, may need additional input of native seed to restore their functionality. Seeding of native forbs and grasses is a conservation action in support of grassland enhancement (GRASS-4). Seeding may include covered plant species. Where possible, seed sources of covered plants will come from the project site itself and, if unavailable from the project site, from adjacent or nearby sites within the same watershed (California Native Plant Society 2001). If no seed source is available from the same watershed, then the seed source will be from as close as possible. Decisions regarding where to introduce seed and from how far away to collect it will be made in light of all available information about the targeted species, the source population, and issues related to maintaining the genetic integrity of existing populations (California Native Plant Society 2001).

To maximize the success of seed addition, pretreatment (e.g., burning 1 year prior to seeding to reduce weed seeds on the surface and in litter) may be required. Recent research conducted on serpentine grasslands in Santa Barbara suggests that seedlings of California native forbs can be excellent competitors when enough seeds are present to overcome the dominance in the seed pool of the exotic grasses and forbs (Seabloom et al. 2002). In a 5-year experiment, burning or mowing had no effect on the abundance or the proportion of native forbs without seeding. Targeted studies could test this approach by seeding grasslands with native and locally collected seeds within the reserves.

Ground-Dwelling Mammals

California ground squirrels play a key role in the grassland natural community. They provide a prey base for raptors and other covered species such as San Joaquin kit fox. In addition, their burrows provide nest sites for burrowing owls, (although their name implies otherwise, burrowing owls do not typically excavate their own burrows) and refugia for covered amphibians.

Historically, hunting and rodenticides have been used to control rodents and reduce conflicts with livestock. These practices may have decreased the populations of rodents, reducing prey availability for their predators. For example, in 1975 California ground squirrel, one of the main prey items for San Joaquin kit fox, was severely reduced in Contra Costa County after extensive rodent eradication efforts (Bell et al. 1994). The history of rodent control in Santa Clara County is unknown.

Under the Plan, a conservation action proposes to minimize existing rodent control measures (e.g., poisoning, hunting, and trapping) in reserves (GRASS-5). Minimizing existing ground squirrel control measures may be sufficient to increase squirrel populations in some areas. However, some rodent control measures will likely remain necessary in certain areas where dense rodent populations may compromise important infrastructure (e.g., pond berms, road embankments, railroad beds, levees, dam faces). The use of rodenticides or other rodent control measures will be prohibited in reserves except as necessary to address adverse impacts on essential structures within or immediately adjacent to reserves, including recreational facilities incorporated into the Reserve System. In addition, the Implementing Entity will introduce livestock grazing where it is not currently used, and where conflicts with covered activities will be minimized, to reduce vegetative cover and biomass that currently excludes ground squirrels to encourage ground squirrel colonization of new areas within the Reserve System (GRASS-6).

Threats and Uncertainties

While focusing on management of nonnative invasive species, the Implementing Entity must also have management practices in place to recognize and account for invasions of nonnative species that have not been previously documented in the study area. When a new invasion is documented, an analysis of the threat it poses to native species and the current extent of the invasion will be conducted in accordance with the invasive plant component of the reserve unit management plan for the Reserve System. In addition, coordination with local, regional, and state-level weed management programs will ensure that new invasions are caught early and their impact on native species minimized. With foreseeable changes in climate, the threat of invasive plants and animals is expected to increase.

Another threat to grasslands, serpentine grasslands in particular, is the ongoing and increasing nitrogen deposition from air pollution (Weiss 1999; California Energy Commission 2006; see **Appendix E**). Nitrogen deposition is predicted to increase during and beyond the term of the Plan due to population growth in the region and from covered activities (although it could possibly decrease if future automobile technologies address this issue; see Chapter 4 and **Appendix E** for details). Serpentine soils are inherently nutrient poor and are particularly limited in available nitrogen. Most serpentine-endemic plant species have evolved to tolerate this condition, while competitive invasive species cannot do so. This nutrient deficiency is believed to be the primary mechanism by which serpentine soils retain a high degree of native diversity (Harrison 1999). Nitrogen deposition has been shown to greatly increase available nitrogen in the soils of the study area and in turn to potentially increase the success of plant invasions into serpentine areas (Weiss 1999). The same study also found that serpentine areas that are grazed do not suffer the same plant invasions, most likely due to the fact that cattle selectively graze the invasive grasses and leave the native species and also because the cattle effectively remove nitrogen from the site (Weiss 1999). Continued active management using livestock grazing, prescribed or natural burning, and other methods will therefore be essential to offsetting the potentially increasing threat of nitrogen deposition in this community. The long-term effects of N-deposition are unknown, but the working hypothesis is that existing grazing regimes will be able to maintain native biological diversity.

5.3.4 Chaparral and Northern Coastal Scrub Conservation and Management

Biological Goals and Objectives

The biological goals and objectives for chaparral and northern coastal scrub communities include enhancement to benefit covered and other native species. The Implementing Entity will accomplish this by protecting land that supports chaparral and northern coastal scrub land cover types through fee title purchase or conservation easement and managing that land as part of the Reserve System. Areas that are protected will contain the full range of chaparral and northern coastal scrub community vegetation associations. An additional objective is to promote regeneration and succession. These natural processes will in turn benefit native species that occur in these land cover types. Acquisition, enhancement, and management actions to achieve these goals are discussed below.

Chaparral and northern coastal scrub conservation and management are anticipated to benefit 15 covered species. Covered species use of the chaparral and northern coastal scrub natural community is varied. Wildlife species use includes upland, movement, and foraging habitat. Chaparral and northern coastal scrub also provide primary and secondary habitat for some covered plant species. Additional details on species specific conservation actions can be found in each of the species sections identified below; however, the following is a summary of covered species use of the chaparral and northern coastal scrub natural community.

Bay checkerspot butterfly uses chaparral and coastal scrub as movement habitat to move between serpentine grassland habitat patches (see Section 5.4.1 *Bay Checkerspot Butterfly*). California tiger salamander uses chaparral and coastal scrub as upland and movement habitat (see Section 5.4.2 *California Tiger Salamander*). California red-legged frog and western pond turtle use chaparral and coastal scrub as movement habitat (Section 5.4.3 *California Red-legged Frog* and Section 5.4.5 *Western Pond Turtle*). Mixed serpentine chaparral serves as primary habitat for Coyote ceanothus (see Section 5.4.11 *Coyote Ceanothus*). Northern sage scrub/ Diablan sage scrub provides secondary habitat for fragrant fritillary (see Section 5.4.14 *Fragrant Fritillary*). Chaparral provides secondary habitat for Loma Prieta hoita (see Section 5.4.15 *Loma Prieta Hoita*). Mixed serpentine chaparral as primary habitat and northern coastal scrub/ Diablan sage scrub provides secondary habitat for Most beautiful jewelflower (see Section 5.4.18 *Most Beautiful Jewelflower*). The acquisition and enhancement conservation actions identified in the following sections are intended benefit the species identified above and contribute to species recovery, as well as benefit the natural community.

Acquisition and Enhancement

During Plan implementation, the Implementing Entity will protect, through fee title purchase or conservation easements, at least 2,500 acres of chaparral and northern coastal scrub (**Table 5-11**).

Chaparral and Northern Scrub Acquisition

The Implementing Entity will acquire at least 400 acres of northern mixed chaparral/chamise chaparral (LAND-C1), at least 700 acres of mixed serpentine chaparral (LAND-C2), and at least 1,400 acres of northern coastal scrub/Diablan sage scrub (LAND-C3) (**Table 5-11**).

The Implementing Entity will acquire all land by Year 45 according to the Stay-Ahead provision described in Chapter 8, Section 8.6.1 *Stay-Ahead Provision*. This provision requires that chaparral and scrub preservation requirements be met prior to impacts occurring to each land cover type, with a 10% allowable deviation.

Acquisition of northern mixed chaparral/chamise chaparral will occur primarily in the Diablo Range in the Pacheco watershed. In the Santa Cruz Mountains, this land cover type is restricted to upper watersheds, so acquisition would occur primarily in Llagas-1, Uvas-1, and Pescadero-1. Acquisition of mixed serpentine chaparral will occur throughout the study area, but primarily on Coyote Ridge. Large stands of serpentine chaparral targeted for preservation are also present in the Santa Teresa Hills (Guadalupe-1), near Chesbro Reservoir (Llagas-2 and Uvas-1), and in the Pacheco watershed. Acquisition of northern coastal scrub/Diablan sage scrub will occur in the Diablo Range near San Felipe Creek and south of Henry W. Coe State Park. In the Santa Cruz Mountains, acquisition of northern coastal scrub/Diablan sage scrub will occur primarily near Pescadero Creek.

Chaparral and Northern Scrub Enhancement

All chaparral acquired for and incorporated into the Reserve System (for the latter, see **Table 5-5**) will be enhanced. Chaparral and northern coastal scrub enhancement will begin immediately after reserve unit management plans are completed or updated for each reserve unit.

Enhancement techniques and frequencies and intensities of application will be informed by pre-acquisition assessments, baseline surveys, and targeted studies (see Chapter 7). Enhancement of chaparral and northern coastal scrub will occur by maintaining or reestablishing natural disturbances such as fire. This will create a mosaic of chaparral and northern coastal scrub stands with varying ages since the last fire, promoting native biological diversity and long-term persistence of this community. However, reestablishing fire through prescribed burning or wildfires will only be possible away from urban or rural areas to minimize risk to human health and structures.

As described in Chapter 3, chaparral and northern coastal scrub are dependent on periodic fires to maintain natural processes such as succession and regeneration. These processes ensure native species diversity and help reduce invasion by nonnative species. Some chaparral species require fire stimulation of the seedbank in order to regenerate. The natural fire frequency and intensity in chaparral and northern coastal scrub habitat is not well understood in the study area, and the effects of prescribed burns on species typically associated with these habitats is unknown. Enhancement of chaparral will involve an investigation of the use of fire to create structural diversity and/or other techniques that mimic the effects of fire.

The Implementing Entity will seek to address uncertainties regarding the enhancement of chaparral and northern coastal scrub through an adaptive management approach and through the monitoring program described in Chapter 7. Targeted research will be conducted to determine factors relevant to the health and regeneration of native chaparral/scrub species (STUDIES-2).

Management Techniques and Tools

Biologically appropriate management techniques will be determined on a site-specific basis and may include those listed below.

- Minimum impact fire suppression techniques (described above in Section 5.3.2 *Landscape Conservation and Management* subheading *Fire Management*).
- Prescribed burning.
- Mechanical or hand clearing.

Prescribed Burning

Where feasible, the Implementing Entity will conduct prescribed burns in chaparral and northern coastal scrub to maintain canopy gaps and promote regeneration (CHAP-1). Prescribed burns may also be needed on portions of the Reserve System closest to urban and suburban areas to reduce the risk of catastrophic wildfires. This management technique is based on four key assumptions: (1) the current fire-return interval in chaparral is longer than historic levels due to modern fire suppression, (2) new growth is lacking and dead material has increased, (3) vegetation density has increased as a result of fire suppression, and (4) this increase in vegetation density has increased the risk of high-intensity fire.

Prescribed burning in chaparral may reduce wildfire risk at some sites, but this benefit will be balanced with the consequences of fires that are too frequent. Fires that occur too frequently in chaparral may reduce chaparral biological diversity by eliminating species not adapted to frequent burning (Zedler et al. 1983). Chaparral that experiences frequent fires is exposed to high rates of erosion, which may damage watershed functions.

Prescribed fires in chaparral should be conducted in late fall or winter when weather conditions maximize the ability of fire crews to control the fire. Burns conducted at that time will exert less effect on the seed banks and reproductive capability of exotic plants. Fall and winter burns will be conducted carefully in order to minimize excessive mortality of native seed banks than can result from lengthy smoldering fires in wet soil conditions (Le Fer and Parker 2005).

Mechanical/Hand Thinning

In areas where burning is not possible, other types of management will be implemented to increase structural diversity (e.g., canopy gaps, variety of stand ages). Mechanical or hand thinning may be used to promote structural diversity in these land cover types (CHAP-2). In addition, these management activities may be used prior to prescribed burns to reduce the chance that the fire will burn too hot and damage the seed bank, or that the fire will escape control due to heavy fuel loads.

Threats and Uncertainties

Many land management plans recommend rotational burning of chaparral and other shrublands to maintain a mosaic of stand ages, providing the maximum benefit to these communities and minimizing the chances of catastrophic wildfire. However, recent research suggests that the assumptions on which these policies are based are erroneous for chaparral communities in southern California (Keeley 2002) and may be erroneous for chaparral communities in central and northern California as well (Keeley 2005). The frequency of fire in southern California shrublands has been as frequent or more frequent in the twentieth century than it was in the nineteenth century (prior to fire-suppression activities), partly because fire-suppression activities have been ineffective at reducing fire frequency in shrublands (Keeley et al. 1999; Keeley and Fotheringham 2001). This pattern appears to hold true in Santa Clara County. Between 1950 and 1985, fire frequency in the county increased significantly, then leveled off and held steady through 2005, despite dramatic population growth in the region (Keeley 2005). Thus, fire suppression has not prevented fires but has been successful at maintaining their frequency and size, despite the increase in ignition sources (i.e., people).

Fire hazard in chaparral habitat appears to be either independent of, or only weakly dependent on, stand age for the first 20 years after fire (Schoenberg et al. 2003). The frequency of severe weather conditions (e.g., low humidity, high winds, and drought) and the number of people with access to stands (providing an ignition source) appear to play much more important roles than do vegetation conditions in determining fire risk. This appears to be true in Santa Clara County, where more than 95% of fires (for the period 1945–2002) were ignited by humans rather than lighting (Keeley 2005). In fact, 60% of the years during that period experienced no lightning-caused fires at all.

Due to the level of uncertainty in managing chaparral and northern coastal scrub communities, some of the management will be undertaken experimentally (STUDIES-2), and changes to the type and frequency of management in all areas will be made through adaptive management.

In some areas, the dynamics of how chaparral or northern coastal scrub interacts with adjacent land cover types is unknown or not well understood. An example is the encroachment of Douglas-fir into chaparral communities on Mt. Tamalpais in Marin County, California. This encroachment is facilitated by the below-ground associations of fungi and plant roots (Horton et al 1999). The Implementing Entity will determine how other communities, such as grassland, oak woodland, and Douglas-fir forests, are affecting chaparral and northern coastal scrub and, as indicated by targeted studies and informed by the monitoring and adaptive management program, work to reduce that impact (CHAP-3).

5.3.5 Oak and Conifer Woodland Conservation and Management

Biological Goals and Objectives

During Plan implementation, the Implementing Entity's goal will be to maintain and enhance oak and conifer woodlands to benefit covered and other native species. The Implementing Entity will accomplish this by protecting land that supports valley oak woodland, mixed oak woodland and forest, coast live oak forest and woodland, blue oak woodland, foothill pine-oak woodland, mixed evergreen forest, redwood forest, and knobcone pine woodland through fee title purchase or conservation easement and enhancing and managing that land as part of the Reserve System.

Areas that are protected will support the full range of oak or conifer woodland community associations found in the study area. Once protected, an additional objective is to enhance oak woodlands using specific management actions to promote regeneration that will in turn sustain beneficial processes and native species diversity. Objectives for conifer woodlands include creating and maintaining the appropriate structure, density, and species composition needed to sustain the natural processes and native species diversity that is typical of these communities. Those management actions are discussed below.

Oak and conifer woodland conservation and management are anticipated to benefit 16 covered species. Wildlife species use includes upland, movement, year-round, breeding and foraging habitat. Oak and conifer woodlands are known to provide primary and secondary habitat for covered plant species. Additional details on species specific conservation actions can be found in each of the species sections identified below; however, the following in a summary of covered species use of the oak and conifer woodland natural community.

Bay checkerspot butterfly uses oak woodlands as movement habitat to move between serpentine grassland habitat patches (see Section 5.4.1 *Bay Checkerspot Butterfly*). California tiger salamander uses oak and conifer woodlands as upland and movement habitat (see Section 5.4.2 *California Tiger Salamander*). California red-legged frog and western pond turtle use oak and conifer woodlands as movement habitat (Section 5.4.3 *California Red-legged Frog* and Section 5.4.5 *Western Pond Turtle*). Western pond turtle uses redwood forest as year-round habitat. Western burrowing owl uses valley oak woodlands for foraging and movement (see Section 5.4.6 *Western Burrowing Owl*). Tricolored blackbird uses valley oak woodlands as year-round foraging habitat (see Section 5.4.8 *Tricolored Blackbird*). San Joaquin kit fox uses oak woodlands with low densities of trees, at lower elevations and with gentle slopes for movement and foraging (see Section 5.4.9 *San Joaquin Kit Fox*). Several oak woodland types provide primary habitat for Santa Clara Valley dudleya (see Section 5.4.13 *Santa Clara Valley Dudleya*). Oak woodlands provide secondary habitat for fragrant fritillary (see Section 5.4.14 *Fragrant Fritillary*). Oak and conifer woodland types are known to provide primary habitat, while others may provide suitable habitat for Loma Prieta hoita (see Section 5.4.15 *Loma Prieta Hoita*). The acquisition and enhancement conservation actions identified in the following sections are intended be beneficial for the natural community and the covered species identified above and contribute to species recovery.

Acquisition and Enhancement

During Plan implementation, the Implementing Entity will protect, through fee title purchase or conservation easement, at least 17,100 acres of oak woodland (**Table 5-11**). In addition, the Implementing Entity will protect at least 500 acres of conifer woodland.

Oak and Conifer Woodland Acquisition

Of the total acquisition of 12,900 acres, valley oak woodland will account for 1,700 acres (LAND-OC3), mixed oak woodland and forest will account for 7,100 acres (LAND-OC1), coast live oak woodland and forest will account for 2,900acres (LAND-OC2), blue oak woodland will account for 1,100 acres (LAND-OC3), foothill pine-oak woodland will account for 80 acres (LAND-OC4), and mixed evergreen forest will account for 20 acres (LAND-OC5) (**Table 5-11**).

The Implementing Entity will acquire all land by Year 45 according to the Stay-Ahead provision described in Chapter 8, Section 8.6.1 *Stay-Ahead Provision*. This provision requires that oak and conifer woodland preservation requirements be met prior to impacts occurring to each land cover type, with a 10% allowable deviation.

Acquisition of oak woodland land cover types will occur throughout the Santa Cruz Mountains and the Diablo Range. Acquisition of mixed evergreen forest, which is restricted to the Santa Cruz Mountains, will occur in the upper Llagas and Uvas watersheds (Llagas-1 and Uvas-1). Valley oak woodland is largely restricted in the study area to the Diablo Range; acquisition of this land cover type will occur where some of the largest stands are found in the Pacheco watershed (Pacheco-4, Pacheco-7, Pacheco-8), near San Felipe Creek (Coyote-4) and in the Alameda Creek and Upper Penintencia Creek watersheds (Alameda-1 and Coyote-7). Portions of County parks to be incorporated into the Reserve System that will permanently protect and allow improved management of large stands of oak woodland include Almaden Quicksilver, Anderson Lake, Calero, Coyote Lake-Harvey Bear Ranch, Joseph Grant, and Santa Teresa (see **Table 5-5** and below for which land cover types benefit).

Acquisition of conifer woodland land cover types is limited to 10 acres of redwood forest (LAND-OC6). Land acquisition requirements for conifer woodland are modest because there are limited opportunities to protect these land cover types within the study area.

Oak and Conifer Woodland Enhancement

All oak and conifer woodland land cover types acquired would be enhanced as indicated by pre-acquisition assessments, baseline surveys, and targeted studies and informed by the monitoring and adaptive management program. Oak and conifer woodland enhancement will occur immediately after reserve unit management plans are completed or updated for each reserve unit. Enhancement will occur in both the Santa Cruz Mountains and the Diablo Range in all oak and conifer woodlands acquired and protected in the Reserve System. Enhancement of oak and conifer woodland may be appropriate at several specific locations, such as those listed below (**Tables 5-5 and 5-22**).

- Almaden Quicksilver County Park (mixed oak woodland, blue oak woodland, and mixed evergreen forest).
- Calero County Park (mixed oak woodland).
- Joseph D. Grant County Park (valley oak woodland, blue oak woodland, mixed oak woodland).

Enhancement in oak woodland or conifer woodland would be determined on the basis of site conditions and needs, and may include the measures listed below.

- Reducing the cover and density of invasive plants.
- Reducing or eliminating exotic wildlife such as wild pigs.
- Restoring natural processes such as fire or moderate levels of grazing.
- In some instances, restoring historic densities of trees through planting acorns or seedlings where they have been removed, where they are not regenerating naturally, or where densities are low relative to vigorous reference stands due to past land uses.

Management Techniques and Tools

Oak Woodland

Many factors may influence the population dynamics of oak woodlands within the study area (Pavlik et al. 1991). A site-specific assessment is required to determine the factors most limiting to stands in reserves, and management will be prescribed accordingly. The factor that may be most limiting to oak woodlands in the study area is a lack of oak regeneration due to a high density of nonnative invasive plants in the understory. A recent study of the effects of wild pigs in Joseph D. Grant County Park showed that pigs can disturb up to 35–65% of the ground annually where they occur in high densities, and that they significantly reduce acorn survival (Sweitzer and Van Vuren 2002).

Some studies have found that browsing by deer or livestock can negatively affect recruitment (Borchert et al. 1989; Bartolome et al. 2002), while others have found that grazing by small mammals (Tyler et al. 2002) is detrimental. The Implementing Entity will experimentally manage oak woodlands to reduce seedling mortality; increase seedling and sapling survival; and determine factors relevant to regeneration, including browsing by mammals, birds, and insects (STUDIES-3). In some cases, fencing may be necessary around seed trees or stands of juvenile oaks to exclude native herbivores such as California ground squirrels, rabbits, or black-tailed deer until juvenile trees grow above the browse line.

One possible approach might be to manage oak stands in reserves using the decision-making process adopted by Cal-Fire (Jones & Stokes Associates 1988) and used for management of oak stands in the Los Vaqueros Watershed in eastern Contra Costa County (Brady and Associates 1997; Jones & Stokes Associates 1991; Contra Costa Water District 2001). If canopy coverage is declining, stands will be surveyed to determine if recruitment is adequate to replace lost trees and meet canopy coverage goals. The age structure of the tree population will also be considered to determine if stands may be increasing or in decline. If surveys indicate that recruitment is insufficient, management actions will be implemented to improve recruitment. Decision-making would be reassessed every five years.

To aid in oak regeneration, the Implementing Entity will eradicate feral pigs where feasible, and will reduce the overall number of pigs in the Reserve System through fencing, trapping, or other control methods (LM-12). Henry W. Coe State Park has been operating a successful pig-trapping program for several years (Sweitzer and Loggins 2001) and could be used as a model for the Reserve System.

The Implementing Entity will continue to employ livestock grazing in areas where nonnative vegetation is preventing successful oak regeneration and recruitment (GRASS-1). Modifying livestock stocking rates, timing of grazing, grazer species, or livestock access to certain areas may improve results in oak or conifer woodland. Where grazing is not feasible or not successful, the Implementing Entity will mow, hand clear, or selectively apply herbicides to reduce the nonnative vegetation in the understory of oak woodlands (GRASS-3, LM-14, LM-11). Prescribed burning may also be used in low-density oak woodlands to reduce nonnative invasive grass cover beneath oaks and encourage growth of a native understory and oak seedlings (OAK-1). Oak woodlands will also benefit from a let-burn policy within the study area. Both prescribed burns and the let-burn policy are described above in Section 5.3.2 *Landscape Conservation and Management*.

Conifer Woodland

Conifer woodlands within the study area may have grown denser over time with the suppression of fire and lack of management. There are three types of conifer communities in the study area: redwood forest, knobcone pine woodland, and ponderosa pine woodland; however, the Plan only requires the protection of redwood forest. All but 5 acres of ponderosa pine woodland occur within Henry W. Coe State Park, which is outside of the permit area, and within San Felipe Ranch, which is protected by conservation easement. Although five acres of ponderosa pine woodland are located within the permit area, just north of Henry Coe State Park, impacts to ponderosa pine woodland are not covered under this Plan because there are no opportunities to mitigate and conserve the natural community within the permit area (**Table 5-11**). Knobcone pine woodlands do not provide important habitat for the covered species; as such they are not targeted for acquisition.

Redwood forest require tailored management techniques based on forest condition, levels of regeneration, and on management goals. Management of redwood forest within the Reserve System will focus on retaining stands of more natural densities that will promote a more natural succession of native species in the understory and mid-canopy. At times this goal may entail some targeted thinning. As indicated by pre-acquisition assessments and targeted studies and informed by the monitoring and adaptive management program, that thinning will involve conducting the appropriate type of prescribed burns in redwood forest (OAK-2). When burning is not possible, other forms of mechanical thinning (e.g., cutting) will be selectively used to reduce the densities of trees in target areas to promote a healthy understory and mid-canopy (OAK-3). Whenever thinning takes place it will be carried out experimentally to determine the factors relevant to regeneration and maintenance; adaptive management will inform changes in this practice as experimental programs generate a body of knowledge (STUDIES-4).

In redwood forests, redwood trees regenerate by sprouting from the base and therefore do not require frequent burning to expose bare soil for regeneration. Management issues in this forest type instead often focus on the reintroduction of fire for fuel reduction, and on trying to create a late successional stage forest, mimicking the old growth forests (G. Gray pers. comm.). Big Basin State Park has one of the largest redwood burn programs in the world. They conduct prescribed broadcast burns in second growth forest to help thin it. They do not conduct mechanical thinning due to cost and the potential for damage to trees by equipment. In the North Coast Redwoods State Parks District, management techniques vary by stand conditions and age of the trees. They may remove redwoods if they are too close together. In old-growth forests, 30 trees/acre is common. In second-growth forests, there can be 200–1,000+ trees/acre. In these densely packed stands, a fire would kill most of the trees, so they often only do mechanical thinning to reduce the available fuel while retaining many of the trees (J. Harris pers. comm.). All of the redwood forest in the study area is second growth forest. Therefore, the Implementing Entity will conduct mechanical thinning or develop a prescribed burning program based on stand conditions. Further research will be conducted on how to best recreate late successional forests (STUDIES-4).

Threats and Uncertainties

Substantially reducing the feral pig population in the Reserve System is an important long-term goal that will benefit all oak and conifer woodland natural communities. However, to be successful, such an effort must also be promoted on private and public land adjacent to, but outside of the Reserve System. This will reduce the number of pigs immigrating into the Reserve System. An extensive trapping effort has proven successful in Henry W. Coe State Park in recent years, substantially reducing the feral pig population and the habitat destruction that the pigs cause (B. Patrie pers. comm.). It is evident that the feral pig population can be controlled but not eliminated in the Reserve System and that some level of damage to natural communities is likely to continue even with aggressive control measures.

5.3.6 Riverine and Riparian Forest and Scrub Conservation and Management

Biological Goals and Objectives

The overarching biological goals for riverine and riparian habitats are to improve the quality of streams and the hydrologic and geomorphic processes that support them to maintain a functional aquatic and riparian community that benefits covered species and promotes native biodiversity. An additional goal is to maintain a functional riparian forest and scrub community at a variety of successional stages and to improve these communities to benefit covered species and promote native biodiversity. This includes specific objectives to protect and restore streams, riparian forest and scrub, and intermittent/ephemeral upper watershed tributaries within and outside the Reserve System. Land acquisition will target protection of key high-quality stream reaches and riparian woodland land cover types that provide habitat for covered species. Stream segments that could benefit from restoration will also be targeted for acquisition to allow the Implementing Entity to conduct physical and biological improvements to selected streams (actions that are often not possible on private land). Degraded streams and riparian woodland/scrub within the Reserve System will be improved to the maximum extent possible to increase overall ecological functions and values (i.e., species richness and diversity, vegetative cover, wildlife habitat function) and to enhance the ability of these habitats to support existing and new populations of covered species. Additional objectives focus on promoting community functions and habitat heterogeneity and connectivity, including specific targets for maintaining hydrologic and geomorphic stream processes.

Riverine (i.e., streams) and riparian forest and scrub mitigation includes a minimum preservation and restoration requirements to contribute to recovery and impact based mitigation ratios (see Section 5.3.1 *Land Acquisition and Restoration Actions*, subheading *Acquisition and Restoration Requirements for Aquatic Land Cover Types* for rationale). The Plan requires a minimum amount of preservation and restoration to occur regardless of the level of impact to riverine and riparian land cover types (**Table 5-13**). These minimum requirements ensure that the conservation goals of the Plan will be met even if all of the anticipated impacts do not occur. Minimum preservation requirements can be met through the acres preserved according to the preservation mitigation ratios (minimum acres preserved are not in addition to acres preserved according to the preservation mitigation ratios). The rationale for this is that the preservation ratios include a recovery component as explained Section 5.3.1 *Land Acquisition and Restoration Actions*, subheading *Acquisition and Restoration Requirements for Aquatic Land Cover Types* where factors used to determine the preservation ratios are identified.

The preservation and restoration mitigation ratios for streams and riparian forest and scrub are additive (**Table 5-12**). For example, for every 1 mile of streams impacted, 3 miles must be preserved and enhanced (3:1) and 1 mile must be restored (1:1). This results in a mitigation ratio of 4:1 for all stream impacts. For every 1 acre of willow riparian forest and scrub or mixed riparian forest and woodland impacted, 2 acres must be preserved and enhanced (2:1) and 1 acre must be restored (1:1). This results in a mitigation ratio of 3:1 for all impacts to willow riparian forest and scrub or mixed riparian forest and woodland. For every 1 acre of Central California sycamore alluvial woodland impacted, 2 acres must be preserved and enhanced (2:1) and 2 acres must be restored (2:1). This results in a mitigation ratio of 4:1 for all Central California sycamore alluvial woodland impacts.

Regardless of the level of impacts, a minimum of 250 acres of riparian forest and scrub, 40 acres of Central California sycamore alluvial woodland, and 100 miles of streams must be preserved and enhanced to contribute to recovery (**Table 5-13**).

As explained above, the preservation mitigation counts towards the minimum preservation requirement. For example, the impacts to streams are capped at 9.4 miles. If all impacts occur, 28.2 miles of streams must be preserved and enhanced (3:1 preservation ratio). Since the minimum preservation and enhancement requirement is 100 stream miles, the Implementing Entity will be required to preserve and enhance an additional 71.8 stream miles (28.2 + 71.8 = 100) to meet the minimum requirement, if all impacts occur. The minimum target of 100 miles of streams was determined to meet multiple needs: requirements for stream mitigation, preservation of habitat for foothill yellow-legged frog that would contribute to species recovery, preservation of habitat for California red-legged frog and western pond turtle that would contribute to species recovery (along with preservation of ponds and freshwater wetlands), and mitigation for temporary impacts (48.0 miles of impacts over the permit term). The Reserve System is expected to preserve substantially more than 100 miles of streams.

The same rationale applies to Central California sycamore alluvial woodland. If all impacts occur, 14 acres of Central California sycamore alluvial woodland must be preserved and enhanced (2:1 preservation ratio). Since the minimum preservation and enhancement requirement is 40 acres, the Implementing Entity will be required to preserve and enhance an additional 26 acres of Central California sycamore alluvial woodland (14 + 26 = 40) to meet the minimum requirement, if all impacts occur. For willow riparian forest and scrub or mixed riparian forest, impacts are capped at 289 acres. If all impacts occur, 578 acres of willow riparian forest and scrub or mixed riparian forest must be preserved and enhanced. In this case, if all impacts occur, the minimum preservation and enhancement requirement of 250 acres will be met by the mitigation ratio. If less than 125 acres of impacts occur, the Implementing Entity will still be required to preserve and enhance 250 acres to meet the minimum preservation requirement.

Riverine and riparian forest and scrub conservation and management are anticipated to benefit 12 covered species. Wildlife use includes movement, foraging, breeding, and year-round habitat. The riparian forest and scrub natural community is known to provide primary for one covered plant, Loma Prieta hoita (see Section 5.4.15 *Loma Prieta Hoita*). Bay checkerspot butterfly uses riverine and riparian forest and scrub natural communities as movement habitat to move between serpentine grassland patches (see Section 5.4.1 *Bay Checkerspot Butterfly*). California tiger salamander uses the riverine natural community for foraging and movement habitat and riparian forest and scrub as movement habitat (see Section 5.4.2 *California Tiger Salamander*). California red-legged and western pond turtle use riverine and riparian forest and scrub natural communities as year-round habitat (see Section 5.4.3 *California Red-Legged Frog* and Section 5.4.5 *Western Pond Turtle*). Foothill yellow-legged frogs use the riverine natural community as year-round habitat and the riparian forest and scrub natural community as foraging and movement habitat. Least Bell's vireo uses riparian forest and scrub as foraging and breeding habitat (see Section 5.4.7 *Least Bell's Vireo*). Tricolored blackbird uses the riparian forest and scrub natural community as breeding and year-round habitat (see Section 5.4.8 *Tricolored Blackbird*). San Joaquin kit fox may use low-density riparian forest and scrub as movement habitat (see Section 5.4.9 *San Joaquin Kit Fox*). The riparian forest and scrub acquisition and enhancement conservation actions identified in the following sections are intended to benefit these species and the natural community as a whole.

Acquisition, Enhancement, and Restoration

Conservation of riverine habitats and riparian woodland and scrub combine land acquisition, habitat restoration, and habitat enhancement. All Reserve System lands will be enhanced. Each of these components is described below separately for riverine and riparian communities. Separate discussions are provided for organizational purposes only. Riverine and riparian woodland and scrub communities are closely tied to one another ecologically and both communities are often present in the same location. Land acquisition and restoration will be planned and implemented for both communities simultaneously for the same sites.

Riverine Acquisition

Streams (riverine habitat) will be preserved in the permit area at a ratio of 3 stream miles to every mile affected (**Table 5-12**). An estimated 9.4 miles of stream is the most that would be permanently affected by covered activities. If this maximum level is reached, then at least 28.2 miles of stream would need to be preserved. The minimum requirement of stream preservation, regardless of the level of impact, is 100 miles (**Table 5-13**).

During Plan implementation, the Implementing Entity will therefore protect at least 100 miles of stream (LAND-L3) (**Table 5-11**) according to the land acquisition priorities described in Section 5.3.1 *Land Acquisition and Restoration Actions* and below. All Reserve System lands will be enhanced.

All riverine protection will occur by Year 45 according to the Stay-Ahead provision described in Chapter 8, Section 8.6.1 *Stay-Ahead Provision*. This provision requires that stream preservation requirements be met prior to stream impacts occurring, with a 10% allowable deviation. Because streams are distributed widely throughout the study area, they will be part of nearly every land acquisition. The Implementing Entity will protect stream segments on key stream reaches through land acquisition (fee title or purchased conservation easement) or through landowner dedications through the Stream and Riparian Setback Condition when covered activities are proposed (see Chapter 6, Section 6.5, subheading *Condition 11 Stream and Riparian Setbacks* and **Figure 6-2**). Protection will provide opportunities to enhance habitat for native fish, covered amphibian and reptile species, and restore streams and riparian woodland and scrub. At a minimum, riverine acquisitions will include the following:

- Extending the Uvas Creek Park Preserve 1.6 miles upstream to Hecker Pass Highway and set back expected development adjacent to this stream segment to protect the Uvas Creek Corridor consistent with Goals 5-5, 5-7, and 5-8 of the approved City of Gilroy Hecker Pass Specific Plan (LAND-R1). The City of Gilroy Hecker Pass Specific Plan Goals 5-5, 5-7, and 5-8 are as follows:
  - *Goal 5-5: Extend the Uvas Creek Park Preserve and trail to the western boundary of the Hecker Pass Specific study area at the intersection of Uvas Creek and Hecker Pass Highway*
  - *Goal 5-7: Ensure the protection of Uvas Creek Corridor by establishing policies and protective measures for adjacent land uses.*
  - *Goal 5-8: Preserve and enhance the Uvas Creek corridor and the associated riparian habitat wherever possible.*
- At least 1.0 mile of Uvas Creek above Uvas Reservoir.
- At least 1.0 mile of Llagas Creek above Chesbro Reservoir. Pacheco Creek mainstem (2.0 miles) between Pacheco Reservoir and San Felipe Lake (LAND-R1).

Protected streams will include those in upper tributaries that have high sediment loads or other functional shortfalls that limit native fish productivity. Such streams have not been identified in the study area but likely include Bodfish Creek and Little Arthur Creek. Additional study will be needed in implementation to verify these assumptions and determine the locations of other functionally-limited streams.

Riparian Acquisition

Willow riparian forest and scrub or mixed riparian forest and woodland would be acquired for the Reserve System, depending on the level of impact of covered activities (LAND-R2). Two acres of these land cover types would be acquired for every acre impacted by covered activities (2:1) (**Tables 5-13 and 5-21**). The Implementing Entity will protect, through fee title or conservation easement, a minimum of 250 acres of willow riparian forest and scrub or mixed riparian forest and woodland. If all impacts on these land cover types occur as predicted, then up to 578 acres would be acquired. Riparian woodland protection would occur primarily in north County on Upper Penitencia Creek, Upper Coyote Creek, and San Felipe Creek. In south County, riparian woodland protection would occur primarily on Uvas Creek, Bodfish Creek, Little Arthur Creek, Tar Creek, Pescadero Creek, Pajaro River, and Pacheco Creek and its tributaries (LAND-R2, LAND-R3). All Reserve System lands will be enhanced.

In addition to the riparian acquisition described above, a minimum of 40 acres of Central California sycamore alluvial woodland would be acquired for the Reserve System even though only 7 acres of impact are predicted (LAND-R2). This requirement is designed to ensure that this very rare and threatened land cover type (Keeler-Wolf et al. 1997) is adequately preserved in the study area.

All riparian woodland and scrub protection will occur by Year 45 according to the Stay-Ahead provision described in Chapter 8, Section 8.6.1 *Stay-Ahead Provision*. This provision requires that stream woodland and scrub protection requirements be met prior to impacts occurring to these land cover types, with a 10% allowable deviation.

Riverine and Riparian Enhancement

All the riparian woodland/scrub and streams acquired and incorporated into the Reserve System would be enhanced, as indicated by pre-acquisition assessments and targeted studies and informed by the monitoring and adaptive management program. Up to approximately 592 acres of riparian woodland and scrub (including California sycamore alluvial woodland) and a minimum of 100 miles of stream will be enhanced in the Reserve System (**Tables 5-12 and 5-13**). Enhancement techniques are described below.

Habitat enhancement is the improvement of an existing terrestrial vegetation community or aquatic habitat. The overall goal of enhancement actions is to promote natural community functions and habitat heterogeneity and connectivity. Enhancement on streams and riparian woodland/scrub will occur throughout the Reserve System as indicated by pre-acquisition assessments and targeted studies and informed by the monitoring and adaptive management program.

Enhancement of riparian woodland and scrub will include enhancing the cover, density, structural diversity, and species diversity of riparian vegetation in the understory or small stream segments (STREAM-2).

Riverine and riparian enhancement will occur immediately after reserve unit management plans are completed or updated for each reserve unit.

Riverine Restoration

Stream restoration would be accomplished according to the level of impacts on streams. One mile of stream would be restored for every mile of stream permanently affected by covered activities (**Tables 5-13 and 5-21**). A minimum of 1.0 mile of stream would be restored to contribute to species recovery (i.e., regardless of the level of stream impact). If all impacts occur, 10.4 miles of stream would be restored. Stream restoration would occur within the Reserve System and outside the Reserve System in partnership with private and public landowners as long as the conditions specified in Section 5.2.5 *Land Management,* subsection *Habitat Restoration* are met. The Implementing Entity would conduct additional site assessments during implementation to identify specific restoration project areas based on the site selection guidelines described below. Stream restoration techniques and guidelines are defined below.

Habitat restoration is the establishment of a vegetation community or aquatic habitat in an area that historically supported it, but no longer does because of the loss of one or more required ecological factors or as a result of past disturbance. Unlike other natural communities for which restoration is required, streams are unique—restoration occurs within the footprint of existing streams, rather than the creation of new ones, with some exceptions such as Fisher Creek, where the stream has been historically redirected. Stream restoration is defined as any substantial physical alteration to stream systems to return them to natural or semi-natural conditions and to restore specific ecological function in a site where that function has been lost (see Section 5.2.5 *Land Management* and **Appendix A** for definitions). For example, stream restoration includes removing hardscape features from concrete-lined or rip-rapped stream banks or restoring earthen or otherwise engineered channels to a more natural condition that allows for water infiltration, percolation, and groundwater recharge (STREAM-4). Restoration may also, when absolutely necessary, include stabilizing stream banks to manage fine sediment inputs and preventing excessive erosion (STREAM-6).

All stream restoration construction will be completed by Year 40 according to the Stay-Ahead provision described in Chapter 8, Section 8.6.1 *Stay-Ahead Provision*. All required stream restoration must be initiated (ground breaking) prior to impacts occurring to these land cover types. In addition, the Implementing Entity will complete stream restoration to contribute to species recovery according to the deadlines in **Table 5-14**.

Riparian Restoration

Riparian restoration (STREAM-3) is required to offset any impacts on riparian woodland and scrub land cover types and to contribute to species recovery (e.g., least Bell's vireo). One acre of willow riparian forest and scrub or mixed riparian forest and woodland, at a variety of successional stages, would be restored for every acre impacted by covered activities (**Table 5-12**).

Riparian restoration is defined as the re-establishment of riparian vegetation in areas where it has been severely degraded and once occurred. Stream restoration is defined for the purposes of this Plan as substantial physical modifications to stream banks or stream channels (see Section 5.2.5 *Land Management* and **Appendix A** for definitions). Riparian restoration and stream restoration may often occur together in the same location.

A minimum of 50 acres of willow riparian forest and scrub or mixed riparian forest and woodland would be restored in the Reserve System to contribute to the recovery of covered species and an estimated 289 acres would be restored to compensate for all impacts. Therefore, a total of 339 acres of these land cover types would be restored if all impacts occurred (**Tables 5-13 and 5-21**). Riparian restoration opportunities have not been evaluated in detail in the study area. Riparian restoration opportunities have been defined for Upper Penitencia Creek (Biotic Resources Group 2001) and within the City of San José (Jones & Stokes 2000).

Riparian restoration would occur within the Reserve System and outside the Reserve System in partnership with private and public landowners as long as the conditions specified in Section 5.2.5 *Land Management,* subheading *Habitat Restoration* are met. The Implementing Entity would conduct additional site assessments during implementation to identify specific restoration project areas based on the site selection guidelines described below. Site assessments are a necessary first step in the restoration design process and therefore will occur approximately one year before restoration projects are to be constructed in order to meet Stay-Ahead requirements and other deadlines (**Table 5-14**). The Implementing Entity would restore riparian woodland using techniques and guidelines described below.

An estimated 14 acres of Central California coastal sycamore alluvial woodland would be restored to compensate for the 7 acres of expected impacts (**Tables 5-13 and 5-21**). Opportunities for restoration of this land cover type are limited to locations where this land cover type can be supported (Keeler-Wolf et al. 1997). Examples include Pacheco Creek, Upper Coyote Creek, San Felipe Creek, and lower Uvas Creek.

Construction of all restoration of these land cover types will be completed by Year 40 and according to the Stay-Ahead provision described in Chapter 8, Section 8.6.1 *Stay-Ahead Provision*. All required restoration of riparian woodland and scrub must be initiated (ground breaking) prior to impacts occurring to these land cover types (see Section 8.6.1 for details). In addition, the Implementing Entity will complete restoration of riparian woodland to contribute to species recovery according to the deadlines in **Table 5-14** (Years 15, 30, and 40).

Guidelines for Selecting Restoration Sites

Potential restoration sites in the study area will be evaluated in coordination with the other local agencies or organizations active in riparian restoration in the study area (e.g., SCVWD, The Nature Conservancy). As described in the Section 5.3.1 *Land Acquisition and Restoration Actions*, the Implementing Entity will likely be conducting most riparian restoration in the locations listed below.

- Coyote Creek and tributaries (including tributaries such as Fisher Creek and Thompson Creek).
- Alamitos Creek and tributaries.
- Los Gatos Creek below Vasona Dam
- Uvas and Carnadero Creeks (including tributaries such as Little Arthur Creek and Bodfish Creek), including reaches above Uvas Dam.
- Llagas Creek, particularly above Chesbro Dam.
- Pajaro River.
- Pacheco Creek.

Restoration sites will be selected according to criteria that include but are not limited to those listed below.

- The potential success of restoration activities, based on site-specific conditions (e.g., hydrology, soils).
- The ability of the site to support covered species after restoration.
- Historic conditions that supported or likely supported the target land cover type (San Francisco Estuary Institute 2007).
- The proximity of the site to the area in which streams or riparian woodland/scrub were (or are predicted to be) lost to covered activities.
- The proximity of the site to other intact riparian corridors that support, or are likely to support, covered species.
- The extent and quality of existing habitats (e.g., percent native vegetation and presence/absence of nonnative wildlife such as bullfrogs or cowbirds).
- Existing wildlife use and the potential for adverse effects of the restoration project (e.g., disturbance to or removal of existing wetland habitat).
- The ability of the restored stream and/or riparian woodland/scrub to contribute to the conservation goals of habitat connectivity in this Plan.

Riverine and riparian restoration sites will be selected using the best available assessments (e.g., Biotic Resources Group 2001 for Alum Rock County Park and Jones & Stokes 2000 for San José streams). Where assessments are not available, the Implementing Entity will, in coordination with the Wildlife Agencies, conduct detailed site assessments to determine the best available restoration sites.

Site Restoration Plans

Detailed restoration plans, including plans and specifications, will be developed for individual sites or stream reaches based on specific geomorphic, hydraulic, and hydrologic conditions; extent and quality of existing habitats; existing wildlife use; and the potential for adverse effects (e.g., disturbance and/or removal of existing habitat or wetlands). Site restoration plans will be developed prior to construction of stream, riparian, and wetland restoration projects. These plans will be prepared consistent with the reserve unit management plan for the site[26]. Restoration plans will satisfy the requirements listed below.

- Define restoration goals and objectives, performance indicators, and success criteria.
- Collect and analyze baseline data (e.g., soil type and suitability for riparian planting, low-flow conditions, past land use history/alterations).
- Identify suitable/feasible restoration measures.
- Develop conceptual restoration designs.
- Develop detailed restoration designs (plans and specifications) that identify and describe construction methods, planting areas and methods, planting species (including collection and propagation methods), and maintenance requirements.
- Prepare an adaptive management and monitoring plan based on the guidelines in Chapter 7 that includes descriptions of responsible parties; monitoring methods and schedule; indicators (e.g., vegetative cover); success criteria (e.g., 20% cover by year 5); and adaptive management measures (e.g., replanting with different species).

Management Techniques and Tools

General Principles for Riverine/Riparian Management

Streams and adjacent riparian forest/scrub communities are dynamic habitats resulting from the confluence of hydrology with the geology, soils, and vegetation of the environment. The management tools discussed below will be used in concert to maintain natural or semi-natural functions or to achieve them in currently degraded communities. In many cases these techniques can also be used to manage existing high-quality habitats to the benefit of streams and riparian communities. Several guidance documents and local programs provide the basis for the selection and application of these management tools and techniques; these are listed below.

- *California Salmonid Stream Habitat Restoration Manual* (Flosi et al. 1998).
- *California Salmonid Stream Habitat Restoration Manual*. Part XI, *Riparian Habitat Restoration* (Circuit Rider Productions 2004).

[26] Site restoration plans on newly-acquired lands may be prepared prior to or concurrent with the reserve unit management plan.

- *Federal Stream Corridor Restoration Principles and Practices* (Federal Interagency Stream Restoration Working Group 1999).
- Three Creeks HCP (plan is pending)
- *Watershed Action Plan* (Santa Clara Basin Watershed Management Initiative 2003).
- Upper Llagas Creek Riparian Corridor Assessment (Tetra Tech, Inc. 2006).
- *Coyote Watershed Stream Stewardship Plan* (Santa Clara Valley Water District 2002c).
- *Stream Maintenance Program* (Santa Clara Valley Water District 2010).

Large riparian and stream restoration projects have been conducted or are planned in the permit area by SCVWD and other agencies along Guadalupe Creek, the Guadalupe River, Coyote Creek, Upper Penitencia Creek, and Llagas Creek. Project planning and construction documents and follow-up monitoring reports are excellent sources of information to guide future riparian and stream restoration and enhancement projects. Additional sources are provided below specifically for riparian restoration projects.

In-Channel Habitat Management

In-channel habitat actions may include the complete restoration of the channel to remove anthropogenic features (e.g., concrete, earthen, or otherwise engineered channels), as well as enhancement actions that modify specific elements of in-channel habitat (e.g., large woody debris, gravel placement and cleaning, and laying back steep banks). Only in-channel restoration is covered in this section; each of the specific enhancement actions is covered in separate sections.

Formation and sustainability of riverine habitat is directly related to channel processes and channel form. Where these processes or forms are out of balance with their natural inputs or where they have been disturbed, restoration of the channel may be an appropriate technique to restore a sustainable natural channel and floodplain (STREAM-5).

The Implementing Entity will also reduce chronic anthropogenic sources of sediment and restore balanced input of substrate material within stream reaches. This will be accomplished through the implementation of conditions on covered activities that minimize inputs of fine sediment delivery to streams (STREAM-6; also see Chapter 6, Section 6.4.2, subheading *Condition 4 Stream Avoidance and Minimization for In-Stream Projects*). Stabilizing stream banks on selected reaches could also achieve this goal.

Channel restoration may entail direct restoration (reconstruction of a channel) or incremental process restoration (installation of a natural structural feature to induce change in a channel), consistent with the guidelines of the *California Salmonid Stream Habitat Restoration Manual* (Flosi et al. 1998; Circuit Rider Productions 2004). Channel restoration can also be used to restore bank stability and reduce bank erosion; such restoration may improve aquatic habitat and water quality. Channel restoration techniques may affect the local slope, length, sinuosity, and dimensions of the channel, as well as alter basic channel processes related to sediment transport, and are very useful for treating the underlying causes of habitat degradation, as seen within the study area in the restoration of Guadalupe Creek upstream of the confluence with the Guadalupe River near Almaden Lake. Channel restoration under the Habitat Plan would only be considered as a potential solution where there are chronic anthropogenic problems. In implementation, the effects of restoration on local channel geometry will be carefully considered and proper hydraulic analysis performed (Flosi et al. 1998).

Under the Habitat Plan, the Implementing Entity will restore concrete, earthen, or other engineered channels as part of the 10.4 miles of stream restoration (STREAM-4).

Riparian Vegetation Management

Successful implementation of riparian restoration can, over time, result in significant improvements in the cover and diversity of desirable native riparian plant communities.

An excellent example of successful riparian and stream restoration is the Guadalupe Creek restoration project. The project combined channel realignment with retention of existing vegetation, extensive riparian enhancement plantings and placement of in-stream woody debris along more than 12,000 linear feet of the creek. The project was completed in 2002. As of 2007, the riparian vegetation has developed into a multi-storied canopy, indicative of a healthy riparian corridor.

Establishment and recovery of native riparian plants will be faster in sunny, low-elevation, or moist sites than in shady, higher-elevation, or arid sites. However, advantageous growing conditions can also trigger rapid establishment of weedy or undesirable aggressive species; accordingly, weeds at and upstream of project sites will be evaluated before implementation of any treatments. Invasive plant removal will continue until desirable riparian vegetation is established and target invasive pants are substantially eradicated (i.e., greater than 50% eradicated and not expanding in range).

Use of riparian management techniques will consider the land use setting—that is, whether the site is in an urban, agricultural, or wildland environment. Some riparian management treatments may be appropriate in one type of setting and not in another. For example, the allowable height of vegetation may be constrained by its proximity to utilities, to address safety concerns, or to preserve views.

When placing plant materials, fences, offsite watering facilities, plant irrigation systems, and other materials in the riparian zone, the effects of flood flows (e.g., deposition of sediments and debris, scour) must be taken into account. It may be necessary to install such facilities outside the flood prone area. To address these issues, vegetation management techniques will be developed in consideration of the recommendations presented in Part XI, *Riparian Habitat Restoration*, of the *California Salmonid Stream Habitat Restoration Manual* (Circuit Rider Productions 2004). Irrigation systems may be necessary to help establish riparian vegetation temporarily. However, these systems will be installed so that they can be removed (or left in place non-functioning) once the vegetation becomes self-sustaining and no longer requires supplemental irrigation.

The Implementing Entity will develop a successional management strategy for riparian vegetation communities to ensure that a diverse cross section of successional stages is fostered in the riparian corridor to promote natural stream functions during the permit term. This management strategy will be incorporated into the reserve unit management plans prepared according to Section 5.3.6 *Riverine and Riparian Forest and Scrub Conservation and Management*. Reserve unit management plans must be prepared within 5 years of acquisition of the first parcel in the reserve unit.

The management strategy for successional riparian vegetation would be of greater importance downstream of reservoirs, where altered flow regimes reduce flood flows and the frequency and intensity of droughts, which would otherwise produce a mosaic of successional stages over time. This strategy may include such actions as girdling trees, moving gravel, or other techniques of managing physical process and vegetation to ensure a variety of successional stages of riparian forest and scrub land cover types. Development of the successional management strategy will be undertaken in consideration of existing plans in the study area, which can vary with the goals of the implementing agency and the context of the stream. Existing plans that could be used to inform this management strategy are listed below.

- *Coyote Creek Parkway County Park—Final Integrated Natural Resources Management Plan and Master Plan* (County of Santa Clara Parks and Recreation Department 2007).
- *Alum Rock Park Riparian Management Plan* (Biotic Resources Group 2001).
- *Riparian Restoration Action Plan for the City of San José* (Jones & Stokes 2000).
- *Stream Maintenance Program* (Santa Clara Valley Water District 2010).
- *Guidelines and Standards for Land Use Near Streams* (Santa Clara Valley Water District 2006).

Invasive Species Management

The Habitat Plan includes objectives to reduce or remove invasive plant and fish species from stream channels to encourage establishment of native plant and wildlife species. Invasive species management will comprise existing actions under SCVWD's existing Stream Maintenance Program and additional actions under the Habitat Plan that are consistent with the Stream Management Program and the Santa Clara County Integrated Pest Management Program and Pesticide Use Ordinance (Section B28-10). Invasive species management is described above in Section 5.3.2 *Landscape Conservation and Management*.

Livestock Management

As part of the grazing management program (see Section 5.3.3 *Grassland Conservation and Management*) the Implementing Entity will exclude livestock along targeted stream segments (e.g., Pacheco Creek, floodplain of Coyote Creek) using exclusion fencing, off-channel water sources, and other potential actions as needed. This program will be implemented within the Reserve System and could be implemented outside the Reserve System if appropriate willing partners are identified.

Private Landowner Education

The Implementing Entity will develop Stream Management (Riparian Land Use) Guidelines for private landowners, and an educational program to assist in the implementation of the guidelines, within five years of permit issuance. Details are found in Section 5.3.2 *Landscape Conservation and Management* subheading *Public Education and Outreach* above.

Threats and Uncertainties

Within the study area, the San Francisco Regional Board is developing Total Maximum Daily Loads (TMDLs) for mercury and diazinon that could influence the implementation of covered activities and the conservation strategy related to riverine habitats in the Guadalupe River watershed. Instream activities within the Guadalupe watershed (e.g., stream crossings, bank stabilization activities, barrier removal, and stream enhancement and restoration projects) could increase the methylation of mercury that is found in sediments resulting from historic mining operations in the watershed. Final targets and strategies related to mercury TMDLs in the study area will affect the Local Partners' (especially SCVWD's) management of sediment in streams and will potentially affect the cost of restoration and enhancement opportunities in the Guadalupe watershed.

Availability of water from Central Valley Project facilities currently substantially supplements water supply in north county streams. The impact of climate change on the availability of this water is critical to the Habitat Plan conservation activities. In addition, Sacramento-San Joaquin Delta water quality and endangered species concerns (delta smelt and central valley salmon and steelhead) are affecting, and will continue to affect to an unknown degree, the timing and amount of water diversions from the delta. Any loss of water supply as the result of drought conditions could reduce or eliminate water supply allocated for the conservation strategy.

The study area lies in an area with several major and minor faults; moreover, the study area is susceptible to significant wildfires in the dry months of June–October. These natural events have the ability to damage the Reserve System and certain structural elements of the conservation strategy.

Fire would remove vegetation, potentially including riparian vegetation, and, in the event of significant precipitation following the fire, could compromise water quality in streams and reservoirs by increasing turbidity, increasing suspended sediment loads, and introducing high volumes of organic carbon into watersheds. This may affect the suitability of habitat for native fish and covered amphibians. Additionally, loss of riparian vegetation can lead to loss of habitat for terrestrial species found in riparian habitats. See Chapter 10 for additional discussion of foreseeable and unforeseen circumstances addressed by this Plan.

5.3.7 Wetland and Pond Conservation and Management

Biological Goals and Objectives

During Plan implementation, the Implementing Entity will work toward the goal of maintaining and enhancing functional wetland and pond habitats to benefit covered and other native species. The Implementing Entity will accomplish this by protecting lands with predominantly grassland, oak woodland, and conifer woodland land cover and that contain ponds or wetlands through fee title purchase or conservation easement. The Reserve System will contain the full range of pond and seasonal and perennial wetland communities that occur within the study area, and those ponds and wetlands and their adjacent uplands will be managed as part of the Reserve System. In addition, all Reserve System lands will be enhanced. Freshwater perennial and seasonal wetlands and ponds enhancement includes increasing native vegetative cover, biomass, and structural diversity in and around the margins of these aquatic habitats.

Wetland and pond conservation and management will benefit 8 covered species. Wildlife use includes movement, foraging, breeding, and year-round habitat. Seasonal wetlands may provide suitable habitat for one covered plant, fragrant fritillary (see Section 5.4.14 *Fragrant Fritillary*). Bay checkerspot butterfly may use wetland and pond habitat for movement as they move within and between serpentine grassland habitat patches (see Section 5.4.1 *Bay Checkerspot Butterfly*). California tiger salamander uses wetland and pond habitats for breeding and foraging (see Section 5.4.2 *California Tiger Salamander*). California red-legged frog uses perennial wetlands as year-round habitat and seasonal wetlands and ponds for breeding and foraging (see Section 5.4.3 *California Red-legged Frog*). Western pond turtle uses perennial wetlands and ponds as year-round habitat and seasonal wetlands as foraging habitat (see Section 5.4.5 *Western Pond Turtle*). Western burrowing owl uses season wetlands as movement habitat (see Section 5.4.6 *Western Burrowing Owl*). Tricolored blackbird uses wetlands and ponds as foraging and breeding habitat (see Section 5.4.8 *Tricolored Blackbird*). The acquisition, enhancement, restoration, and creation conservation actions identified in the following sections are intended to benefit these species and the natural communities.

The preservation and restoration/creation mitigation ratios for impacts to ponds and wetlands are additive (**Tables 5-13 and 5-21**). For example, for every one acre of perennial wetland impacted, 2 acres must be preserved and enhanced (2:1) and 1 acre must be restored (1:1). This results in a mitigation ratio of 3:1 for all perennial wetland impacts. For every 1 acre of seasonal wetlands impacted, 2 acres must be preserved and enhanced (2:1) and 2 acres must be restored (2:1). This results in a mitigation ratio of 4:1 for all impacts to seasonal wetlands. For every 1 acre of pond impacted, 2 acres must be preserved and enhanced (2:1) and 1 acre must be created (1:1). This results in a mitigation ratio of 3:1 for all pond impacts.

Regardless of the level of impacts, a minimum of 10 acres of perennial wetlands, 5 acres of seasonal wetlands, and 50 acres of ponds must be preserved to contribute to recovery. As explained above, minimum preservation requirement can be met by the impact ratios. For example, if 5 acres of perennial wetlands are impacted, and 10 acres are preserved, this will fulfill the minimum preservation requirement for perennial wetlands.

There are also minimum wetland restoration and pond creation requirements that must occur regardless of the level of impact (**Table 5-13**). In addition to the mitigation ratios, a total of 20 acres of perennial wetlands must be restored and 20 acres of ponds must be created to contribute to recovery.

Uplands between ponds and wetlands will be similarly managed to attain regional connectivity for native species (See Sections 5.3.3 *Grassland Conservation and Management* and 5.3.4 *Chaparral and Northern Coastal Scrub Conservation and Management*, above). Ultimately the result will be a wetland/pond/upland habitat matrix that will support multiple life stages of covered and other native species (LAND-G2, LAND-OC1, LAND-OC2, LAND-OC3, LAND-OC4, LAND-OC5). Ponds and wetlands will be further enhanced by eradicating or reducing exotic species (e.g., nonnative fish, bullfrogs, nonnative plants) that are detrimental to covered and other native pond and wetland species. These and other specific management prescriptions are discussed below.

Acquisition, Enhancement, Restoration, and Creation

The Implementing Entity will acquire an estimated 184 acres of wetlands and ponds within the Reserve System (**Table 5-12**). The Implementing Entity will enhance all Reserve System lands. The Implementing Entity will also restore or create an estimated 147 acres of wetlands and ponds (**Tables 5-12 and 5-13**).

Wetland and Pond Acquisition

The amount of wetlands and ponds protected will be driven, in part, by the level of impact. Wetland and pond impacts require a 2:1 preservation ratio. During Plan implementation, the Implementing Entity will protect an estimated 50 acres of perennial wetlands (coastal and valley freshwater marsh; LAND-WP1a, LAND-WP1b), 30 acres of seasonal wetlands (LAND-WP2a, LAND-WP2b), and 104 acres of ponds through fee title purchase or conservation easement and manage them as part of the Reserve System (**Table 5-12**).

Regardless of the level of impact, a minimum of 50 acres of ponds must be protected to protect habitat for covered species (tricolored blackbird, California red-legged frog, California tiger salamander, and western pond turtle; **Table 5-12**). Ponds will be protected on both sides of the Santa Clara Valley to ensure that representative populations of pond-associated covered species are included in the Reserve System (LAND-G2, LAND-OC1, LAND-OC2, LAND-OC3, LAND-OC4, LAND-OC5). The land acquisition strategy focuses on land acquisition in areas with higher concentrations of ponds; these areas include, but are not limited to, the area between Alum Rock Park and Joseph D. Grant County Park, the area between Cañada de Oro Preserve and Chesbro Reservoir, and the area south of Henry W. Coe State Park along the Cañada de los Osos. When possible, pond protection will be pursued within designated critical habitat for California tiger salamander and California red-legged frog. Joseph Grant County Park has existing open space that will be added to the Reserve System that includes substantial ponds (**Table 5-5**).

In addition to the pond acquisition described above, a minimum of 10 acres of perennial wetland and 5 acres of seasonal wetland will be acquired, regardless of the level of impact (**Table 5-13**). These land cover types are rare in the study area but occur mostly on the floor of the Santa Clara Valley or in the nearby foothills.

All wetland and pond protection will occur by Year 45 according to the Stay-Ahead provision described in Chapter 8, Section 8.6.1 *Stay-Ahead Provision*. This provision requires that stream woodland and scrub protection requirements be met prior to impacts occurring to these land cover types, with a 10% allowable deviation.

Wetland and Pond Enhancement

The Implementing Entity will enhance all Reserve System lands. All estimated 184 acres of wetlands and ponds acquired for the Reserve System (**Table 5-12**) will be enhanced to benefit covered and other native species. In addition, the estimated 147 acres of wetlands and ponds restored and created will be maintained once they meet their success criteria, and enhanced, as indicated by targeted studies and informed by the monitoring and adaptive management program. Wetland and pond enhancement will begin immediately after reserve unit management plans are completed or updated for each reserve unit.

Habitat enhancement is the improvement of an existing terrestrial vegetation community or aquatic habitat. Within the Reserve System, degraded ponds and wetlands will be improved to increase overall ecological functions and values (e.g., native species richness and diversity, wildlife habitat function) and to enhance the ability of these habitats to support existing and new populations of covered species. Wetland and pond enhancement measures will be designed for specific wetland or pond types (e.g., hydrogeomorphic context, surrounding natural community) and, in some cases, for specific sites. As described below, the success of various techniques depends on the wetland or pond type and the site conditions under which they are applied. Wetlands or ponds that are highly degraded may require more intensive management. Wetlands or ponds already in good condition (e.g., that support healthy populations of covered species) may require little or no enhancement measures.

Perennial and Seasonal Wetland Restoration

Wetland impacts require a 1:1 restoration ratio for perennial wetlands and 2:1 restoration ratio for seasonal wetlands. The Implementing Entity will restore freshwater perennial and seasonal wetlands in-kind within the Reserve System according to the level of impact to these land cover types. If all expected impacts occur, this will result in an estimated total restoration of 25 acres of freshwater marsh and 30 acres of seasonal wetlands, per the required mitigation ratio (**Table 5-12**). In addition to the mitigation ratios, the Implementing Entity will restore at least 20 acres of perennial wetlands within the Reserve System to contribute to recovery (POND-6) (**Table 5-13**). This wetland restoration will occur regardless of the level of impacts and will contribute to the recovery of covered wetland species.

Habitat restoration is the establishment of a vegetation community or aquatic habitat in an area that historically supported it, but no longer does because of the loss of one or more required ecological factors or as a result of past disturbance. Wetland restoration will be carried out in areas that will increase available habitat and enhance connectivity between existing ponds and wetlands within the Reserve System. Potential wetland restoration and pond creation sites will be selected within the same watershed as the expected wetland impacts. This prioritization will ensure that wetland mitigation occurs close to the impact area and preserves and enhances watershed functions. Restoration will occur on suitable soils and in areas where wetlands historically occurred and have since been drained or severely degraded. Additional site selection guidelines are provided below under *Guidelines for Selecting Restoration or Creation Sites*. Restoration may include recreating the historic topography of the site and planting native freshwater emergent and aquatic plants. Seasonal wetlands may be restored along floodplain benches of intermittent streams or in grassland swales. Additional guidelines for restoring wetlands is provided below under *Restoration and Creation Principles and Techniques*.

All restoration of these land cover types will be completed by Year 40 (i.e., construction will be completed) and according to the Stay-Ahead provision described in Chapter 8, Section 8.6.1 *Stay-Ahead Provision*. All required restoration of perennial or seasonal wetlands must be initiated (ground breaking) prior to impacts occurring to these land cover types. In addition, the Implementing Entity will completerestoration of perennial wetland to contribute to species recovery according to the deadlines in **Table 5-14** (Years 15, 30, and 40).

Pond Creation

Pond impacts require a 1:1 creation ratio (**Table 5-12**). The Implementing Entity will create ponds lost to covered activities, in-kind, within the Reserve System. The total allowable impact on pond land cover during the permit term is 52 acres. In addition to the creation ratio, the Implementing Entity will create a minimum of 20 acres of ponds to contribute to recovery (POND-9) (**Table 5-13**). Pond creation to contribute to recovery is in addition to the mitigation ratio and will occur regardless of the level of impacts on ponds to contribute to the recovery of covered pond species (California red-legged frog, California tiger salamander, western pond turtle). Consequently, an estimated 72 acres of ponds will be created and managed as part of the Reserve System to offset these impacts and contribute to species recovery (52 acres + 20 acres = 72 acres). Pond creation will increase available habitat and enhance connectivity among existing ponds and wetlands within the Reserve System (**Figure 3-13**). Pond creation will only occur off-stream to avoid additional impacts to streams. Additional site selection guidelines are provided below under *Guidelines for Selecting Restoration or Creation Sites*.

The Habitat Plan assumes that ponds will be created (i.e., development of the pond land cover type in an area that did not previously support it). However, if an existing or historic pond were degraded to the point that it lacks certain ecological functions that are essential to support covered species (e.g., a pond is filled with sediment and no longer holds water), then restoration of a pond may be counted toward the Plan's creation requirements for ponds. Whether a pond restoration may be counted toward pond creation requirements will be determined by the Implementing Entity and Wildlife Agencies during the Wildlife Agency review of the proposed restoration design.

New ponds will be sited to improve habitat connectivity for California red-legged frog, California tiger salamander, and western pond turtle. The Implementing Entity will identify gaps between occupied ponds that are greater than typical dispersal distances (e.g., California tiger salamander may travel up to 1.3 miles from a breeding site) but short enough such that the creation of a pond may bridge the gap.

Where feasible, created ponds will rely on passive management (e.g., they will dry on their own periodically) to minimize the need for artificial draining. However, all created ponds will include a mechanism for draining, to control bullfrogs and other invasive nonnative wildlife species (described in Section 5.3.2 *Landscape Conservation and Management*). Pond creation to mitigate for impacts will be accomplished by creating ponds of approximately the same size as those lost. Pond creation to contribute to recovery will be accomplished by creating ponds with an approximate average size of 0.5 acre, although small isolated ponds may be created that are only a few meters across because such ponds may provide habitat for California red-legged frogs and California tiger salamander, but may not be attractive to bullfrogs (U.S. Fish and Wildlife Service 2002). Native emergent and aquatic vegetation will be planted in ponds to provide suitable breeding habitat for covered species. Additional guidelines for restoring wetlands is provided below under *Restoration and Creation Principles and Techniques.*

Construction of all ponds will be completed by Year 40 and according to the Stay-Ahead provision described in Chapter 8, Section 8.6.1 *Stay-Ahead Provision*. All required pond creation must be initiated (ground breaking) prior to impacts. In addition, the Implementing Entity will complete pond creation to contribute to species recovery according to the deadlines in **Table 5-14** (Years 15, 30, and 40).

Management Techniques and Tools

Wetland Restoration and Pond Creation

All wetlands and ponds restored or created will be designed to support covered aquatic or amphibian species when physical and biological conditions allow. Biologically appropriate management techniques will be determined on a site-specific basis.

Guidelines for Selecting Restoration or Creation Sites

Potential restoration sites will be identified and selected on the basis of their physical processes and hydrologic, geomorphic, and soil conditions to ensure that successful restoration can occur and be self-sustaining. Such an approach increases the likelihood of successful restoration and reduces long-term management and maintenance costs.

Restoration sites will be selected within the same watershed as the expected wetland impacts. This prioritization will ensure that wetland mitigation occurs close to the impact area and preserves and enhances watershed functions. Restoration of perennial and seasonal wetlands will occur on suitable soils and in areas where perennial wetlands historically occurred and have since been drained or severely degraded, if appropriate hydrologic conditions still exist (San Francisco Estuary Institute 2006, 2007).

Restoration sites will also be selected on the basis of their ability to support covered species, support implementation of species-specific conservation actions, and meet species-specific biological goals and objectives. For example, sites designed to support tricolored blackbird will be located a sufficient distance away from black-crowned night-heron rookeries to minimize predation on tricolored blackbirds. Sites designed to support breeding habitat for covered amphibians must have adequate nearby upland habitat. Restoration and creation sites for wetlands and ponds must meet minimum distances from urban development to receive credit under this Plan (**Table 5-15**). Created ponds will be sited away from busy roads to reduce the likelihood of mortality during periods when frogs, turtles, and salamanders move between ponds and uplands. In accordance with the California red-legged frog Recovery Plan, ponds created to provide red-legged frog habitat shall incorporate the *Guidelines for Voluntary Pond Management for the Benefit of the California Red-legged Frog* or the best available science during Plan implementation. This currently includes the following siting and design criteria.

- Evaluate the distance from known occurrences California red-legged frog to increase the likelihood of species dispersal to the created habitat.
- Place ponds at least one kilometer (0.6 miles) from known occurrences of bullfrogs.

Restoration and Creation Principles and Techniques

Wetland restoration or pond creation will be accomplished using the techniques outlined in this section.

Coastal and Valley Freshwater Marsh Restoration (Perennial Wetlands)

The Implementing Entity will restore perennial freshwater wetlands at a ratio of 1:1 to replace wetlands lost to covered activities (estimated to be 25 acres of compensation) and restore an additional 20 acres of perennial freshwater wetlands to contribute to species recovery (**Table 5-12**).

One of the key principles of successful restoration is the presence of the processes that create and maintain wetlands (Middleton 1999; Keddy 2000; Mitsch and Gosselink 1993). The most important processes are related to the availability of water and appropriate hydrology to create and maintain hydric soils and plants. Therefore, restoration of perennial wetlands will occur on sites with appropriate hydrology. This may include areas where perennial wetlands historically occurred and have since been drained or severely degraded. Additionally, there may be sites that are currently appropriate for perennial wetlands that did not historically support them, because of changing land uses and altered hydrologic flows. It is imperative that perennial wetlands restoration sites be located directly adjacent to or connected to a source of permanent water.

Restoration will occur on suitable soils and may include creating wetland topography. Specifically, this might include site grading and creation of depressions to hold water. The choice of plant species for perennial wetland restoration sites will be based on a palette of native wetland plants including freshwater emergent and aquatic species. The palette will be developed during the implementation process. Ideally, the plants will be grown from soil, seed, or plant stock from local wetland sites. In addition, vegetation is expected to evolve after the original planting such that “volunteer” species may move into the wetland over time. In some cases, this can include nonnative invasive species that are not desirable within the Reserve System. Therefore, restoration plans will include plans for management of nonnative invasions. Additional issues that will be addressed in wetland design include preventing fish from becoming trapped in the ponds if the hydrology source is from a perennial waterbody that supports fish (e.g., by the use of fish screens or other appropriate devices).

Examples of wetland restoration projects in the study area that will be consulted for lessons learned (e.g., the Coyote Creek wetland restoration project (SCVWD), which occurs off-channel on Coyote Creek adjacent to U.S. 101).

Seasonal Wetland Restoration

The Implementing Entity will restore seasonal wetlands at a ratio of 2:1 to replace all functions and values lost to covered activities (estimated to be 30 acres[27] of compensation; **Table 5-12**).

As with perennial wetlands, the most important principle for successful restoration and maintenance of seasonal wetlands is appropriate hydrology. However, for seasonal wetlands, the source of water should be available during the winter rainy season and not available during the dry summer months. Therefore, seasonal wetland restoration will include appropriate hydrologic sources and processes to support the seasonality of the wetland feature. This may occur on sites that supported seasonal wetlands historically, if appropriate hydrologic processes are still in place or can be restored. It may also include sites that have been altered by recent land uses and now support suitable hydrology.

The soils for seasonal wetlands generally will have water-holding capacity. This usually means some amount of clay content. Soils will be examined and tested before seasonal wetlands are sited. The plant palette for seasonal wetlands, as with perennial wetlands, will be developed during the restoration planning process. The choice of plant species for seasonal wetland restoration sites will be based on a palette of native seasonal wetland plants. Plants used for restoration will ideally be grown from local plant sources (soil, seed, and plant stock).

Because plant species composition, along with hydrologic processes, may change after the original planting, “volunteer” species may move into the wetland over time. This is to be expected because wetlands are dynamic systems. In some cases, such changes may include nonnative invasive species that are not desirable within the Reserve System. Therefore, restoration plans will include plans for management of nonnative invasions.

Pond Creation

Ponds will be created to support breeding habitat for California red-legged frog, California tiger salamander, western pond turtle, tricolored blackbird, or a combination of these species. Pond depth will be sufficient to provide suitable breeding habitat for red-legged frogs or tiger salamanders and to preclude dense growth of emergent aquatic vegetation. Pond size will vary depending on the availability of water and site and watershed conditions. Ponds will be created to supplement the existing important network of stock ponds that exist in the study area, particularly in the Diablo Range where livestock grazing is more common. Ponds will not be created in streams to avoid stream impacts, preclude fish-

[27] Actual acreage of seasonal wetland compensation is expected to be less than 30 acres because seasonal wetland impacts and compensation will be tracked based on the wetland delineation submitted to, and verified by, the Local jurisdictions or Implementing Entity (See Chapter 6, Section 6.8.4). This land cover type was mapped at a regional scale using wetland complexes rather than site-specific data.

stranding, and avoid creating predator sinks. Ponds will be created so that they can be drained if necessary to control bullfrogs and other nonnative invasive animals.

Sediment inputs to ponds must be controlled to maintain the pond in the long term and minimize the need for periodic dredging. Upstream in-channel measures and small forebays can be used to reduce sediment delivery to the created ponds.

Ponds will be designed so that they either do not retain water long enough to support establishment of bullfrogs, nonnative fish, or other predators of California red-legged frog and California tiger salamander, or can be artificially drained to deter such establishment. At the same time, they will be designed to remain ponded for sufficient duration to support successful breeding of California red-legged frog and/or California tiger salamander. A deep-water escape portion, deeper than 1 meter (3 feet) and shallow, tadpole- and juvenile rearing portion to provide high quality breeding habitat for California red-legged frog shall be included (U.S. Fish and Wildlife Service 2002). Native emergent and aquatic vegetation will be planted in ponds to provide suitable breeding habitat for these covered species.

Wetland and Pond Enhancement

All wetlands and ponds within in the Reserve System will be enhanced. The Implementing Entity will use the management techniques described below to enhance Reserve System wetlands and ponds.

Vegetation Management

Vegetation management is a critical component of optimizing the habitat function of ponds and wetlands for covered species. Consequently, wetland and pond vegetation will be managed depending on the site-specific conditions of individual wetlands and ponds, and will largely depend on the individual species or group of species targeted for enhancement (or removal in the case of invasive nonnative species). Vegetation management will involve several techniques, often used in concert, to achieve the species composition and habitat structure necessary to benefit covered and other native species.

Some existing ponds or wetlands and all created ponds or restored wetlands will be seeded with native vegetation appropriate for the surrounding natural communities for replacement of lost ecological services and function. Planting of emergent vegetation (POND-3) such as bulrushes or willows in ponds that lack vegetation can improve breeding habitat and cover for California red-legged frog, western pond turtle, and California tiger salamander in the deepwater portions (i.e., greater than 1 meter deep); however, they should be kept clear of the shallow portions as tadpole-rearing portions should remain unshaded and shallow for California red-legged frog breeding habitat (U.S. Fish and Wildlife Service 2002). Further, tall emergent vegetation, such as bulrushes, can provide roost and nest sites for tricolored blackbirds where the wetlands or ponds are located near foraging habitat. Wetlands or ponds with adjacent grasslands or oak woodlands will benefit from selective seeding of native forbs or grasses in the uplands surrounding the pond/wetland fringe (GRASS-4).

Vegetation may have to be removed from ponds where little open water remains to improve conditions for western pond turtle, California tiger salamander, and California red-legged frog. Vegetation removal can be accomplished through grazing (see below), selective herbicide application using label-approved application technique and in calm winds, or mechanical means (LM-11, LM-14). Where feasible, prescribed burns will be used to control nonnative vegetation around ponds and wetlands and within pond or wetland complexes (GRASS-2). Any herbicide application conducted in ponds or wetlands must use products that have been approved for aquatic communities. Mechanical removal of vegetation would occur after the breeding season for wetland- and pond-dependent wildlife, including nesting migratory birds, to minimize impacts. If surveys identify California red-legged frog presence at a pond requiring vegetation management, such activities would be restricted to between August 30th and October 15th. In cases where covered species are dependent on nonnative vegetation (e.g., tricolored blackbirds nesting in Himalayan blackberry) the removal of nonnative vegetation will be undertaken in phases over a 3 to4-year period and replaced with the appropriate native vegetation.

Overgrazing by cattle and rooting by feral pigs can cause trampling of vegetation, soil compaction, development of "cow contours," and bank destabilization. Fencing ponds and wetlands (POND-1) has been shown to be a rapid, successful, and cost-effective method of enhancing some wetlands. After fencing, vegetation cover and wetland species diversity can increase substantially in stock ponds and other permanent or near-permanent freshwater wetlands that have been degraded by cattle grazing (Contra Costa Water District 2002). In this Plan, fencing locations and specifications will depend on several factors, including site-specific conditions and the biological objectives that are being addressed. Fencing wetlands may not be appropriate in locations where retaining open water for species such as western pond turtle and California tiger salamander is an objective. In such cases, fencing half of a pond or wetland (split fencing) may accommodate the needs of multiple covered species (U.S. Fish and Wildlife Service 2002).

Livestock grazing (LM-11) will be introduced or continued at some wetlands and ponds to eliminate or reduce cover of exotic plants and to maintain ponds by preventing excessive plant growth when such a technique is consistent with maintaining values for covered species. Grazing rotation and fencing can also reduce the erosive impacts described above. Ford et al. (2012) provide details about pond habitat quality for the special-status California red-legged frog and California tiger salamander. The period of a pond's inundation is critical to habitat value as well as the livestock operation that is associated with the pond's establishment and maintenance. Ponds that draw down in the late spring or early summer can become unsuitable for livestock use due to lack of water and dangerous muddy banks.

To support successful reproduction of these special-status amphibians, their pond or stream habitats must remain inundated long enough to support successful metamorphosis, which for California red-legged frog is December through April, and for California tiger salamander through May (U.S. Fish and Wildlife Service 2010). The California red-legged frog need ponds with a mix of open surface water and vegetated cover in the pond and at the edges. Emergent and edge vegetation provides cover for adult frogs from native and non-native predators, which is especially important if the non-native predators are not controlled. Emergent or submerged vegetation is also important in providing structure for attachment of frog eggs. The California tiger salamander typically use ponds free of emergent vegetation. Aquatic vegetation can be compatible, especially submerged vegetation, but salamander breeding appears to be rare with moderate levels of emergent vegetation. Allowing limited livestock access to a pond will help maintain its usefulness as habitat for covered species by preventing excessive plant growth that can lead to rapid sedimentation of ponds (U.S. Fish and Wildlife Service 2002). Seasonally limited grazing can be effective at reducing competition for nonnative plant species in seasonal wetlands (Marty 2005).

In addition to managing grazing of ponds and wetlands, grazing of surrounding grassland will be managed to maintain optimal habitat conditions. The use of livestock grazing within the Reserve System is discussed above (Section 5.3.3 *Grassland Conservation and Management*).

Water and Other Management

It is assumed that many ponds in the study area are in disrepair. Repairs could be made to improve water retention in ponds created as stock ponds that are not retaining water due to leaks and, as a result, not functioning properly as habitat for covered species. Additionally, pond capacity and water duration can be increased (e.g., by raising spillway elevations) to support covered species populations.

In order to retain the habitat quality of ponds and wetlands over time, occasional sediment removal may be needed to address the buildup of sediment that results from adjacent land use or upstream factors (POND-4). Dredging will be conducted during the non-breeding periods of covered and other native species.

The Implementing Entity will also work with private landowners who own key ponds to secure funding to improve and maintain their ponds as habitat for covered species (e.g., tricolored blackbird, California tiger salamander, California red-legged frog, or western pond turtle). The Implementing Entity will help landowners apply for existing grants to enhance pond and freshwater marsh habitat on their land (e.g., North American Wetlands Conservation Act Small Grants Program [USFWS], or Environmental Quality Incentives Program of the Farm Bill [USDA Natural Resources Conservation Service]) (POND-11, POND-14). The Implementing Entity will work closely with existing organizations that have strong relationships with private landowners such as the Natural Resources Conservation Service, the local Resource Conservation District, and the California Cattlemen's Association. A program could be developed in the study area modeled after the successful Alameda County Conservation Partnership in Alameda County. This program provides technical assistance, funding, and permit streamlining to private landowners wishing to maintain and enhance stock ponds to benefit endangered species.

Coarse woody debris or anchored basking platforms will be installed in ponds to improve habitat for western pond turtles (Hays et al. 1999) (POND-2). This modification will increase the habitat value in locations with existing western pond turtles and in newly created ponds where it is hoped that new pond turtle populations will establish. These structures may also enhance habitat for native amphibian species.

Nonnative Wildlife Management

The Implementing Entity will work to reduce and, where possible, eradicate nonnative exotic species that adversely affect native pond and wetland species. These efforts will include prescribed methods for removal of bullfrogs, mosqitofish, and nonnative predatory fish from stock ponds and wetlands within the Reserve System. Further, the Implementing Entity will reduce the overall population of feral pigs within the permit area to reduce degradation of pond and wetland habitats. In some cases monitoring exotic species can be best accomplished by documenting the impact of those species on natural landscapes. It would be difficult to census the number of feral pigs within the Reserve System without an extensive effort. However, rooting disturbance can be monitored. The pig population will be controlled to levels that do not preclude the Implementing Entity's ability to successfully reach the Plan's goals and objectives.

Private Landowner Education

The Implementing Entity will establish a landowner education program to provide technical and financial assistance to maintain and enhance ponds and other wetlands on private lands. Wetland enhancement may include pond stabilization, nonnative species control, pond or wetland expansion, or water management structures. Details are found under *Public Education and Outreach* in Section 5.3.2 *Landscape Conservation and Management* above. A similar, successful program operates in Alameda County in similar habitat under the auspices of the Alameda County Resource Conservation District and the USDA National Resource Conservation Service.

Threats and Uncertainties

In general it is anticipated that a greater acreage of ponds than of wetlands will be protected through fee title acquisition or conservation easement because wetland protection and restoration opportunities are likely to be rare on the Santa Clara Valley floor, where most of the study area's wetlands are found. Although pond habitat is not a complete surrogate for wetland habitat in terms of ecological services and function, it does support the necessary life history stages for all the covered pond species in this Plan. However, ponds will not be used as out-of-kind mitigation for impacts to wetlands.

When creating or restoring aquatic habitat, the success of the habitat transformation is always dependent upon adequate water supplies during critical life stages of covered species. During periods of drought, pond and wetland habitat may dry prior to the completion of covered species' aquatic life stages (i.e., breeding ponds for California tiger salamander and/or California red legged frogs may dry prior to metamorphosis). While ponds and wetlands will be created or restored to periodically dry on their own, periods of extended drought are inevitable and may diminish the quality of the aquatic habitat in some years.

Limitations of Restoration

Restoring or enhancing hydrologic function to the immediate watersheds of wetlands and ponds will enhance habitat function of these features. Upstream factors that may be contributing to the decline of seasonal wetlands in the study area include hydrologic changes that lead to channel incision, changes in channel runoff, hydrologic disconnection of channel and floodplain, lowering of groundwater, and reduction of soil moisture in riparian areas. A variety of methods/approaches are available to arrest channel incision. For example, grazing management and fencing (see above) can be used to curtail negative hydrologic effects. Check dams have been shown to be effective at arresting channel erosion in seasonal wetlands in the Los Vaqueros Watershed in Contra Costa County within 6 months of dam installation (Jones & Stokes Associates 1992). Over time, such small dams may also increase the recharge of the local aquifer, raising the water table and increasing soil moisture levels near the surface. This effect could, in turn, increase the cover and extent of seasonal wetland vegetation along stream channels.

Mosquito Abatement

Enhancement of pond and wetland habitats must be balanced with the need to minimize mosquito production. Encouraging adequate populations of mosquito predators, such as native frogs, swallows, and bats, offers an approach to mosquito control that is compatible with management for covered species. Wetlands will be designed to reduce mosquito production by minimizing suitable habitat for mosquitoes (primarily *Culex torsalis*) and other human disease vectors, particularly between mid-July and late September or October when mosquito productivity is highest. Any mosquito control activities to be performed on Reserve System land will be addressed in the reserve unit management plan in consultation with the Santa Clara County Vector Control District. The reserve unit management plan will detail the nature of mosquito control activities and explain specific measures implemented to avoid and minimize impacts to covered species consistent with the Habitat Plan.

5.4 Benefits of and Additional Conservation Actions for Covered Species

Most species-specific conservation is accomplished by protecting, restoring, and managing natural communities as described above. For 17 of the covered species, a GIS-based approach was used to estimate the amount of modeled habitat to be protected within the Reserve System. The species account for most species contains a section called *Modeled Habitat Distribution in Study Area* detailing the parameters used to identify modeled species habitat (see **Appendix D**). Modeled species habitat was overlaid with the proposed Reserve System (see Section 5.2.3 *Reserve System*). The amount of modeled species habitat protected within the proposed Reserve System is identified for each covered species below. In addition, the number and size (if known) of covered plant occurrences protected within the proposed Reserve System are also discussed. Some species-specific actions were also included within these natural community management sections. The following section describes the biological goals and objectives for covered species and summarizes the benefits of the conservation actions for each species. When applicable, conservation actions in this Plan are related to federal critical habitat designations and federal Recovery Plan actions.

As discussed in Chapter 1, California State Parks lands are excluded from the permit area. Because of this exclusion, all of the land cover-related analyses in the Plan are based on the study area less State Parks lands unless otherwise noted. The size of the study area less State Parks lands is 460,205 acres.

5.4.1 Bay Checkerspot Butterfly

Biological Goals and Objectives

The Implementing Entity will improve the viability of existing Bay checkerspot butterfly populations, increase the total number of populations, and expand the geographic distribution of the species to ensure its long-term persistence in the study area. This will be accomplished by protecting most serpentine grasslands within the study area to ensure protection of the ranges of slopes, aspects, and microhabitats important to the species. Acquisition, enhancement, and restoration/creation of natural communities adjacent to serpentine grasslands, including grasslands (see Section 5.3.3 *Grassland Conservation and Management*), chaparral and coastal scrub (see Section 5.3.4 *Chaparral and Northern Coastal Scrub Conservation and Management*), oak woodlands (see Section 5.3.5 *Oak and Conifer Woodland Conservation and Management*), riparian forest and scrub (see Section 5.3.6 *Riverine and Riparian Forest and Scrub Conservation and Management*), and wetlands and ponds (see Section 5.3.7 *Wetland and Pond Conservation and Management* are expected to benefit Bay checkerspot butterfly through the conservation and management of movement habitat.

Additionally, the Implementing Entity will improve management in degraded serpentine grasslands in the Reserve System to enhance populations of the larval host plants and adult nectar sources to benefit Bay checkerspot butterfly populations.

Habitat Acquisition and Enhancement

The 1998 serpentine soils species Recovery Plan prioritizes 8,674 acres of then-unprotected habitat (i.e., not “fully or partially protected park lands”) within specific portions of the study area that “are considered essential to the recovery” of the species (U.S. Fish and Wildlife Service 1998a). The 1998 Recovery Plan also states that there are “other current or historic localities or suitable habitat areas, generally larger than” 2.5 acres that are also “essential to the recovery” of the species; however, these areas were not specifically identified (U.S. Fish and Wildlife Service 1998a). These prioritizations for protection were based on habitat mapping that occurred prior to the development of the Habitat Plan. The mapping of Bay checkerspot habitat for the Plan resulted in a new more accurate estimate of unprotected habitat in the study area of a total of 7,285 acres (total habitat modeled less habitat in Type 1 Open Space) (**Table 5-7**; see Chapter 3 and the species account in **Appendix D** for details on the habitat mapping).

Habitat models developed for this Plan estimated 8,621 acres of Bay checkerspot butterfly modeled habitat within the study area; this does not include all serpentine bunchgrass lands within the study area. Areas mapped as serpentine rock outcrop in this Plan are excluded from modeled Bay checkerspot butterfly habitat because these land cover types are assumed to be barren and thus not considered suitable habitat for the species. 2,921 acres (34%) of modeled habitat are located on Type 1, 2, or 3 open space with 1,336 acres (15%) permanently protected as Type 1 open space. The Plan will acquire 3,800 acres of lands modeled as habitat for the Reserve System and add 754 acres of modeled habitat from existing open space to the Reserve System (**Table 5-17**). With the total Reserve System lands (4,554 acres = 3,800 acres + 754 acres) added to land already protected as Type 1 open space (1,336 acres), a total of 5,890 acres of Bay checkerspot butterfly modeled habitat would be protected, or 68% of total modeled habitat in the study area.

The Implementing Entity will protect at least 4,000 acres of serpentine bunchgrass grassland (**Tables 5-19**) (3,800 acres of which includes modeled habitat for Bay checkerspot butterfly) through fee title acquisition or the acquisition of conservation easements. The conservation strategy for the Bay checkerspot butterfly, in combination with existing Type 1 open space, protects 70% of the core habitat on Coyote Ridge, extending from the north end of Coyote Ridge south to Anderson Dam (including the Pigeon Point unit). This acquisition will include the core habitats along the ridge tops, which have historically (since 1984) supported the densest populations of Bay checkerspot butterfly. Of the 4,000 acres of serpentine grassland to be preserved, the proposal is to acquire a minimum of 2,900 acres located on Coyote Ridge (LAND-L5). Extensive land acquisition will occur in all four of the core habitat areas as defined in the Recovery Plan for the species (U.S. Fish and Wildlife Service 1998a): Kirby, Metcalf, San Felipe, and Silver Creek Hills (see **Table 5-7** for a cross-walk of site names between this Plan and the Recovery Plan). The primary focus of land acquisition will be Coyote Ridge. The Plan also protects secondary sites deemed essential for the recovery of the species, including:

- The Santa Teresa Hills, a "potential core area" and "stepping stone" in the Recovery Plan. Approximately 877 acres (53%) of Santa Teresa County Park are proposed for incorporation into the Reserve System and would be managed to improve habitat for this species; most of this area supports serpentine bunchgrass grassland (over 670 acres). Once enhanced through livestock grazing, the improved habitat is expected to attract Bay checkerspot butterfly back to this part to re-establish a lost population (**Table 5-5**)[28].
- Tulare Hill (deemed an important corridor for this species to connect populations in the Diablo Range with populations in the Santa Cruz Mountains),
- West hills of the Santa Clara Valley: 75% of the currently unprotected portions of Hale/Falcon Crest, Kalana Avenue, and Canada Garcia sites.

Land acquisition will protect occupied and potential habitat for the species, and protect critical linkages for the species. Protection of landscape linkages 6 and 8 (**Table 5-9** and **Figure 5-9**) will directly benefit Bay checkerspot butterfly. Protection of the linkage between the Silver Creek and Metcalf populations (LAND-9, LAND-L4) and the linkage between Coyote Ridge and Tulare Hill is critical for the species and will be necessary to meet the biological goals and objectives for this species.

The Implementing Entity will acquire and manage enough habitat to ensure occupancy by Bay checkerspot butterfly of each of the four core habitat units identified in the 1998 Serpentine Recovery Plan (Kirby, Metcalf, San Felipe, and Silver Creek Hills). Occupancy in these four core habitat units will be demonstrated at least four out of every 10 consecutive years of the permit term. The Implementing Entity will also acquire and manage land to ensure occupancy of at least three of the six (50%) satellite habitat units identified in the 1998 serpentine Recovery Plan (**Table 5-7**) by Year 45 (see Section 5.3.1 *Land Acquisition and Restoration Actions* subheading *Acquisition of Occupied Habitat for Select Wildlife Species*).

Successful implementation of the Plan will result in the protection of a portion of all Bay checkerspot critical habitat units (**Table 5-21** and **Figure 4-3**) (U.S. Fish and Wildlife Service 2008). In most cases, more than 48% of each of the 9 critical habitat units will be protected.[29] Habitat protection will occur on Coyote Ridge (northwest and southeast of Motorcycle County Park; Units 5 and 13), Tulare Hill (Unit 6), Santa Teresa Hills (Unit 7), west of Calero Reservoir (Unit 8), the Kalanas and Hale/Falcon Crest (Units 9a and 10), and Bear Ranch (Unit 11) (LAND-G3). These acquisitions will permanently protect important linkages between core and satellite habitat units and guarantee standardized management and monitoring, something that has not occurred in the past. Protection of sites will be prioritized according to threat, occupancy history and

[28] Estimates of County Park lands incorporated into the Reserve System are approximations. Final amounts will be determined during implementation when conservation easements are established and more detailed mapping is conducted.

[29] Critical habitat units 9a and 9b are referred to a single unit in this Plan. Reference to % protected includes existing Type 1 Open Space at the time of permit issuance in addition to critical habitat preserved during the permit term.

at the time of acquisition, proximity to occupied habitat, and prevalence of cool microsites with the proper slope, aspect, and microclimate for Bay checkerspot butterflies. All land protected will be enhanced, as described below. See Chapter 4, Section 4.7.1 *Bay Checkerspot Butterfly*, for a discussion regarding the limitations of land acquisition in specific Bay checkerspot critical habitat units.

Most of the serpentine areas in the study area are expected to be acquired as part of the Reserve System (see above). While the allowable impacts to serpentine bunchgrass grassland is limited to 550 acres (**Table 4-2**), impacts to Bay checkerspot butterfly modeled habitat mapped (see **Appendix D** and **Table 5-7**) as “occupied” or “potential” are capped at 300 acres (**Table 4-4**). Impacts to modeled habitat mapped as “historic/unoccupied” and “occupancy unknown” are not subject to this cap. In addition, impacts to Bay checkerspot butterfly modeled habitat is limited to no more than 3% of the unprotected portion (everything except Type 1 open space) of any core or satellite habitat unit targeted for conservation (as defined in **Table 5-7**). The one exception is the Kirby/East Hills core habitat unit which has an 11% allowance to accommodate the Kirby Landfill expansion (80 acres). Therefore, impacts to Bay checkerspot butterfly modeled habitat are limited in total amount (up to 4% of total modeled habitat) and in geographic scope (no more than 3% of any one core or satellite habitat unit targeted for conservation with one exception). These caps do not apply to habitat units in Type 1 open space because loss of habitat will be extremely limited in permanently protected open space (i.e., limited to trail construction and management activities).

Some impacts on serpentine grassland may still occur. Because of the high importance and rarity of serpentine soils and their habitats, these areas will be avoided whenever feasible during project planning (see Chapter 6, Section 6.5, subheading *Condition 13 Serpentine and Associated Covered Species Avoidance and Minimization*).

In the study area, an estimated 12% of designated critical habitat for Bay checkerspot butterfly is currently protected as Type 1 open space and another 25% occurs in open space Types 2, 3, and 4 (**Table 5-21**). Portions of the critical habitat units have been preserved through project compensation (e.g., Silver Creek Hills) and conservation agreements and easements from private entities (e.g., Tulare Hill and Kirby Canyon Landfill). However, this leaves 38% of critical habitat outside any type of open space. The Habitat Plan will protect an estimated 66% of all critical habitat not currently protected under Type 1 open space, including existing parklands that will be incorporated into the Reserve System. When added to the currently protected portions of critical habitat, approximately 70% of Bay checkerspot critical habitat in the study area will be preserved as Type 1 open space upon successful implementation of the Habitat Plan.

Management Techniques and Tools

The general principles for grassland management will be followed in all serpentine grassland areas (Section 5.3.3 *Grassland Conservation and Management*). All management actions in this Plan are consistent with management guidelines in the species' Recovery Plan (U.S. Fish and Wildlife Service 1998a).

Once land is protected it will be beneficially managed for Bay checkerspot butterflies. The Implementing Entity will also enhance degraded areas to benefit serpentine grasses and encourage growth of host plants and nectar sources for the butterfly through techniques such as exotic plant control and removal, beneficial livestock grazing, and prescribed burning (GRASS-2). In the study area, grazing has been shown to benefit most covered plant species and Bay checkerspot butterfly by reducing cover of invasive plants and increasing habitat for dwarf plantain, the butterfly's host plant (Weiss and Wright 2005, 2006; Santa Clara Valley Transportation Authority 2006).

It is expected that Bay checkerspot butterflies from core populations will colonize previously unoccupied areas or areas that historically supported the species but lost its habitat value (i.e., lack of grazing, etc.). If it becomes apparent that site management is adequate and natural dispersal is not occurring, the Implementing Entity may translocate individuals (i.e., assisted migration) to increase the distribution of the species in the study area. The decision of when this should occur would be made in coordination with species experts and the Wildlife Agencies. At a minimum, the Implementing Entity will propose translocation efforts if natural colonization fails after five seasons in which core populations are at above-average population sizes. In such an event, Bay checkerspot butterflies (eggs, larvae, or adults) may be translocated from core populations into suitable but unoccupied sites to reestablish populations (GRASS-7). Translocation proposals will be provided to CDFG and USFWS for review and approval before translocation efforts are implemented and will be carried out experimentally. This is an important action identified in the Recovery Plan (U.S. Fish and Wildlife Service 1998a).

Public education and outreach is also identified as an important action in the species' Recovery Plan. The Habitat Plan provides funding for a full-time public education and outreach specialist, as well as public outreach materials. As described in this chapter, the focus of the public outreach and education campaign will be to work with landowners to minimize their impacts and improve their management to benefit covered species. Because some Bay checkerspot butterfly habitat will remain in private ownership (even after full implementation of this Plan), landowner outreach will be important to ensure populations persist on these sites.

Threats and Uncertainties

Because this Plan will protect in perpetuity the majority of the remaining occupied and suitable habitat for this species, the threat of habitat loss from development will be greatly reduced. However, there will be a continued threat from nitrogen deposition on serpentine grasslands and the encroachment of nonnative grasses and herbs. Active livestock grazing and other management will minimize these on-going (and, over time, increasing) effects. Because management and monitoring for this species has been ongoing for many years, many of the management and monitoring techniques are well established and can be applied immediately following acquisition of new lands for the Reserve System, if funds are available (see Section 5.2.5 *Land Management*). The success of translocation is unknown but it may be attempted experimentally under the Plan to address this uncertainty.

5.4.2 California Tiger Salamander

Biological Goals and Objectives

The Implementing Entity will support viable populations and contribute to the regional recovery of the California tiger salamander by increasing the number of individuals and expanding the distribution of this species within the Reserve System. This will be accomplished by protecting and enhancing land through fee title purchase or by obtaining easements that are managed as part of the Reserve System.

Within the Reserve System the amount and quality of California tiger salamander habitat will be increased and improved through restoration, enhancement and creation of breeding and upland habitat. Lands that are protected will include land cover types that provide breeding habitat like ponds and wetlands and upland habitat like grassland, oak woodland, riparian, or chaparral. Acquisition, enhancement, and restoration/creation conservation actions identified for the following natural communities will benefit California tiger salamander through upland, movement, breeding, and foraging habitat conservation and management:

- grasslands (see Section 5.3.3 *Grassland Conservation and Management*),
- chaparral and coastal scrub (see Section 5.3.4 *Chaparral and Northern Coastal Scrub Conservation and Management*),
- oak woodlands (see Section 5.3.5 *Oak and Conifer Woodland Conservation and Management*),
- riparian forest and scrub (see Section 5.3.6 *Riverine and Riparian Forest and Scrub Conservation and Management*), and
- wetlands and ponds (see Section 5.3.7 *Wetland and Pond Conservation and Management*).

The Reserve System will be designed to maintain and improve connectivity between breeding habitat and upland habitat and to provide essential upland refugia by protecting areas with existing ground squirrel colonies or promoting new colonies in areas adjacent to known California tiger salamander breeding habitat. The Reserve System will be designed to reduce habitat fragmentation, which in turn will ensure that proper genetic exchange can occur and that the population has the opportunity to expand its distribution within the study area. In addition, the Reserve System will link California tiger salamander habitat within the study area to areas important to the species outside of the study area, such as San Francisco Public Utilities Commission Alameda Watershed properties in Santa Clara and Alameda counties and the Soap Lake region in San Benito County.

Habitat Acquisition, Restoration, and Creation

There are 324,748 acres of California tiger salamander modeled habitat (breeding and non-breeding) within the study area. There are 97,423 acres (30%) of modeled habitat located on Type 1, 2, or 3 open space with 45,767 acres (14%) permanently protected as Type 1 open space. The Plan will acquire a minimum of 30,150 acres of modeled habitat for the Reserve System. In addition, 11,745 acres of modeled habitat will be added to the Reserve System from existing open space. This will nearly double the proportion of California tiger salamander modeled habitat in the study area in Type 1 open space (to 27%) and increase Type 1, 2, or 3 open space to 39% (**Table 5-17**). This includes 195 acres of modeled breeding habitat (150 acres of newly acquired land and 45 acres of existing open space incorporated into the Reserve System) and 41,700 acres of modeled upland habitat (30,000 acres of newly acquired land and 11,700 acres of existing open space incorporated into the Reserve System).

The Implementing Entity will protect (through acquisition or easement) and enhance a minimum of 50 acres of ponds that either support, or have the potential to support, breeding California tiger salamander. In addition, a minimum of 20 acres of ponds will be created that either support or have the potential to support breeding California tiger salamander. Up to 104 acres of ponds will be protected and enhanced and up to 72 acres of ponds will be created if all estimated impacts occur (**Tables 4-4, 5-13, and 5-21**).

Similarly, the Implementing Entity will protect and enhance a minimum of 15 acres of wetlands (perennial and seasonal) that either support or have the potential to support breeding California tiger salamanders. Up to 80 acres of wetlands will be protected and enhanced and up to 75 acres of wetlands (perennial and seasonal) will be restored if all estimated impacts occur. As described in the species account in **Appendix D**, seasonal wetlands are more likely to support adequate breeding habitat for California tiger salamander because nonnative predators and hybrid salamanders are less likely to persist in these habitats. However, some perennial wetlands may still support California tiger salamander if they are periodically drained or nonnative predators are controlled in other ways (see the section below for a discussion of management of these ponds and wetlands to support California tiger salamander.)

By the time the Reserve System is fully acquired (which will be at or before Year 45), a minimum of 30% of all ponds and wetlands in the Reserve System will be or will have been occupied by California tiger salamander, as described in the Section 5.3.1 *Land Acquisition and Restoration Actions* subheading *Acquisition of Occupied Habitat for Select Wildlife Species*. By Year 30, at least 25% of all ponds and wetlands will be occupied or will have been occupied by the species.

Further, the Implementing Entity will protect grassland, oak woodland, riparian, or chaparral habitat within California tiger salamander modeled habitat (*California tiger salamander*, **Appendix D**) to provide upland refugia for the species. Land acquisition of modeled upland habitat for California tiger salamander will occur in all of the focus areas described below and will be adjacent to modeled breeding habitat. In most cases when modeled breeding habitat is acquired, modeled upland habitat will also be acquired because it will occur on the same parcel.

Land acquisition will substantially benefit California tiger salamander by protecting existing modeled breeding and upland habitat, protecting known occurrences, enhancing habitat through improved management, and providing opportunities for restoration of breeding habitat (freshwater wetlands) and creation of breeding habitat (ponds). To maximize the benefits of acquisition for this species, the Implementing Entity will acquire aquatic and upland modeled habitat in areas adjacent to existing open space with known occurrences of California tiger salamander such as Joseph D. Grant County Park, Palassou Ridge Open Space Preserve, or Henry W. Coe State Park (LAND-WP5).

Portions of the critical habitat units have already been preserved through acquisition and conservation easements (**Figure 4-4**). **Table 5-21** shows that 23% of all critical habitat in the study area is currently protected as Type 1 open space and another 33% is located in space Types 2–4. However, this leaves 41% of critical habitat outside of any type of open space. The Habitat Plan anticipates protecting an estimated 31% of all critical habitat in the study area within the Reserve System, including existing parklands that will be incorporated into the Reserve System. Land acquisition and incorporation of existing open space into the Reserve System will occur in 7 of 8 critical habitat units within the study area[30], substantially contributing to species recovery in the study area. See Chapter 4, Section 4.7.2 *California Tiger Salamander*, for a discussion regarding the limitations of land acquisition in specific California tiger salamander critical habitat units.

Within the Diablo Range, land acquisition will be focused on protecting the connection between the southern parts of Henry W. Coe State Park, an area with high California tiger salamander densities, to the Soap Lake region in northern San Benito County. Some of the land acquired in this area falls within Critical Habitat Unit 12 and would include up to three known occurrences. Unit 11 is

[30] Subunits EB_10A and B were counted as one unit. The remaining critical habitat unit in the study area (Unit 9) is almost entirely contained within the Palassou Ridge Open Space (owned by the Open Space Authority) and Coyote Lake-Harvey Bear Ranch County Park.

almost entirely within Henry W. Coe State Park (94%), so the unprotected area may or may not be incorporated into the Reserve System (for this analysis, it is assumed to not be incorporated). Land acquisition will also occur within Unit 7 along lower San Felipe Creek and along Coyote Ridge, protecting up to 7 known occurrences. By bringing most of Joseph D. Grant County Park into the Reserve System (**Table 5-5**), protection and management is enhanced within much of Unit 6 (Grant Park supports up to 14 known occurrences, most of which would be brought into the Reserve System). Another connection will be protected between Alum Rock Park and the Blue Oak Ranch in the northeastern part of the study area (Coyote-7 and Alameda-1). Land acquisition in this area would protect a small portion of Critical Habitat Unit 5 and one known occurrence. Additional populations are likely to be found in this area due to a high density of ponds and a high concentration of known occurrences nearby on existing open space.

The Santa Cruz foothills are another area where acquisition will benefit the California tiger salamander. Though salamander densities are low in the Santa Cruz Mountains when compared to the Diablo Range, protecting the remaining breeding and upland habitat is important in order to retain genetic diversity among the populations in the study area. Retaining connectivity between Uvas Reservoir and Calero County Park would benefit many species, including the California tiger salamander. Acquisitions west of Calero Reservoir will buffer California tiger salamander habitats against urban development in southern San José and also protect the only piece of Critical Habitat Unit 8 that falls outside of Calero County Park. By bringing a portion of Calero County Park into the Reserve System (**Table 5-5**), protection and management is enhanced within the rest of Unit 8. Land acquisition in this area also protects two known occurrences of the species.

Acquisitions targeted north of Gilroy would entirely protect Critical Habitat Unit 10b[31], including up to three known occurrences. Substantial land acquisition in the Santa Cruz Mountains at the southern end of the study area (Uvas-5 and 6) would protect large stands of annual grassland (i.e., suitable upland habitat), a high density of ponds (i.e., suitable breeding habitat), and up to four known occurrences.

To ensure habitat connectivity within the study area the Implementing Entity will also protect modeled upland habitat between existing ponds and wetlands to provide a linked matrix of pond, wetland, and upland habitat as part of the Reserve System (LAND-G2, LAND-OC1, LAND-OC2, LAND-OC3, LAND-OC4, LAND-OC5). Acquisition will be prioritized to retain or improve habitat connectivity between breeding California tiger salamanders in the Santa Cruz foothills and in the Diablo Range. To accomplish this, the Implementing Entity will acquire land near the Santa Teresa Hills and Tulare Hill as well as areas along the Pajaro River south of Gilroy (LAND-WP7). The Implementing Entity will create at least 20 acres of ponds at 40 locations to increase available habitat and enhance connectivity among existing ponds and wetlands within the Reserve System (POND-9). Pond creation will occur regardless of the level of impacts on

[31] Unit 10a encompasses many small parcels that are not feasible to acquire at this time.

pond habitat. The purpose is to contribute to the recovery of the California tiger salamander in the study area. In addition to this pond creation the Implementing Entity will create ponds lost to covered activities, in-kind within the Reserve System, at a ratio of 1-acre of conservation to 1-acre of impact (1:1) (estimated to be 52 acres) (POND-10). An estimated 72 acres of ponds will be created to mitigate this impact (**Tables 5-13 and 5-21**). The total allowable impact on California tiger salamander modeled breeding habitat during the permit term is 77 acres of permanent impacts and 14 acres of temporary impacts, for a total of 91 acres (**Table 4-4**). To offset these impacts, a minimum of 195 acres of modeled breeding habitat will be protected and managed as part of the Reserve System to offset these impacts (**Table 5-17**). To achieve the biological goal for the California tiger salamander, acquisition of wetlands and ponds will be prioritized by: (1) sites with documented records of breeding California tiger salamander, (2) sites with known occurrences, though not necessarily breeding, and (3) sites without known occurrences of California tiger salamander but with pond turtle habitat and known occurrences of other covered species.

Within the Reserve System the Implementing Entity will restore 20 acres of perennial wetlands and create 20 acres of ponds (in 40 locations) (**Tables 5-13 and 5-21**) in areas within the typical dispersal distance of known breeding sites to create new breeding opportunities for this species (POND-7, POND-8, POND-9) (**Appendix D**). These wetlands and ponds will contribute to the recovery of the species while additional wetlands and ponds will be created to replace those lost to covered activities. See Section 5.3.7 *Wetland and Pond Conservation and Management* for details on restoration. This will further serve to reduce habitat fragmentation and promote genetic exchange within the population. The locations selected for wetland restoration and pond creation will be determined on the basis of physical processes, including hydrologic, geomorphic, and soil conditions to ensure that successful restoration or creation can occur and be self-sustained.

Management Techniques and Tools

In order to increase the habitat quality of modeled upland habitat the Implementing Entity will continue or introduce livestock grazing within grassland communities in the Reserve System in a variety of grazing regimes (GRASS-1, LM-11). Other techniques that will be employed to reduce nonnative vegetation and increase the quality of upland habitat for California tiger salamander include prescribed burns (GRASS-2) and the selective application of herbicides or other treatments (e.g., hand or mechanical removal) to reduce the biomass of nonnative vegetation and increase the success of native vegetation (LM-14). To further increase the quality of modeled upland habitat, native grasses will be planted around the perimeter of ponds and wetlands (POND-3).

Fencing that allows for covered species passage will be installed on portions of ponds and wetlands to reduce grazing pressure and feral pig access to provide vegetated refuge sites for native amphibians (POND-1). If entire ponds or wetlands need to be fenced, alternate water sources will be provided for livestock. These fences will also serve to protect breeding habitat from destruction from feral pigs. Additional measures will be implemented like trapping, hunting or other control methods, to reduce the feral-pig when feral pigs are hindering the Implementing Entity's ability to achieve the biological goals and objectives of the Plan (LM-12).

The Implementing Entity will increase the quality of modeled breeding habitat within the permit area by periodically clearing vegetation or removing sediment (POND-4) to create a variety of microhabitats within a single pond or wetland. This will provide shallow areas for California tiger salamander larvae while also accommodating other native aquatic species (POND-13). The Implementing Entity will also reduce nonnative predators (bullfrogs, invasive fish). It will use a variety of management techniques, which include habitat manipulation (e.g., periodic draining of ponds and other wetlands), trapping, hand capturing, and electroshocking to reduce nonnative predator populations (LM-13). Other techniques may be employed upon the approval of the USFWS and CDFG. New ponds will be designed to rely on passive management (e.g., dry on their own periodically), minimizing the need for artificial draining, or minimal management (e.g., stock pond dams fitted with drainage structures).

Threats and Uncertainties

Although expected, it is uncertain whether acquiring and managing land to favor California tiger salamander will ultimately result in the species expanding its range within the study area. One limiting factor might be the presence of fossorial rodents (e.g., California ground squirrels) in upland habitats. California tiger salamanders depend on the underground refugia provided by these burrowing mammals, and without them, upland habitats are less suitable. In general, where burrowing rodents are lacking in the ecosystem it is due to human-caused eradication, but in some cases other environmental factors may influence whether fossorial rodents are present (e.g., soil, slope, water table). In addition, there may be cases where a portion of potential upland habitat is in a parcel adjacent to an acquired parcel containing potential breeding habitat. These factors will be considered when adding lands to the Reserve System to contribute to the recovery of California tiger salamander.

Since this Plan will both increase the connectivity between breeding sites and increase the frequency of surveys in the permit area it also has the potential to facilitate the spread of detrimental environmental factors (e.g., chytrid fungus, nonnative predators). To minimize this impact, Condition 4, *Stream Avoidance and Minimization for In-Stream Projects,* and Condition 12, *Wetland and Pond Avoidance and Minimization*, outline measures to be used by anyone working or studying in aquatic habitats. If ponds, wetlands, and the native amphibian populations that they support, become infected with chytrid fungus or other diseases, the Implementing Entity will use the best scientific information available to manage and stop the spread of the epidemic (STUDIES-7). Further, the Implementing Entity will conduct a risk assessment, using the best information available, when siting California tiger salamander breeding habitat to determine the risk of increasing the nonnative predator population (i.e., potential of bullfrog colonization of the new breeding site).

Hybridization with Nonnative Salamanders

Barred salamander (*Ambystoma tigrinum mavortium*) is native to parts of Texas, eastern New Mexico, Oklahoma, Kansas, Nebraska, eastern Wyoming, and Colorado. It has been found in isolated locations throughout much of California, including Santa Clara County. The barred salamander is much larger than the California tiger salamander (it is the second largest salamander in the United States) and exhibits different behavior and life-history traits than the California tiger salamander. Native California tiger salamanders and introduced barred tiger salamanders are capable of inter-breeding (hybridizing) and have been hybridizing for 50–60 years (Fitzpatrick and Shaffer 2007). This hybridization is a major threat to California tiger salamanders.

Barred tiger salamander adults retain juvenile traits such as gills when they breed in aquatic habitats. These individuals, called "paedomorphs," provide the opportunity to readily distinguish barred salamanders and hybrids from native California tiger salamanders in breeding ponds and wetlands. Hybridization and introgression between the California tiger salamander and the barred tiger salamander is most likely occurring at many breeding sites throughout Santa Clara County, especially in the southern portion of the county (e.g., Bluestone Lake, North Fork Pacheco Creek) at areas located within close proximity to introduction sites (**Appendix K** *California Tiger Salamander Hybridization*).

Appendix K provides a management, monitoring, and adaptive management strategy for California tiger salamanders and hybrids. Key components of the strategy include management, public education, outreach, and targeted studies in close coordination with the Wildlife Agencies.

The initial management strategy for hybrids will focus on restoring and maintaining wetland and pond conditions within the Reserve System that favor California tiger salamanders. Perennial breeding sites studied in the hybrid zone often contained paedomorphic tiger salamanders, relative to more seasonal aquatic sites like vernal pools (Fitzpatrick and Shaffer 2004). Therefore, initial restoration actions will target sites where paedamorphs have been observed because presence of paedamorphs would indicate presence of nonnative alleles in the tiger salamander population. Since different individual tiger salamanders are expected to return to breeding ponds every year, these targeted perennial ponds will be periodically drained to control nonnative introductions. The adaptive management process will be used to adjust monitoring and management as described in **Appendix K**.

New nonnative salamander introductions are caused by humans, and therefore could be decreased with a public education campaign. Public education will be conducted to inform the public that the use of any salamander as bait in the State of California is illegal (POND-12). The Implementing Entity will also conduct education and outreach to pond landowners, provide technical assistance, and offer financial and regulatory (Safe Harbor Agreement) incentives to private landowners to restore, create, and maintain breeding habitat conditions on their land that favor native California tiger salamanders (POND-11). Finally, the Plan will contribute toward research to determine the distribution of, and ecological effects resulting from, introgression and interbreeding of native and nonnative tiger salamanders (e.g., effects due to competition [lower growth rates, adult survival]; effects due to predation; effects due to reduced fitness of hybrids) and effect on covered amphibians and reptiles (STUDIES-8). These studies will be coordinated with, and be complementary to, similar studies conducted outside of the purview of this Plan. With Wildlife Agency approval, the Implementing Entity will incorporate specific management prescriptions supported by this research, and research conducted by others, in the applicable reserve unit management plans.

5.4.3 California Red-Legged Frog

Biological Goals and Objectives

The Implementing Entity will support viable populations and contribute to the regional recovery of the California red-legged frogs by increasing the number of individuals and expanding the distribution of this species within the Reserve System. This will be accomplished by protecting land through fee title purchase or by obtaining easements that are managed as part of the Reserve System.

Within the Reserve System the amount and quality of California red-legged frog habitat will be increased and improved through restoration, enhancement and creation of breeding and upland habitat. The Reserve System will be designed to maintain connectivity between breeding habitat and upland habitat and to provide essential short-term upland refugia as well as dispersal habitat by protecting landcover types that provide breeding habitat like ponds and wetlands and upland refugia and dispersal habitat like grassland, oak woodland, riparian, or chaparral. Acquisition, enhancement, and restoration/creation conservation actions identified for grasslands (see Section 5.3.3 *Grassland Conservation and Management*), chaparral and coastal scrub (see Section 5.3.4 *Chaparral and Northern Coastal Scrub Conservation and Management*), oak woodlands (see Section 5.3.5 *Oak and Conifer Woodland Conservation and Management*), riparian forest and scrub (see Section 5.3.6 *Riverine and Riparian Forest and Scrub Conservation and Management*), and wetlands and ponds (see Section 5.3.7 *Wetland and Pond Conservation and Management*) will benefit California red-legged frog through upland, movement, breeding, foraging and year-round habitat conservation and management.

In addition, the Reserve System will link California red-legged frog habitat within the study to areas important to the species outside of the study area, like San Francisco Public Utilities Commission Alameda Watershed properties in Santa Clara and Alameda counties and the Soap Lake region in San Benito County.

Habitat Acquisition, Restoration, and Creation

There are 341,773 acres of California red-legged frog modeled habitat (primary and secondary habitat) within the study area. A total of 101,164 acres (30%) of that modeled habitat are located in Type 1, 2, or 3 open space with 46,253 acres (14%) permanently protected as Type 1 open space. The Plan proposes to acquire a minimum of 31,300 acres of modeled habitat for the Reserve System. In addition, 11,930 acres of modeled habitat for California red-legged frog will be added to the Reserve System from existing open space. These acquisitions and additions will increase the proportion of protected habitat in the study area to about 26% in Type 1 open space and 39% in Type 1, 2, and 3 open space (**Table 5-17**). The Reserve System will include 1,430 acres of modeled primary habitat and 41,800 acres of modeled secondary habitat.

The Implementing Entity will protect (through acquisition or easement) and enhance a minimum of 50 acres of ponds that support or have the potential to support breeding California red-legged frogs. In addition, a minimum of 20 acres of ponds will be created to support aquatic covered species and tri-colored blackbird. Up to 104 acres of ponds will be protected and enhanced and up to 72 acres of ponds will be created if all estimated impacts occur (**Tables 5-13 and 5-21**). Similarly, the Implementing Entity will protect and enhance a minimum of 10 acres of perennial wetlands and up to 50 acres of perennial wetlands that either support or have the potential to support aquatic covered species and tri-colored blackbird. A minimum of 20 acres of perennial wetlands will be restored to support aquatic covered species and tri-colored blackbird. Up to 45 acres of perennial wetlands will be restored if all estimated impacts occur. In addition, a minimum of 100 miles of streams will be protected that either support or have the potential to support breeding California red-legged frogs, breeding foothill yellow-legged frogs, and/or foraging/basking western pond turtles. A minimum of 1 mile of streams will be restored that have the potential to support these same species. Up to 10.4 miles of streams will be restored if all estimated impacts occur. Further, it will protect grassland, oak woodland, riparian, or chaparral habitat within the California red-legged frog modeled habitat (*California red-legged frog*, **Appendix D**) to provide upland refugia and dispersal opportunities for the species. To maximize benefits to the species the Implementing Entity will target acquisitions in the East San Francisco Bay Recovery Unit (U.S. Fish and Wildlife Service 2002) (LAND-WP4) and in areas adjacent to existing open space with known occurrences of California red-legged frog, such as Joseph D. Grant County Park or Palassou Ridge Open Space Preserve (LAND-WP5).

In the Diablo Range, land will be acquired along Coyote Ridge to ensure that an area with high concentrations of California red-legged frogs is protected. Up to 15 known occurrences (breeding sites or movement locations) on Coyote Ridge could be preserved. The Implementing Entity will also target acquisition of parcels northeast of Alum Rock Park to connect Alum Rock Park and Cherry Flat Reservoir (Alameda-1 and Coyote-7) with protected open space outside the study area (i.e., San Francisco Public Utilities Commission Alameda Watershed). This will also protect suitable habitat for this species and up to one known occurrence in Critical Habitat Units STC-1 and STC-2 (75 FR 12815 12959). Incorporation of most of Joseph Grant County Park into the Reserve System will provide substantial opportunity to enhance suitable and occupied breeding habitat (**Table 5-5**). The portion of Grant Park proposed for the Reserve System supports at least two known occurrences of the species.

Portions of the critical habitat units have already been preserved through acquisition and conservation easements (**Figure 4-5**). **Table 5-21** shows that 24% of all critical habitat in the study area is currently protected as Type 1 open space and another 14% is located in open space Types 2–4. However, this leaves 62% of critical habitat outside of any type of open space. The Habitat Plan anticipates protecting an estimated 14% of all critical habitat in the study area within the Reserve System, including existing parklands that will be incorporated into the Reserve System.

Additional target areas of land acquisition that will benefit this species and support implementation of the Recovery Plan include the area between Henry W. Coe State Park and the Soap Lake region of San Benito County (LAND-WP5). This area is important for many covered species and will help retain a connection between breeding populations in the state park and in areas outside of the study area. Although there are no known occurrences in this area due to a lack of survey effort, there is a high density of ponds, many of which are expected to be suitable breeding habitat.

Land acquisition in the Pacheco Watershed will protect high densities of suitable ponds and other wetlands, including up to three known occurrences of California red-legged frogs. Protection of the creek and the associated riparian areas will increase the level of protection of breeding and movement habitat in this part of the study area. Further, this area likely provides and important movement corridor between the Soap Lake region of San Benito County to areas northeast in Santa Clara County such as Romero Ranch and Pacheco State Park.

By the time the Reserve System is fully acquired (which will be at or before Year 45), a minimum of 40% of all ponds and wetlands in each of the federal Recovery Units 4 and 6 in the Reserve System will be or will have been occupied by California red-legged frog, as described in the Section 5.3.1 *Land Acquisition and restoration Actions* subheading *Acquisition of Occupied Habitat for Select Wildlife Species*. By Year 30, at least 35% of all ponds and wetlands in each of the federal Recovery Units 4 and 6 will be occupied or will have been occupied by the species.

There is no designated critical habitat for California red-legged frog in the Santa Cruz Mountains. However, land acquisition in this area will protect a substantial amount of suitable breeding, aestivation, and movement habitat. For example, land acquisition around Calero Lake, Chesbro Reservoir, and Uvas Reservoir will protect suitable habitat, some of which is within a mile of known occurrences. Land acquisition in the south end of the study area will protect up to four known occurrences and a high density of ponds and other wetlands suitable for California red-legged frog breeding.

To achieve the biological goal for the California red-legged frog, acquisition of wetlands, ponds, and streams will be prioritized by: (1) sites with documented records of breeding California red-legged frog, (2) sites with known occurrences, though not necessarily breeding, and (3) sites without known occurrences of California red-legged frogs but with pond turtle habitat and known occurrences of other covered species.

The Implementing Entity will create at least 20 acres of ponds at 40 locations to increase available habitat and enhance connectivity among existing ponds and wetlands within the Reserve System (POND-9). Pond creation will occur regardless of the level of impacts on pond habitat by covered activities. The purpose of this habitat creation is to contribute to the recovery of the California red-legged frog in the study area. In addition to pond creation the Implementing Entity will create ponds lost to covered activities, in-kind within the Reserve System, at a ratio of 1-acre of creation to 1-acre of impact (1:1) (estimated to be 52 acres) (POND-10). Together with the minimum creation requirements, up to 72 acres of ponds (minimum of 20 acres plus 52 acres to offset impacts) will be created within the Reserve System (**Tables 5-13 and 5-21**).

The Implementing Entity will also restore at least 20 acres of perennial wetlands within the Reserve System. All of this will be characterized as coastal and valley freshwater marsh (POND-6) and will be restored regardless of the level of impacts to wetlands in the study area from covered activities. In addition to those 20 acres, the Implementing Entity will restore impacted perennial freshwater wetlands "in-kind" at a ratio of one-acre of conservation to one-acre of impact (1:1) (POND-7) (estimated to be 25 acres). The Implementing Entity will also restore impacted seasonal wetlands "in-kind" at a ratio of two-acres of conservation to one-acre of impact (2:1) (POND-8) (estimated to be 30 acres). Restoration will be carried out in areas that will increase available habitat and enhance connectivity among existing ponds and wetlands within the Reserve System.

Management Techniques and Tools

Since the California red-legged frog utilizes pond and wetland habitats, as well as riverine habitats within the study area, management actions that enhance and restore those natural communities will benefit this species. In addition, many of the management actions outlined for the California tiger salamander will benefit the California red-legged frog. For a description of the management techniques that will be implemented to increase the quality and quantity of California red-legged frog habitat within the Reserve System refer to Section 5.4.2, *California Tiger Salamander* subheading *Management Techniques and Tools*, above. In addition, the Implementing Entity may utilize translocation of California red-legged frog to help establish new populations in the study area. This activity will only be undertaken with the approval of the Wildlife Agencies, and when biologically appropriate and necessary to meet biological goals and objectives of the Plan.

For a general description of pond, wetland, and riverine restoration, creation, and management refer to Sections 5.3.6 *Riverine and Riparian Forest and Scrub Conservation and Management* and 5.3.7 *Wetland and Pond Conservation and*

Management, above. All management actions in this Plan are consistent with management guidelines in the species' Recovery Plan (U.S. Fish and Wildlife Service 2002).

Uncertainties and Threats

Since this Plan will both increase the connectivity between breeding sites and increase the frequency of surveys in the permit area it also has the potential to facilitate the spread of detrimental environmental factors (e.g., chytrid fungus, nonnative predators). If ponds, wetlands, and the native amphibian populations that they support, become infected with chytrid fungus or other diseases, the Implementing Entity will use the best scientific information available to manage and stop the spread of the epidemic (STUDIES-7). Further, the Implementing Entity will use the best information available to determine whether the benefits of creating more California red-legged frog breeding habitat in an area outweighs the risk of increasing the nonnative predator (i.e., bullfrogs) population along with it.

5.4.4 Foothill Yellow-Legged Frog

Biological Goals and Objectives

The goal of the Implementing Entity will be to maintain or increase the population of foothill yellow-legged frog in the study area. The objectives toward meeting that goal are to acquire, through fee title or conservation easement, streams that have or historically had perennial flows. Additionally, the Implementing Entity will enhance or restore perennial streams to provide higher quality habitat for all riverine species, including foothill yellow-legged frog. Acquisition, enhancement, and restoration/creation conservation actions identified for streams and riparian forest and scrub (see Section 5.3.6 *Riverine and Riparian Forest and Scrub Conservation and Management*), and redwood forests (see Section 5.3.5 *Oak and Conifer Woodland Conservation and Management*) will benefit foothill yellow-legged frog through movement, foraging, and year-round habitat conservation and management.

Acquisition, Restoration, and Enhancement

There are 690 miles of foothill yellow-legged frog modeled primary and secondary habitat within the study area. A total of 222 stream miles (32%) of modeled primary and secondary habitat are located on Type 1, 2, or 3 open space with 119 stream miles (17%) permanently protected as Type 1 open space. The Plan proposes to acquire a minimum of 80 miles of primary and secondary modeled habitat for the Reserve System. In addition, 24 miles of primary and secondary modeled habitat will be added to the Reserve System from existing open space. These acquisitions and additions will increase the proportion of total protected primary and secondary modeled habitat in the study area to about 32% in Type 1 open space and 44% in Type 1, 2, or 3 open space (**Table 5-17**).

The Implementing Entity will target acquisition of streams that currently have, or historically had, perennial flows and cobblestone substrate (LAND-R5) along with intermittent and ephemeral streams that connect to those perennial streams. A recent study in Tehama County has revealed that foothill yellow-legged frogs utilize perennial systems primarily but also use associated intermittent and ephemeral streams within the same watershed (Bourque 2008). These stream reaches will be located along:

- Uvas/Carnadero Creek above Uvas Reservoir,
- small creeks above Calero Reservoir,
- Alamitos and Guadalupe Creeks upstream and outside of urban San José,
- Llagas Creek above Chesbro Reservoir,
- San Felipe Creek, above Anderson Reservoir,
- Uvas Creek below Uvas Reservoir,
- Little Arthur Creek,
- Upper Penitencia Creek.

Occupied habitat for foothill yellow-legged frog will be protected in the Reserve System in at least four of the watersheds in **Figure 3-6**, in both the Diablo Range and in the Santa Cruz Mountains (as described in the Section 5.3.1 *Land Acquisition and Restoration Actions* subheading *Acquisition of Occupied Habitat for Select Wildlife Species*). The Reserve System is expected to protect at least four known occurrences of the species, three on Llagas Creek above Chesbro Reservoir, and one on San Felipe Creek above Anderson Reservoir. Additional occurrences may be found in the Reserve System on Upper Penitencia Creek, Uvas Creek below Uvas Reservoir, and Little Arthur Creek due to their proximity to known occurrences in the same stream systems and the lack of survey effort for the species in those areas. To achieve the biological goal for the foothill yellow-legged frog, acquisition of streams will be prioritized by: (1) sites with documented records of breeding foothill yellow-legged frog, (2) sites with known occurrences, though not necessarily breeding, and (3) sites without known occurrences of foothill yellow-legged frogs but with pond turtle habitat and known occurrences of other covered amphibian species.

The Implementing Entity will restore a minimum of 1 mile of stream to support breeding yellow-legged frogs, breeding California red-legged frogs, and/or foraging/basking western pond turtles regardless of the level of impact (**Table 5-13**). Up to 10.4 miles of stream will be restored if all estimated impacts occur (**Table 5-13**). This could include the perennial stream reaches mentioned above. For foothill yellow-legged frogs this restoration will involve adding sufficient sediment to stream courses so that sand bars will form to create egg laying substrate, or adding large rocks to the stream course for the same purpose. Management will include selectively applying herbicides or other treatments to control nonnative invasive vegetation along creek corridors (LM-14) that might inhibit sediment movement and restrict the creation of egg laying habitat.

Management Techniques and Tools

Foothill yellow-legged frogs require streams with fast moving water and cobblestone substrate. Channel rehabilitation will increase the amount of this type of habitat that is available in the study area. The Implementing Entity will replace concrete, earthen or other engineered channels to restore floodplain connectivity (STREAM-4, STREAM-5). This gives the frog some areas of slower flow or other a natural habitats adjacent to the stream, in which to take refuge during high water. It also allows the streams to form gravel bars, behind which this species often lays eggs. To further enhance these rehabilitated channels the Implementing Entity will plant and/or seed in native understory and overstory riparian vegetation within 15 feet of the edge of the low-flow channel to create structural diversity, provide overhead cover, and moderate water temperature (STREAM-2). This can be done in other reaches as well, where there is an unnatural void in riparian vegetation. In all streams mentioned above there will be opportunities to increase the amount of cobblestone substrate by actually adding rocky substrate to the stream channel (STREAM-8). Gravel augmentation will avoid the breeding season. This management action will be applied to areas close to known occurrence(s) of foothill yellow-legged frog or immediately upstream or downstream of known occurrences or other high quality foothill yellow-legged frog breeding habitat.

The Implementing Entity may utilize translocation of foothill yellow-legged frog to help establish new populations in the study area. This activity will only be undertaken with the approval of the Wildlife Agencies, and when biologically appropriate and necessary to meet biological goals and objectives of the Plan.

Threats and Uncertainties

The biggest threat to foothill yellow-legged frog is continued alteration of the hydroperiod of streams within the study area. Managing for this species downstream of reservoirs in northern watersheds is difficult because flows are controlled as part of a water delivery system to the City of San José. Restoration and management efforts will always be subject to whether there is enough water to support perennial flows in these watersheds. In the southern watershed there are fewer limitations on how and when the water is released out of reservoirs. Still managing riverine systems downstream of reservoirs is not a guaranteed solution every year. Augmenting streams with cobblestone substrate to increase the amount of breeding habitat for this species is a short-term solution unless accompanied by complimentary land management practices upstream that can sustain the flows and sediment delivery. If there are uncontrolled sources of sediment upstream then the habitat quality will continue to be diminished, eggs could be silted in, or egg laying habitat could be removed as the stream changes course in reaction to high sediment deposition. If the stream is not in a relatively natural condition then flows during high water events will continue to degrade the habitat even after cobblestone substrate is added.

Global climate change could impact this species through changes in the amount of precipitation and therefore the amount of surface water in occupied streams. Areas that receive less rainfall will support less high-quality habitat for foothill yellow-legged frog in the future. One benefit of the Reserve System is that species will have more ability to move away from areas that are less suitable and into areas that are more suitable over the long-term. Protecting small, isolated breeding locations for this species might not adequately protect the species over the long term if rainfall patterns change stream hydrology.

Watersheds with a high level of agricultural production were associated with the decline of the species, due to airborne agro-chemicals (Lind 2005). In general, the Reserve System is far from agricultural production that uses pesticides, raising the chance of achieving the biological goals and objectives for this species.

5.4.5 Western Pond Turtle

Biological Goals and Objectives

The Implementing Entity will support viable populations and contribute to the regional recovery of the western pond turtle by maintaining or increasing the number of individuals and expanding the distribution of this species within the Reserve System. This will be accomplished by protecting land through fee title purchase or by obtaining easements that are managed as part of the Reserve System. Within the Reserve System the amount and quality of western pond turtle habitat will be increased and improved through restoration, enhancement, and creation of basking habitat and breeding sites. Acquisition, enhancement, and restoration/creation conservation actions identified for grasslands (see Section 5.3.3 *Grassland Conservation and Management*), chaparral and coastal scrub (see Section 5.3.4 *Chaparral and Northern Coastal Scrub Conservation and Management*), oak woodlands (see Section 5.3.5 *Oak and Conifer Woodland Conservation and Management*), riparian forest and scrub (see Section 5.3.6 *Riverine and Riparian Forest and Scrub Conservation and Management*), and wetlands and ponds (see Section 5.3.7 *Wetland and Pond Conservation and Management*) will benefit western pond turtle through movement, breeding, foraging and year-round habitat conservation and management.

Habitat Acquisition, Restoration, and Creation

There are 314,916 acres of western pond turtle modeled habitat (primary and secondary) within the study area. A total of 98,060 acres (31%) of that modeled habitat are located in Type 1, 2, or 3 open space with 44,967 acres (14%) permanently protected as Type 1 open space. The Plan proposes to acquire a minimum of 27,000 acres of modeled habitat for the Reserve System. In addition, 11,900 acres of modeled habitat will be added to the Reserve System from existing open space. These acquisitions and additions will increase the proportion of protected modeled habitat in the study area to about 27% in Type 1 open space and about 40% in Type 1, 2, or 3 open space (**Table 5-17**).

The Implementing Entity will protect, through acquisition or easement, and enhance a minimum of 50 acres of ponds, 10 acres perennial freshwater wetlands, and 100 miles of stream that either support or have the potential to support covered aquatic species, including western pond turtle. Up to 104 acres of ponds and 50 acres of perennial freshwater wetlands will be protected and enhanced if all estimated impacts (LAND-WP2a, LAND-WP2b, LAND-WP3a, LAND-WP3b, LAND-WP6a, LAND-WP6b). To achieve the biological goal for the western pond turtle, acquisition of wetlands, ponds, and streams will be prioritized by: (1) sites with documented records of breeding western pond turtles, (2) sites with known occurrences, though not necessarily breeding, and (3) sites without known occurrences of western pond turtle but with pond turtle habitat and known occurrences of other covered species. Most of the land acquisition that will benefit western pond turtle will occur along the Pacheco Creek riparian corridor and between Henry W. Coe State Park and the Soap Lake region of San Benito County. Additional acquisitions west of Chesbro reservoir and west and east of Calero Reservoir will also benefit this species, where both ponds will be acquired as well as perennial reaches of streams.

During the course of Plan implementation, the Implementing Entity will protect and enhance a minimum of 100 miles of streams and 250 acres of riparian forest and scrub to benefit aquatic covered species and least Bell's vireo. Up to 592 acres of riparian forest and scrub (including California alluvial sycamore woodland) will be protected and enhanced if all estimated impacts occur. In addition, a minimum of 1 mile of stream and 50 acres of riparian forest and scrub (including California alluvial sycamore woodland) will be restored. Up to 10.4 miles of streams and 353 acres of riparian forest and scrub will be restored if all estimated impacts occur (STREAM-4, STREAM-5).

Ponds that are lost to covered activities will be created at a ratio of 1:1 (estimated at 52 acres) within the Reserve System in (POND-10) (**Table 5-12**). In addition, the Implementing Entity will create a minimum of 20 acres of new ponds at approximately 40 locations to create new breeding opportunities for aquatic covered species and tri-colored blackbird (POND-9). The intent of these new ponds is to contribute to the recovery of the species beyond the replacement of pond habitat lost to covered activities.

By the time the Reserve System is fully acquired (which will be at or before Year 45), a minimum of 25% of all ponds and wetlands in the Reserve System will be or will have been occupied by western pond turtle, as described in the Section 5.3.1 *Land Acquisition and Restoration Actions* subheading *Acquisition of Occupied Habitat for Select Wildlife Species*. By Year 30, at least 20% of all ponds and wetlands will be occupied or will have been occupied by the species.

Management Techniques and Tools

For a detailed discussion of the management techniques that will be implemented to increase the quality and quantity of western pond turtle habitat within the study area refer to Section 5.3.6 *Riverine and Riparian Forest and Scrub Conservation Management* and Section 5.3.7 *Wetland and Pond Conservation Management*.

In addition, the Implementing Entity will install artificial basking substrate and add woody debris to ponds that otherwise lack suitable basking sites to enhance habitat for western pond turtles (POND-2). Woody debris and artificial basking substrate enhance habitat by providing areas for turtles to thermoregulate, an essential biological function. Basking platforms might also be used when natural debris in not suitable. Basking platforms differ from woody debris in that they can be anchored, are durable, and will not be submerged by rising water levels. The basking platforms and added woody debris will also facilitate species-level monitoring by providing a consistent and stable point at which to count pond turtles. Populations of nonnative competitors such as red-eared sliders will also be reduced (Objective 19.3).

The Implementing Entity may utilize translocation of western pond turtle to help establish new populations in the study area. This activity will only be undertaken with the approval of the Wildlife Agencies, and when biologically appropriate and necessary to meet biological goals and objectives of the Plan.

Threats and Uncertainties

A lack of nesting sites is likely the limiting factor for this species in the study area. Identifying and protecting potential nesting habitat is important to ensure recruitment of juveniles into the population (STUDIES-9). In order to accomplish that, the Implementing Entity will focus on protecting buffers around aquatic habitats that might support nesting pond turtles. That in turn should increase the productivity of this species during the permit term, though there is some uncertainty that an increase in productivity will occur. Continued alteration of streams and wetlands and continued disconnection of streams and their floodplains is the greatest threat to pond turtles. Adequate time will be given to determine whether newly created habitat is successfully replacing habitat that is lost to covered activities.

5.4.6 Western Burrowing Owl

A complete conservation strategy for western burrowing owl, including background information, conservation region descriptions, and expanded biological goals and objectives discussion, is provided as **Appendix M**, *Western Burrowing Owl Conservation Strategy*. A summary of this strategy is provided below. Because of the unique nature of the conservation strategy for this species, this section is organized differently than the rest of the covered species sections in this chapter.

Background

Nesting burrowing owls in the greater San Francisco Bay Area, and the South Bay area in particular, are a dwindling resource. In the early 1990s there were an estimated 150–170 breeding pairs in the San Francisco Bay Area (DeSante and Ruhlen 1995; DeSante et al. 1993). It was estimated that these numbers represented a 53% decline from the previous census period of 1986–1990 (DeSante et al. 1997) and more recent numbers indicate that, if anything, the downward trend is increasing. In those estimates it was assumed that 75% of the San Francisco Bay Area burrowing owl population occurred in Santa Clara County and nearly all of those owls were congregated around the southern edge of the San Francisco Bay (DeSante et al. 1997). Surveys in the early 1990s revealed that about a third (43–47 pairs) of Santa Clara County breeding pairs occurred inside what is now the Santa Clara Valley Habitat Plan study area (Albion Environmental Inc. 2000).

Overview of Burrowing Owl Conservation Strategy

The Plan proposes to undertake an aggressive suite of measures aimed at reversing the declining trend of the burrowing owl population in Santa Clara County. The goal of the Plan is to establish a burrowing owl population in the study area and the expanded study area (**Figure 5-10**) that is first stable, then increasing over time, while accounting for normal fluctuations in population levels. The general approach will be to increase the numbers, distribution, and connectivity of burrowing owl colonies in the permit area. This will be accomplished by using a phased conservation approach, initially focusing efforts on areas within immediate flight distance from known colonies while gathering data to inform future efforts. Later phases, triggered as more resources are available and in response to initial results, will focus on lands further out to allow for growth in both numbers and range. Initial techniques will include data gathering and analysis to inform management decisions, utilizing current best management practices, testing newly proposed management techniques through pilot scientific studies, acquisition of existing and potential breeding and foraging areas, management (both permanent and temporary agreements) of burrowing owl habitat and, and population augmentation.

These measures will be applied in four burrowing owl conservation regions: North San José/Baylands, South San José, Morgan Hill, and Gilroy (**Figure 5-10**). Opportunities to conduct meaningful burrowing owl conservation inside the Habitat Plan study area are limited because the most effective conservation measures must take place in near proximity to the remaining burrowing owl occurrences. Since those occurrences are clustered around the southern part of the Bay and northern San José, there is little unused land available and that which is not built on has high land values. As a result the conservation focus for burrowing owls was expanded to include the entire Baylands region, in addition to the Habitat Plan study area (**Figure 5-10**).

Acquisition and permanent protection of land is generally infeasible in the areas most valuable for this species because of the limited availability of land and its high cost. What land is available and likely most suitable for the species is already publically owned. Therefore, to ensure enhanced management on sites to support the species and meet population growth goals, the Implementing Entity will either acquire in fee title, secure conservation easements, or secure management agreements. At least initially, limited burrowing owl habitat acquisition and/or management will occur along the southern edge of the study area and more limited conservation activities will occur in the two middle regions because of the current lack of occupied nesting burrowing owl colonies in these areas (**Figure 5-10**). If conservation actions in the North San José/Baylands region prove successful, it is reasonable to assume the nesting burrowing owl population will expand into suitable habitat in the South San José, Morgan Hill, and Gilroy regions. Management of overwintering habitat will also occur in the Reserve System.

Conservation targets for western burrowing owl that are based on habitat availability (similar to what was done for other covered wildlife species) are likely to be inadequate to ensure population recovery in the study area because of the relatively low existing population size. Instead, conservation targets for population size were developed. These population targets were then used to develop targets for the amount of habitat needed to support that population.

To determine the population target needed for burrowing owls in the Plan, a count-based population viability analysis (PVA) was used. This analysis was used to determine the probability of persistence of three burrowing owl nest colonies in the South Bay. This analysis was performed on the three largest remaining burrowing owl colonies in the South Bay Area (Moffett Airfield, San José International Airport, and Shoreline at Mountain View) using survey data of adult burrowing owls from the 11-year period of 1999–2009. These sites were chosen because they are the primary remaining population clusters and because data was available for the period of time recommended for the analysis (i.e., at least 10 years). The intent of the analysis was to quantify population size, trend, growth rate, and variance in the three burrowing owl colonies and to evaluate the probability of persistence of these colonies (individually and combined) during that 11-year period. It was assumed that the population performance at these three sites can be used as an index for population performance for burrowing owls in the Habitat Plan study area.

In order to develop a burrowing owl population size goal for the Habitat Plan, the annual population size of adult owls was artificially increased in a statistical model to determine the rate at which the numbers of adult burrowing owls at the three baseline colonies (San José International Airport, Moffett and Shoreline) would need to increase and over what period of time to change the PVA probability of extinction trend from a negative growth rate to a positive growth rate. It was determined that if currently measured population characteristics held true (i.e., growth rate and variance were constant) changing the overall number of adult burrowing owls in this type of model did not change the probability of persistence significantly (**Appendix N**). Instead, increasing the change of population persistence was best achieved by a steady increase in the number of adult burrowing owls. Therefore, for the purposes of this Plan, growth rate is a more correct predictor of persistence than an ultimate population size.

During 2009, there were 51 adult burrowing owls observed at the three reference nest colonies. Based on these numbers and the PVA, it was determined that in order to change the population trend in the South Bay from negative to positive within a 10-year time period, there would have to be an increase of three adult owls per year. A period of at least 10 years is also needed to allow time for collection of data at occupied nest sites in the permit area and integration of that data into the PVA model. To account for these factors and to provide additional time to achieve the population targets, the Plan has a goal to achieve a positive growth rate in the burrowing owl population in South Bay Population by Year 15.

The total population of burrowing owls in the South Bay is estimated at 70 adults (51 adults at the three reference sites plus 19 adults observed in 2008 in other parts of the study area). If three burrowing owls were recruited to the population every year for the permit term, an additional 150 adults would be added, for a total population size of 220 adults. The Habitat Plan would be responsible for 70% of this population growth (154 adults at the end of the permit term) based on its proportion of the South Bay and burrowing owl population. This equates to a land management need of 5,300 acres of occupied or potential nesting habitat (see **Appendix M** for calculations) in the permit area. Of the 5,300 acres, a minimum of 600 acres of occupied nesting habitat will be protected in fee title or conservation easement. Similar to the conservation strategy for other covered species, these lands will be under permanent management agreements administered by the Implementing Entity no later than Year 45. The Plan also provides a species-specific Stay-Ahead provision for the burrowing owl (see Section 8.6.1). Priority will be given towards management on occupied habitat (**Figure 5-11**), followed by potential nesting habitat (see Chapter 4, Section 4.6.4 *Western Burrowing Owl* for habitat definitions).

Specific burrowing owl conservation actions that would occur on the 5,300 acres of occupied and potential nesting habitat are grouped into three "tiers" of priority:

- **Tier 1 conservation actions** are designed to stabilize the existing population by protecting and/or managing occupied burrowing owl nesting habitat. Tier 1 actions may indirectly increase the numbers of owls in extant colonies. Tier 1 conservation actions will take place initially in the North San José/Baylands Region where owls currently occur. Tier 1 conservation actions will occur immediately upon Plan implementation.
- **Tier 2 conservation actions** are designed to facilitate growth and expansion of existing colonies, the number of colonies, and the range of the species in the permit area by managing potential burrowing owl nesting habitat in all portions of the permit area. Tier 2 conservation actions will also take place

immediately and will initially be implemented in the North San José/Baylands Region where owls currently occur.

- **Tier 3 conservation actions** consist of more experimental and active methodologies such as population augmentation and owl relocation within the permit area to increase owl numbers and expand distribution. Tier 3 actions will be implemented in response to population performance at the three index sites (Shoreline Park in Mountain View, San José International Airport, and Moffett Federal Airfield) but these actions could occur in any of the burrowing owl conservation regions. These actions will be coordinated with the Wildlife Agencies and will only be implemented upon their approval. Upon approval, these actions could occur immediately upon implementation of the Plan and are not dependent upon the grant awards.

Appendix M describes the specific conservation actions proposed for the western burrowing owl conservation strategy. Examples include:

- Protect existing colonies through fee title acquisition, purchase of a conservation easement, or management agreements (Tier 1).
- Increase survival rates at existing nest colonies through focused management actions (Tier 1).
- Survey all undeveloped parcels within 7.5-miles of documented nest colonies and complete an opportunities and constraints assessment of each for the potential of the site to function as a burrowing owl reserve (Tier 2).
- Employ population augmentation techniques to increase the local population size (Tier 3).

Biological Goals and Objectives

The Implementing Entity will work to increase the size and sustainability of the breeding and overwintering burrowing owl population and increase the distribution of breeding and overwintering burrowing owls in the permit area (**Figure 5-10**). This goal will be met by achieving a positive growth rate by Year 15 of the Plan using annual data for the San José International Airport, Moffett and Shoreline colonies or other colonies formed in the permit area. This will be accomplished by protecting land on the valley floor and in the Diablo Range in fee title purchase or by obtaining easements as part of the Reserve System, or through management agreements. Target areas will include modeled overwintering only, occupied nesting, and potential nesting habitat (LAND-G6, G7, and G8). As a result, nesting habitat will be protected or managed within four distinct geographical regions: North San José /Baylands, Gilroy, Morgan Hill, and South San José (**Figure 5-11**).

All sites protected within the Reserve System and on lands where management agreements exist will be enhanced to encourage the expansion of burrowing owls (GRASS-5, 6, 8, and 9). Acquisition, enhancement, and restoration conservation actions identified for grasslands (see Section 5.3.3 *Grassland Conservation and Management*), valley oak woodlands (see Section 5.3.5 *Oak and Conifer*

Woodland Conservation and Management), and seasonal wetlands (see Section 5.3.7 *Wetland and Pond Conservation and Management*) are intended to benefit western burrowing owl through breeding and foraging habitat conservation and management.

Habitat Acquisition and Enhancement

As indicated above, the Implementing Entity will manage a minimum of 5,300 acres for the western burrowing owl nesting habitat (occupied and potential) by Year 45. Of this acreage, a minimum of 600 acres of occupied nesting habitat must be protected in fee title or conservation easement in accordance to the rough proportionality provision for the burrowing owl, described in Section 8.6.1. For the remaining 4,700 acres, land acquisition (fee title or easement) or management agreements may be used. The Implementing Entity will prioritize land acquisition over management agreements. All 5,300 acres of western burrowing owl nesting habitat will be acquired or under a permanent management agreement by Year 45.

The 5,300 acres will include burrowing owl nesting habitat within 5 miles of the San José water Pollution Control Plant bufferlands, north of Highway 237 (LAND-G6) and burrowing owl nesting habitat within 5 miles of the San José International Airport or other important northern San José breeding sites (LAND-G7). Because the North San José/Baylands region is the most important for burrowing owl conservation and has the most conservation opportunities, a goal is set for 70% (3,700 acres) of the total land management commitment occurring in that region and the expanded permit area. Further, a recommended 15% (800 acres) of the total land managed would occur in the Gilroy region. The remaining 15% should remain flexible and could occur in any of the regions, but it is assumed that 5% (270 acres) occur in the South San José region and 10% (530 acres) occur in the Morgan Hill region.

Management agreements may be used in place of land acquisition on up to 4,700 acres, if the specified regional targets cannot be met through land acquisition. During the permit term, temporary management agreements may be put into place rather than permanent management agreements. Temporary management agreements (e.g., 10–20 year agreements as opposed to agreements in perpetuity) may be used to protect nesting habitat on areas not immediately planned for development as long as the amount of land permanently protected in fee title or conservation easement is consistent with the Stay-Ahead provision (Chapter 8, Section 8.6.1 *Stay-Ahead Provision*, subheading *Rough Proportionality and Stay-Ahead for the Burrowing Owl Conservation Strategy*). By Year 45 of the permit term, all management agreements must be permanent.

The management agreements must be legally binding documents to which the Wildlife Agencies are parties. Their establishment will follow a process similar to land acquisition described in Chapter 8, Section 8.6 *Land Acquisition*. The management agreements will be consistent with the land acquisition process; however, the Implementing Entity would work with the land owner to establish the management agreement rather than acquiring the land in fee title or with a conservation easement. The duration and management requirements will be agreed upon by all parties and specified in the management agreement document. For the permanent management agreements, management must be assured in perpetuity. For temporary management agreements, management must be assured for the duration of the agreement. As parties to the management agreements, the Wildlife Agencies will have review and approval authority.

Although the Implementing will protect and/or manage a minimum of 5,300 acres no later than Year 45 of the permit term, the preliminary goals described above regarding the distribution of these lands in the amongst the burrowing owl conservation zones may shift during the permit term upon close coordination with the Wildlife Agencies. However, the total amount of lands managed for the burrowing owl will be maintained or increase until the goals of the Plan are achieved. In other words, parcels where management for burrowing owls is discontinued need to be replaced prior to discontinuation of management with parcels of equal or better habitat value and size. The Implementing Entity will track management agreements to ensure the amount of managed lands for the burrowing owl at no time decrease during the permit term.

To ensure the burrowing owl conservation strategy's progress, the Implementing Entity will confer with the Wildlife Agencies no later than Year 15 to assess how well the strategy is meeting its intended purpose. This coordination will be in addition to the annual reporting described in Chapter 8. If it becomes evident that portions of the burrowing owl strategy will not be feasible, a Plan amendment, as described in Chapter 10, may be necessary.

In addition to managing 5,300 acres of occupied and potential nesting habitat, the Implementing Entity will also protect, through fee title or easement, modeled overwintering habitat. There are 132,770 acres of western burrowing owl overwintering modeled habitat within the permit area. A total of 28,517 acres (21%) of that modeled habitat are located in Type 1, 2, or 3 open space with 12,584 acres (9%) permanently protected as Type 1 open space. The Plan proposes to acquire a minimum of 17,000 acres of modeled overwintering habitat for the Reserve System. In addition, 4,310 acres of modeled habitat will be added to the Reserve System from existing open space. These acquisitions and additions will increase the proportion of protected overwintering habitat in the permit area to 26% in Type 1 open space and about 34% in Type 1, 2, or 3 open space (**Table 5-17**).

Modeled overwintering habitat for western burrowing owl will be permanently preserved, managed, and enhanced throughout the Reserve System in all major watersheds in the permit area. Overwintering habitat will be protected in low elevation grassland valleys in the Diablo Range that currently support California ground squirrels, have supported California ground squirrels since 1997, or are adjacent to lands with existing California ground squirrel colonies (LAND-G8). Low elevation valleys within the Reserve System that are located on the valley floor or in the Diablo Range will be managed to benefit nesting and overwintering burrowing owls. Some locations on the southern edges of the City of San José could support burrowing owls in the future. In addition, several acres will be acquired in the southern part of the permit area in the Pescadero watershed that could be converted to annual grassland and managed for western burrowing owls. Nearly all land acquisition in areas dominated by annual grassland has the potential to benefit overwintering owls. Most of that land acquisition will occur along Coyote Ridge, west of Chesbro Reservoir, west and east of Calero Reservoir, and between Henry W. Coe State Park and the San Benito County line. This land acquisition has been primarily targeted for other covered species but will have incidental conservation benefit for western burrowing owls, especially during the winter months.

Land that is acquired through fee title purchase or easement to meet biological goals and objectives for burrowing owl occupied nesting and overwintering habitat in the permit area will be selected using the reserve design principles described in Chapter 5. Lands acquired and/or managed for burrowing owl nesting habitat will also meet the following criteria.

Location Criteria

When identifying and acquiring the 600 acres for permanent protection and enrollment into the Reserve System, the Implementing Entity will use the following guidelines.

1. The Implementing Entity will preferentially select a parcel that is inside of the Habitat Plan study area over a parcel that is inside of the expanded study area for burrowing owl conservation.
2. The Implementing Entity will preferentially select parcels that are closer (i.e., within 0.5 mile) to documented nest locations over those that are farther away.
3. Parcels that do not meet criteria 2 (above) may be considered on a case-by-case basis to allow the Implementing Entity to take advantage of opportunities that better fit the conservation strategy[32].

Habitat Criteria

The 600 acres of occupied nesting habitat acquired for the Reserve System must have the following:

1. Documented nesting burrowing owls on the parcel in at least one of the previous 3 years. Parcels that are currently occupied should be selected first, followed by parcels that have been occupied in the previous 3 three years.
2. Be surrounded by at least 140 acres of foraging habitat within 0.5 mile of a nest site (including the parcel where nesting was documented). If there is no potential for foraging habitat to be protected through future acquisition, conservation easement, or management agreement, the nest site should not be

[32] It is not the intent of the burrowing owl conservation strategy to permanently protect or permanently manage lands in urban areas that are anticipated to be developed (e.g., the North First Street area of San José).

acquired unless long-term viability of the site can be in some other way demonstrated.

3. Currently supports ground squirrels or is located adjacent to another parcel with ground squirrels.
4. Currently support grassland, barren, or other land cover types that can be managed or modified to enhance the site to increase the habitat quality for burrowing owls.

Management Techniques and Tools

The general principles for grassland management will be followed in all grassland or barren areas (Section 5.3.3, *Grassland Conservation and Management*). Management techniques may include any or all of those outlined in Section 5.3.3 *Grassland Conservation and Management*, and those that will be most beneficial to burrowing owls are grazing and mowing. See **Appendix M** for more details on management techniques and tools for western burrowing owl.

Uncertainties and Threats

Urbanization has been a threat to western burrowing owls in the South Bay Area for many years and as suitable habitat is developed that threat remains. All of the remaining nesting locations are very near urban development and are located on vacant lands that either have a high potential to be developed in the future, or are managed for purposes other than burrowing owl (e.g., airports). As such, nesting habitat will be subject to many threats typically associated with urban areas, feral cats, pets, commensally wildlife (e.g., skunks, raccoons), and disturbance from humans. Because many of the conservation actions will occur in proximity to urban areas, these threats will continue.

Because population numbers are so low and the number of nesting locations is less than 10, the PVA in this Plan (**Appendix N**) has demonstrated that there is considerable danger of the local population going extinct. While the conservation strategy is designed to reverse this trend, there is uncertainty in its likelihood of success. The success of the strategy is contingent on the remaining colonies being viable over the long term through protection and improved management. This strategy must also be implemented over a shorter time period than for other covered species in order to be successful. This time constraint creates additional uncertainty.

5.4.7 Least Bell's Vireo

Biological Goals and Objectives

The Implementing Entity will work to facilitate the expansion of breeding least Bell's vireos into the study area and increase reproductive success of the bird. This will be done by acquiring and restoring riparian woodland and forest with an open canopy and understory of willows. Acquisition, enhancement, and restoration conservation actions identified for riparian forest and scrub (see Section 5.3.6 *Riverine and Riparian Forest and Scrub Conservation and Management*) will benefit least Bell's vireo through breeding and foraging habitat conservation and management.

Habitat Acquisition, Restoration, and Enhancement

There are 3,097 acres of primary least Bell's vireo modeled habitat in the study area. A total of 330 acres (11%) of modeled habitat are located on Type 1, 2, or 3 open space with 65 acres (2%) permanently protected as Type 1 open space. The Plan proposes to acquire a minimum of 460 acres of least Bell's vireo primary modeled habitat (as described in **Appendix D**) for the Reserve System (**Table 5-17**). In addition, 2 acres of primary modeled habitat will be added to the Reserve System from existing open space. These acquisitions and additions will increase the proportion of protected modeled habitat in the study area to about 17% in Type 1 open space and 26% in Type 1, 2, or 3 open space (**Table 5-17**).

Least bell's vireo primary modeled habitat is defined as willow and mixed riparian forest and scrub, including California sycamore alluvial woodland, in the Uvas, Llagas, Pacheco, and Pajaro watersheds in south Santa Clara County (see **Appendix D**). Riparian land cover types preserved in these watersheds will meet the commitment to acquire 460 acres of least Bell's vireo modeled habitat (**Table 5-17**). Least Bell's vireo acquisition will focus on specific areas within each designated watershed based on historic occurrence information and known range.

In the Pacheco watershed protection will be focused along Pacheco Creek, including the confluence of Little Pacheco Creek and Pacheco Creek. Acquisitions and easements along Uvas Creek will be focused above Uvas Reservoir and intermittently along the creek as it flows southeast to the Pajaro River. Acquisition along lower Uvas-Carnadero Creek will benefit the least Bell's vireo. The only nesting occurrence of least Bell's vireo in Santa Clara County in the last 40-years was along lower Llagas Creek.

The Implementing Entity will focus first on protection of riparian corridors that either have existing nesting habitat for the least Bell's vireo or have the potential to be restored to a riparian condition in the short term. Specific areas of acquisition commitments are listed below.

- 1.6-mile extension of the Uvas Creek Park Preserve upstream to the Hecker Pass Highway (LAND-R1).
- 2.0 miles along the main stem of Pacheco Creek that are in Santa Clara County between Pacheco Lake and San Felipe Lake (LAND-R1).

Additional protection and restoration of riparian corridors in south County watersheds are expected to benefit least Bell's vireo. Similarly, protection and restoration of riparian woodland on Coyote Creek may also benefit least Bell's vireo if that species expands its range to the north into the Coyote Creek watershed. Riparian restoration planned on Coyote Creek under the proposed Three Creeks HCP is likely to count towards Habitat Plan requirements and has potential to benefit this species.

In addition to habitat acquisition into the Reserve System, the Implementing Entity will also restore or create a minimum of 50 acres of willow riparian forest and scrub or mixed riparian forest and woodland to contribute to natural community recovery (**Table 5-12**). If all allowable impacts occur, the Implementing Entity would restore these land cover types at a ratio of 1:1 (an additional 289 acres), for a maximum of 339 acres of restoration or creation. Most of this restoration would occur in south Santa Clara County due to the greater restoration opportunities there. Therefore, most of the 50–289 acres of riparian restoration would create additional foraging and nesting habitat for least Bell's vireo.

Management Techniques and Tools

Several riparian restoration and enhancement techniques will increase the amount and quality of nesting and foraging habitat for least Bell's vireo. In general, returning riverine systems to a more natural condition (i.e., flow and function) will maintain an array of successional stages for riparian vegetation in associated riparian corridors. This in turn will increase the total acreage of nesting habitat available for least Bell's vireo at any given time. In many cases these restoration efforts will constitute replacing concrete channels, to restore geomorphic and ecological functions to stream reaches that currently do not provide those functions (STREAM-4). Channels that are not necessarily concrete but that are similarly confined will also be replaced, to restore floodplain benches and commensurate functions within stream reaches that currently do not provide those functions (STREAM-5). Specific stream and riparian conservation and management goals, objectives, and actions are discussed above (Section 5.3.6 *Riverine and Riparian Forest and Scrub Conservation and Management*), but they are reiterated below.

In order to provide structural heterogeneity the Implementing Entity will plant and/or seed in native understory and overstory riparian vegetation in riparian restoration sites (STREAM-2). In most cases planting or seeding will occur in existing gaps in native riparian vegetation to promote continuity of riparian corridors (STREAM-3). This will ensure that there are various successional stages along these corridors, rather than a corridor that is dominated by mature trees. In a natural setting vegetation succession is controlled by natural events like scouring floods and fires. Absent those events, succession is not interrupted and mature trees dominate the community while early successional vegetation is lost. Without early successional vegetation in a riparian community, species like the least Bell's vireo will not occur. In order to retain some level of all successional stages of vegetation within a riparian community, activities that mimic natural physical processes, such as girdling trees, will be implemented to encourage early successional vegetation to grow (STREAM-5).

A brown-headed cowbird management program will be implemented if least Bell's vireos become regular nesters in the study area (>3 nests over at least two consecutive years) and brown-headed cowbird eggs are discovered in vireo nests (STREAM-7). The monitoring and management program will be implemented consistent with guidelines of the North American Cowbird Advisory Council, or the best scientific information available at the time, and with oversight from CDFG and USFWS. If other predators are shown to adversely affect the nest success of vireo's (e.g., feral cats, raccoons, skunks), additional predator control may be necessary (LM-13). If monitoring shows that cowbirds are not reducing the nest success of vireos then the cowbird management program will be terminated.

Uncertainties and Threats

An ongoing threat to songbird breeding success is the brown-headed cowbird. This brood parasite reduces the total number of young produced per breeding songbird pair and lowers the overall success rate for the population. Attempts to control brown-headed cowbirds through trapping or shooting have shown short-term benefits to riparian songbird species, including the Bell's vireo. Implementation of a brown-headed cowbird control program was discussed above.

5.4.8 Tricolored Blackbird

Biological Goals and Objectives

The Implementing Entity will work to increase the population size of tricolored blackbird in the study area. This will be accomplished by protecting at least four sites that support, historically supported, or could support tricolored blackbird colonies. Each protected site will have at least 2 acres of breeding (marsh) habitat and will have at least 200 acres of foraging habitat within 2 miles. These breeding sites will either be enhanced or restored breeding habitat in historically/currently occupied areas within the Reserve System or newly created ponds suitable for breeding tricolored blackbirds. Acquisition, enhancement, and restoration/creation conservation actions identified for grasslands (see Section 5.3.3 *Grassland Conservation and Management*), valley oak woodlands (see Section 5.3.5 *Oak and Conifer Woodland Conservation and Management*), riparian forest and scrub (see Section 5.3.6 *Riverine and Riparian Forest and*

Scrub Conservation and Management), and wetlands and ponds (see Section 5.3.7 *Wetland and Pond Conservation and Management*) will benefit tricolored blackbird through breeding, foraging, and year-round habitat conservation and management.

Acquisition, Restoration, and Creation

There are 140,291 acres of tricolored blackbird modeled habitat within the study area. A total of 29,435 acres (21%) of that habitat are located in Type 1, 2, or 3 open space with 11,037 acres (8%) permanently protected as Type 1 open space. The Plan proposes to acquire a minimum of 19,000 acres of modeled primary and secondary habitat for the Reserve System. In addition, 3,840 acres of modeled primary and secondary habitat will be added to the Reserve System from existing open space. These acquisitions and additions will increase the proportion of modeled habitat in the study area to about 24% in Type 1 open space and 35% Type 1, 2, or 3 open space (**Table 5-17**).

As part of the preservation acreages above, the Implementing Entity will acquire 5 acres of modeled breeding habitat within dry land farming or ranching complexes in Coyote Valley and the Diablo Hills (LAND-WP8). A high priority will be given to currently occupied sites or sites that have been occupied since 1997. Additional preference will be given to historic breeding sites that could be restored. Land acquisition to benefit tricolored blackbird will occur in the areas between Henry W. Coe State Park and San Felipe Lake in San Benito County. Historically San Benito Lake has supported nesting tricolored blackbirds so protection of modeled breeding and foraging habitat near there will benefit the species over the long term. Additional protection in the Pescadero and Tar Creek watersheds southwest of Gilroy will simultaneously protect modeled nesting habitat and adjacent foraging habitat near two historic occurrences. There are also areas that will be protected along the Pacheco Creek corridor where there is modeled breeding habitat surrounded by agricultural lands or annual grasslands, which provide the necessary breeding and foraging habitat combination. Additional modeled habitat will be preserved, enhanced, and monitored west and south of Chesbro Reservoir.

In order to ensure adequate breeding and foraging habitat is available for future breeding colonies the Implementing Entity will offer financial incentives to private landowners to enhance pond and marsh habitat to suit breeding tricolored blackbirds and to modify farming or ranching techniques to ensure that dry-land farming and ranching activities are executed in a way that is compatible with nesting and foraging tricolored blackbirds (POND-14, POND-15). The Implementing Entity will help landowners apply for existing grants (e.g., North American Wetlands Conservation Act Small Grants Program [USFWS], or Environmental Quality Incentives Program of the Farm Bill [USDA Natural Resources Conservation Service]) as well as provide supplemental funds in the event that grants are unsuccessful. In addition, the Implementing Entity will ensure that there is at least 200 acres of permanently protected modeled foraging habitat within 2-miles of tricolored blackbird breeding sites protected under the Plan (LAND-WP9). If there is not adequate modeled foraging habitat available in existing Type 1 open space within 2 miles of breeding sites protected under the Plan, the difference in acreage, up to 200 acres per breeding site, will be protected through acquisition or easement within 2 miles of each breeding site.

In addition to protecting new breeding habitat the Implementing Entity will also restore freshwater marsh that will support dense reed-like vegetation (cattails) or other native vegetation (nettles) that will attract nesting tricolored blackbirds (POND-16). Each of these areas will include at least 2 acres of breeding habitat surrounded by sufficient foraging habitat. Of the 20 acres of newly created ponds within the permit area (POND-10), and the estimated 52 acres of ponds to mitigate for the loss of ponds to covered activities, those surrounded by suitable tricolored blackbird foraging habitat will be managed to support dense-reed like vegetation adequate for tricolored blackbird nesting.

In areas with nonnative vegetation (e.g., Himalayan blackberry) that supports existing tricolored blackbird colonies, the Implementing Entity will initiate a gradual (3–4-year) transition from nonnative vegetation to native vegetation that is structurally similar (POND-17). This would only be implemented if the USFWS and CDFG determined that the colony was large enough and stable enough to accommodate the change. In most cases the vegetation would not be altered unless the colony was abandoned for at least three breeding seasons. In riparian areas, constrained channels will be replaced with more natural channels to restore geomorphic and ecological functions to stream reaches that currently do not provide those functions (STREAM-4). This will ensure that a variety of successional stages are supported within riparian corridors, including side channels and benches where slower water supports marsh-like vegetation.

Management Techniques and Tools

The management techniques that will be utilized to promote tricolored blackbird nesting colony success are captured above (Section 5.3.7 *Wetland and Pond Conservation and Management*). Those management techniques include:

- Planting of native emergent vegetation.
- Fencing off portions of ponds or wetlands to reduce grazing pressure and exclude feral pig activity.
- Implementation or continuation of a grazing program in potential foraging habitat within 2-miles of known breeding colonies.

Uncertainties and Threats

Tricolored blackbird colonies are an ephemeral resource. Nest colonies can persist for many years in the same location or sites can be occupied irregularly over time. In order to control for this uncertainty when attempting to protect or reestablish nesting colonies it is important to concentrate protection and management efforts in areas that either support or have some documentation of historical breeding colonies. It is highly likely that breeding habitat can be protected, restored, or created and breeding blackbirds will never occupy it.

5.4.9 San Joaquin Kit Fox

Biological Goals and Objectives

The Implementing Entity will work to increase the ability of San Joaquin kit fox to move within and through the study area and increase the likelihood of breeding. Because the study area is outside the three San Joaquin kit fox core areas,[33] land acquisition and habitat enhancement focuses on building connections between the more isolated satellite populations in order to contribute to the *Level A Strategy* to "work toward the establishment of a viable complex of kit fox populations (i.e., a viable metapopulation) on private and public lands throughout its geographic range", as identified in *Recovery Plan for Upland Species of the San Joaquin Valley* (U.S. Fish and Wildlife Service 1998a). In addition, the Plan supports the *Habitat Protection and Population Interchange Recovery Action xiv* to "Protect existing kit fox habitat in the northern, northeastern, and northwestern segments of their geographic range..." (U.S. Fish and Wildlife Service 1998a).

This will be accomplished by protecting land through fee title purchase or easement and managing those lands as part of the Reserve System. Protection will be focused in areas with land cover types such as annual grasslands and oak woodlands, where this species has the highest potential to occur (see **Appendix D**). In accordance with the *Level A Strategy,* these protected areas will have a diversity of soils types, topography, aspect, and other environmental gradients to account for movement, foraging, and resting habitat (U.S. Fish and Wildlife Service 1998a). The Reserve System will benefit San Joaquin kit fox in the Pacheco Creek watershed in the uplands between Pacheco State Park and the Romero Ranch in the southeastern corner of the study area. Additional Reserve lands will be acquired between Henry W. Coe State Park and San Felipe Lake that will also benefit the species. The Reserve System will help to ensure that if San Joaquin kit fox are able to cross SR 152 that they will be able to fully utilize the lowland hills of the Diablo Range. In line with in the *Population Ecology and Management Recovery Action,* the Implementing Entity will enhance grassland and oak woodland habitat within the Reserve System to support a more abundant prey base (i.e., California ground squirrels) for San Joaquin kit fox (U.S. Fish and Wildlife Service 1998a).

Outside of the Reserve System the Plan will also contribute to the *Level A Strategy* goal on private land (U.S. Fish and Wildlife Service 1998a). The Implementing Entity will work to influence land-uses that are compatible with kit fox movement. Most importantly the Implementing Entity will identify

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[33] As identified by the *Recovery Plan for Upland Species of the San Joaquin Valley*, there are three identified core populations of San Joaquin kit fox: Carrizo Plain Natural Area, Natural lands of western Kern County, and Fresno and eastern San Benito Counties (U.S. Fish and Wildlife Service 1998a).

important habitat linkages across SR 152, between the SR 152/156 interchange and the Santa Clara/Merced County line. Working with road operators (VTA and Caltrans), the Implementing Entity will improve passage along this highway when future road improvements are designed and implemented. Improvements will include removal or "perforation" of sections of median barriers along roadways to improve successful wildlife crossings and, if biologically appropriate, installation of fencing or other features to direct wildlife to those open sections (LM-5).

Acquisition, enhancement, and restoration of grasslands (see Section 5.3.3 *Grassland Conservation and Management*), oak woodlands (see Section 5.3.5 *Oak and Conifer Woodland Conservation and Management*), riparian forest and scrub (see Section 5.3.6 *Riverine and Riparian Forest and Scrub Conservation and Management*), and seasonal wetlands (see Section 5.3.7 *Wetland and Pond Conservation and Management*) in the southern portion of the County are expected benefit to San Joaquin kit fox through foraging and movement habitat conservation and management.

Acquisition and Enhancement

There are 40,892 acres of modeled San Joaquin kit fox habitat (includes secondary and low-use secondary habitat) within the study area. Although not modeled, some of this habitat may also be potential breeding habitat. A total of 6,315 acres (15%) of modeled habitat are located in Type 1, 2, or 3 open space with 5,067 acres (12%) permanently protected as Type 1 open space. The Plan proposes to add a minimum of 4,100 acres of modeled habitat to the Reserve System, increasing the proportion of protected modeled habitat in the study area to about 22% as Type 1 open space and 25% as Type 1, 2, or 3 open space (**Table 5-17**).

As stated above, land acquisition and habitat enhancement will contribute to species recovery by building connections among the satellite populations in the northern part of the species' range (U.S. Fish and Wildlife Service 1998a). The Implementing Entity will protect through fee title acquisition or easements annual grassland and associated oak woodland land cover types (e.g., oak savanna and oak woodland within 500 feet of annual grassland) north and south of SR 152, east of the SR 152/156 interchange (LAND-G9).

This portion of the study area has the highest potential to support San Joaquin kit fox, though SR 152 is a considerable barrier across the landscape. Land acquisition along Pacheco Creek would benefit kit fox by preserving likely movement routes, foraging habitat, and possible (although unlikely) den sites (i.e., breeding sites). Specific areas where enhancement could occur to increase the permeability of SR 152 include the undercrossing where Little Pacheco Creek flows into Pacheco Creek and several other small drainages that flow under the roadway before connecting with Pacheco Creek on the south side of the road (**Figure 5-7b**). This will ensure that if costly enhancements are made to roadway infrastructure to create better connections for this species, that the natural lands on either side of the roadway will also remain high quality habitat in perpetuity.

Several grassland restoration and enhancement techniques will increase the amount and quality of movement habitat for San Joaquin kit fox. In general, managing nonnative vegetation and overtime increasing the amount of native vegetation in the ecosystem will have a positive effect on grassland ecosystem function. In turn this will benefit predators like the San Joaquin kit fox by supporting a more sustainable prey population. The Implementing Entity will introduce livestock grazing where it is not currently used, and where conflicts with covered activities will be minimized, to reduce vegetative cover and biomass that currently excludes ground squirrels facilitate colonization of new areas by ground squirrels within the Reserve System (GRASS-6). Specific grassland conservation and management goals, objectives, and actions are discussed above (Section 5.3.3 *Grassland Conservation and Management*).

Management Techniques and Tools

Several specific actions will be taken by the Implementing Entity to improve passage for San Joaquin kit fox. At locations indicated by pre-acquisition assessments and targeted studies and informed by the monitoring and adaptive management program, the Implementing Entity in coordination with the road operator will remove fences, replace culvert, and install free span bridges to allow wildlife to move freely under and over roadways (LM-1, LM-2, LM-3). To increase the probability that wildlife will use these crossings fencing or other features will be installed that will direct wildlife attempting to cross the roadway towards the culvert or other safe crossing (LM-4). Further, road operators will be required to remove or perforate median barriers, where allowable and safe, to improve successful wildlife crossings and, as indicated by targeted studies and informed by the monitoring and adaptive management program, install fencing or other features to direct wildlife to those open sections (LM-5).

To ensure that California ground squirrels and other rodents are as abundant as possible within the Reserve System the Implementing Entity will cease the use of rodenticides within the Reserve System except when necessary to maintain structures (e.g., levees, roads, stock pond dams) or to prevent nuisance populations (as defined in the Fish and Game Code Sections 4150 and 4152) from moving onto adjacent private lands (GRASS-5). Further, the Implementing Entity in coordination with road operators will remove fences and roads where they are no longer needed and to increase landscape permeability for wildlife movement (LM-1). Road removal may include road removal and decommission (i.e., returned to a natural condition) or road stabilization and abandonment to reduce hazards to wildlife and to reduce the erosion potential associated with dirt and gravel roads. This will allow many native species, including San Joaquin kit fox, to move more freely within the Reserve System.

In addition to protecting and restoring modeled habitat and improving structures the Implementing Entity will conduct a public education campaign in the southeastern portion of the study area to provide landowners with information about management and land use techniques that are more compatible with movement and use by San Joaquin kit fox (GRASS-10).

Uncertainties and Threats

The level to which San Joaquin kit fox uses the study area for movement, foraging, or denning is uncertain. San Joaquin kit fox have been documented moving through the lowlands just east of the study area and it is likely that individuals occasionally move into Santa Clara County. Also it will be difficult to monitor and measure the effectiveness of crossings structures. Other wildlife species (e.g., coyote, bobcat) will likely be used as surrogate species to determine whether these crossing structure adequately facilitating movement, since San Joaquin kit fox occur at such low numbers.

5.4.10 Tiburon Indian Paintbrush

There are a total nine known occurrences of Tiburon Indian paintbrush throughout its range. There are two occurrences in the study area. Population estimates for this species exist for all except one of the occurrences (see Chapter 4, Section 4.6.8 *Serpentine Plants* for population estimates). In the study area, one occurrence is located on a mitigation site, under a temporary easement, for creation of the Kirby Canyon Landfill. The second occurrence, located in the North Canyon, is privately owned. At the time this Plan was being developed, the landfill operator was in the process of finalizing a conservation easement as compensation for the recent expansion of the landfill. Impacts from management activities to the one occurrence currently under temporary easement, consistent with the conservation strategy of the Plan, are the only impacts allowed to the species in the permit area. These impacts will be temporary in nature and will result in overall benefits to the occurrence. This Plan does not cover impacts to additional occurrences of Tiburon Indian paintbrush that may be discovered during the permit term (**Tables 4-6 and 5-16**).

Biological Goals and Objectives

The Implementing Entity will protect, maintain the viability of, and enhance Tiburon Indian paintbrush by acquiring the occurrence currently under a temporary easement at the Kirby Canyon Landfill, and by increasing the size of the occurrence within the permit area to at least 2,000 individuals (**Table 5-16**).

Tiburon Indian paintbrush is expected to benefit from acquisition and enhancement of grassland natural communities that serve as primary habitat and/or provide suitable habitat for occurrence expansion (see Section 5.3.3 *Grassland Conservation and Management*).

Occurrence Acquisition

The two known occurrences of Tiburon Indian paintbrush in the study area will be permanently protected upon successful implementation of the Plan. The

North Canyon occurrence is anticipated to be permanently protected with a conservation easement by the landfill operator prior to the finalization of this Plan and permit issuance. The Implementing Entity will acquire the other occurrence of Tiburon Indian paintbrush, which is under a temporary easement to mitigate effects of Kirby Canyon Landfill. Although the current easement expires in 2034, the Implementing Entity may permanently protect this occurrence at any time before Year 45 of the permit term.

In order for an occurrence to count as protected under the Plan, there will be a buffer of at least 500 feet between the occurrence and adverse land uses. Adverse land uses include permanent land uses that could endanger the long-term viability of the occurrence; including urban development, landfill, and other intensive land uses. This buffer may be reduced or increased in specific circumstances where, based on documented site conditions, plant occurrences are protected from adverse land uses by another means or site conditions warrant a larger buffer. For example, if a major physical barrier separates the occurrence from the land use or the occurrence is located upslope from the adverse land use, the buffer may be reduced. Conversely, if there are certain adverse land uses upslope from the occurrence and effects to the occurrence are expected, a buffer greater than 500 feet may be needed. A 500-foot buffer was recommended in the *Recovery Plan for Serpentine Soil Species of the San Francisco Bay Area* (U.S. Fish and Wildlife Service 1998c).

Management Techniques and Tools

The one occurrence protected under this Plan will be increased to or maintained at least 2,000 individuals in order to ensure the yearly viability of the occurrences (U.S. Fish and Wildlife Service 1998c). In order to successfully manage the Reserve System's occurrence of Tiburon Indian paintbrush, targeted studies will be conducted to identify factors limiting the expansion of the occurrence (STUDIES-5). These studies may focus on various factors related to management and microsite needs of the species at all life stages from germination through maturity (STUDIES-5). Additional studies to determine the effects of livestock grazing on Tiburon Indian paintbrush will exclude livestock and monitor the effects on occurrences; control sites will be incorporated into these studies (STUDIES-16), unless the Implementing Entity demonstrates that the required action is biologically inappropriate. Results of all research studies will be incorporated into reserve unit management plans to mitigate or remove the limiting factors.

To help implement the Recovery Plan for this species (U.S. Fish and Wildlife Service 1998c), a permanent conservation seed bank for the Tiburon Indian paintbrush will be established. To assist the long-term viability of this species, a permanent conservation seed bank for Tiburon Indian paintbrush will be established in the National Collection of Endangered Plants operated by the Center for Plant Conservation as a national repository of endangered plant seed stock. Seeds will be deposited at a local custodial institution (e.g., a botanic garden) designated by the Center for Plant Conservation. A permanent conservation seed bank provides long-term storage in an accredited facility of a representative sample of seeds from wild occurrences. All known occurrences in the Reserve System will be represented in the conservation seed bank unless collection would pose a threat to the occurrence's continued existence. Occurrences will be maintained in the seed bank separately to ensure the genetic diversity of the bank. The seed bank will be replenished as necessary to maintain the genetic integrity of the stock. The conservation seed bank will serve as a repository of the species to guard against extinction of the species from chance catastrophic events and to provide potential material for enhancement efforts in existing occurrences, repatriations, or introductions to new sites (STUDIES-14).

Uncertainties and Threats

There is still much to learn regarding the management of Tiburon Indian paintbrush. Because management and conservation decisions for this species are limited in their potential efficacy, the Implementing Entity has little information with which to design and plan specific management and monitoring protocols. Accordingly, directed studies are needed to successfully establish and maintain new occurrences in perpetuity (STUDIES-5).

Potential threats to these occurrences appear to be minimal (S. Weiss pers. comm. b). One threat may be cattle grazing; however, it is not clear whether grazing benefits or adversely affects Tiburon Indian paintbrush. Recent evidence suggests the Paintbrush Hill occurrence of Tiburon paintbrush is being predated upon by black-tailed jackrabbit. This predation may be the cause of occurrence decline at this location. Exclosure experiments are currently being conducted to determine the validity of this hypothesis (C. Niederer pers. comm.). For these reasons, the Tiburon paintbrush occurrence will be monitored to assess the impacts of grazing or predation (STUDIES-16). Adaptive management decisions can then be developed on the basis of monitoring results.

5.4.11 Coyote Ceanothus

There are a total of three known occurrences of Coyote ceanothus throughout its range. One additional reported occurrence, from Croy Canyon in 1929, is believed to be erroneous and will not be discussed further in this section (see **Appendix D** *Species Accounts* for more information). All known occurrences are located in the study area. One of these occurrences is located northwest and southeast of Anderson Dam, east of U.S. 101. The two other occurrences are located on private property near Kirby Canyon Landfill and in Morgan Hill. All three of the known occurrences have population estimates (see Chapter 4, Section 4.6.8 *Serpentine Plants* for more information). Impacts by covered activities are limited to 3,650 individuals or 5%, whichever is less, of the Anderson Dam occurrence (**Tables 4-6 and 5-16**). This standard will be applied to the population as it existed during the 2009 surveys. It will not be applied to any new recruits that are a result of natural or artificial disturbance event such as fire.

Biological Goals and Objectives

The Implementing Entity will protect, maintain the viability of, and increase the number and size of populations of Coyote ceanothus by protecting a total of five occurrences in the permit area (**Table 5-16**). Included in the five occurrences protected will be the three known extant occurrences. Protection of the remaining two occurrences will be accomplished through two possible methods, in order of priority: (1) acquire land for the Reserve System that supports a new occurrence by Year 45, or (2) create new occurrences by Year 40.

Within 5 years of the impact at Anderson Dam, one occurrence will be protected or created. The timing of the seismic retrofit of Anderson Dam is currently uncertain, but is expected to occur within the first 5 years of the permit term. Project implementation may need to occur sooner than anticipated due to public safety concerns. If the impacts of the project on Coyote ceanothus are greater than what was evaluated in the Plan, additional mitigation may be required to offset the additional impacts. This may also require a Plan amendment as described in Chapter 10, Section 10.3 *Modifications to the Plan*.

The total number of Coyote ceanothus occurrences protected by this Plan deviates from the number suggested in the species' Recovery Plan. The Recovery Plan (U.S. Fish and Wildlife Service 1998c) recommends the protection of eight populations prior to the consideration of delisting. There have only been three populations of this species ever discovered[34], even prior to extensive development of the Santa Clara Valley. In addition, the characteristics of existing populations suggest that finding five new occurrences is highly unlikely. The Plan assessed the potential for creation of new occurrences by examining soil types, proximity to known populations, and other features of habitat suitability. It was determined that creation of two occurrences is feasible but not more. Therefore, the Habitat Plan is justified in deviating from the recommendations of the Recovery Plan.

In order for an occurrence to count as protected under the Plan, there will be a buffer of at least 500 feet between the occurrence and adverse land uses, as described for Tiburon Indian paintbrush in Section 5.4.10 *Tiburon Indian Paintbrush*.

In addition, Coyote ceanothus may benefit from acquisition and enhancement of natural communities that serve as primary habitat and may contain known or undiscovered occurrences, and/or provide suitable habitat for occurrence creation, including serpentine grasslands (see Section 5.3.3 *Grassland Conservation and Management*) and serpentine chaparral (see Section 5.3.4 *Chaparral and Northern Coastal Scrub Conservation and Management*).

[34] The Recovery Plan considers the Anderson Dam population as two separate occurrences, consistent with data in the CNDDB (resulting in 5 total occurrences). For the purposes of this Plan, the Anderson Dam population is considered a single occurrence that was split by the construction of the dam (resulting in a total of 3 occurrences). A genetic study underway will help to understand the population structure of this species.

Occurrence Acquisition

Regardless of the level of impact, the three known occurrences in the study area will be incorporated into the Reserve System (LAND-P1). Protection of occurrences will be accomplished by acquiring land for the Reserve System that supports the three unprotected occurrences. In addition, the Implementing Entity will protect two new occurrences. If new occurrences cannot be found or acquired in the Reserve System, then the Implementing Entity will create occurrences to reach this target, as described below. Acquisition may occur through fee title purchase or by obtaining conservation easements. Acquisition of the three known occurrences must occur by Year 45 (the deadline for all Reserve System acquisition).

Occurrence Creation

If acquisition of two new occurrences is infeasible, the Implementing Entity will create up to two new occurrences of Coyote ceanothus (i.e., if no new occurrences are acquired, two will be created and if one new occurrence is acquired, one will be created). The Implementing Entity will develop a plan with the Wildlife Agencies for each occurrence creation. Each plan will include a process for creating the occurrence (e.g., use of propagules vs. use of cuttings), monitoring the created occurrence, and determining viability.

If the creation is not needed to fulfill requirements associated with covered activity implementation, the creation may occur later in the permit term but no later than by Year 40. Creation may be delayed until later in the permit term because of the need to: (1) exhaust opportunities to discover new occurrences (which are the first priority), (2) assemble enough of the Reserve System to provide suitable habitat for occurrence creation, and (3) allow sufficient time to study optimum habitat conditions, target occurrence size and structure, and propagation techniques. The decision to focus conservation efforts on occurrence creation will be made jointly with the Wildlife Agencies. The Implementing Entity, in coordination with the Wildlife Agencies, will determine the target occurrence size and structure for created occurrences based on empirical data collected on occurrences in the Reserve System and other best available science.

Population creation for Coyote ceanothus should occur on suitable sites within the Reserve System if possible. However, if no suitable sites are available in the Reserve System when they are needed to meet the deadlines (either within 5 years of the Anderson Dam impact or prior to Year 40), population creation could occur on suitable sites outside of the Reserve System if the site meets the definition of Type 1 open space and the site is managed and monitored according to the Plan.

Suitable habitat for created occurrences will be identified based on the habitat of known occurrences and any other available data at the time of acquisition (STUDIES-5). Because two of the three known extant occurrences of Coyote ceanothus are on the east side of the Coyote Valley, the focus will be to increase the range of the species by creating the new occurrences on the west side of the valley unless the Implementing Entity demonstrates to the Wildlife Agencies that such occurrence creation is biologically infeasible. This effort will involve identifying a suitable creation site and determining biologically appropriate and viable propagation or planting techniques for this species (STUDIES-13, STUDIES-14). It will also entail studies to determine the biologically appropriate seed sampling techniques and harvest numbers for acquisition of seed from existing occurrences (STUDIES-14). In addition, field experiments will be conducted (if the number of propagules allows) to test alternative techniques for occurrence establishment using seeds (STUDIES-15) or through other mechanisms such as use of cuttings.

Coyote ceanothus is a large, woody shrub that often grows in dense, monotypic stands. Because of the possibility that a new creation could displace serpentine grasslands, created occurrences will be sited to minimize the potential for displacement of habitat for other covered species.

Anderson Dam Seismic Retrofit

One occurrence will be created within 5 years of the Anderson Dam impact if a known or new occurrence has not been protected. The Anderson Dam impact is anticipated to occur in 2016. Because of the challenges of protecting one occurrence early in the permit term, the SCVWD has started efforts that will support creation of a Coyote ceanothus occurrence including the following.

- Communicating with Pepperdine University which is conducting a genetic (microsatellite) study to determine population structure.
- Communicating with UC Davis on its study of genetics (S-allele) to assess breeding system/reproductive success/population viability; and Frankia soils study to examine potential microsymbiont relationship and importance of native soil to population creation.
- Identified and mapped potentially suitable introduction sites on land recently purchased by the SCVWD on Coyote Ridge.
- Seed collection and storage from the Anderson Dam population occurrences.

Based on the studies, SCVWD will prepare a draft occurrence creation plan. Some key components include the following.

- Documentation of successful propagation methods from seed and/or cuttings in test plots by December 2013.
- Verification of site suitability and potential introduction sites through soil analysis of sites with known populations by July 2017.
- Full-scale planting effort (will involve additional seed collection and propagation) with survival monitoring; implemented between July 2017 and February 2018.

The work being conducted by SCVWD may help support the studies requirements of the Plan for this species.

Management Techniques and Tools

To successfully manage existing occurrences and create new occurrences of Coyote ceanothus, targeted studies will be conducted to determine factors limiting the expansion of extant occurrences, as well as those necessary for establishment and maintenance of a created occurrence (STUDIES-5). Such studies will include the effect of fire on seed germination and other possible germination requirements. If necessary, studies may also be conducted to determine requirements for successful transplanting to augment new occurrences. Other studies may focus on various factors related to management and microsite needs of the species at all life stages from germination through maturity (STUDIES-5).

The targeted studies will be used to inform the target occurrence size for managed occurrences. A preliminary goal of 5,000 individuals per occurrence will be implemented as recommended in *Ceanothus ferrisiae (Coyote ceanothus) 5-Year Review: Summary and Evaluation* (U.S. Fish and Wildlife Service 2011); if approved by the Wildlife Agencies, this number will be adjusted as necessary pending research carried out during Plan implementation to assure viable occurrences of this species.

Prescribed burns (CHAP-1) or an appropriate fire-management policy (LM-8) in chaparral, as well as managed grazing or mechanic thinning of chaparral (CHAP-2), may result in improved habitat or occurrence longevity for Coyote ceanothus. Although fire appears to be beneficial to recruitment and regeneration, burning will not be implemented on a large scale in areas with Coyote ceanothus occurrences until additional monitoring or other data collection has occurred to determine if these occurrences would be likely to benefit by being burned. The management actions above are targeted to maintain structural diversity and canopy gaps and to promote regeneration of chaparral species, which may directly or indirectly benefit Coyote ceanothus.

At least one prescribed burn (CHAP-1) will be implemented at a site yet to be identified. This area will be burned to facilitate the species' re-growth within 5 years of implementation of the Anderson Dam seismic retrofit covered activity. Subsequent burns may be conducted during the permit term, as appropriate, through the adaptive management process described in Chapter 7. Prescribed burns will promote regeneration and improve stand health. A qualified biologist will oversee the prescribed burn.

To help implement the Recovery Plan for this species (U.S. Fish and Wildlife Service 1998c), a permanent conservation seed bank for Coyote ceanothus will be established in the same manner as described for Tiburon Indian paintbrush in Section 5.4.10 *Tiburon Indian Paintbrush* subheading *Management Techniques and Tools* (STUDIES-12). Coyote ceanothus is the only covered plant species where created occurrences could be counted toward the mitigation component of the Plan. In all other cases, created plant occurrences will only count toward the conservation component of the Plan. If creation is used to meet the impact mitigation component of the conservation strategy for this species, seed banking will be completed prior to the impacts.

Uncertainties and Threats

Very little precise information about the ecology of this species exists, including information on the relationship between life history stages, population dynamics, and fire. Recent information and observations have indicated that the absence of fire may be detrimental to recovery and long-term persistence of this species (U.S. Fish and Wildlife Service 2011). It is unknown, however, if Coyote ceanothus seeds require fire for germination and establishment; accordingly, directed studies are needed to successfully establish and maintain new occurrences in perpetuity (STUDIES-5).

It is not clear if general management actions (i.e., burning or clearing chaparral) will in fact benefit or adversely affect Coyote ceanothus. For this reason, any such actions in or adjacent to Coyote ceanothus occurrences will include a monitoring component to assess impacts. Adaptive management decisions can then be developed on the basis of monitoring results (STUDIES-11).

5.4.12 Mt. Hamilton Thistle

There are a total of 48 known occurrences of Mt. Hamilton thistle throughout its range. There are 40 known occurrences in the study area. Only 34 of the 48 known occurrences have population estimates (see Chapter 4, Section 4.6.8 *Serpentine Plants* for more information). Impacts to six known occurrences are allowed by covered activities if no additional occurrences are discovered during the permit term (**Tables 4-6 and 5-16**).

Biological Goals and Objectives

The Implementing Entity will protect, maintain the viability of, and increase the number and size of populations of Mt. Hamilton thistle by acquiring and enhancing at least 22 known, extant occurrences (**Table 5-16**) if no additional occurrences are discovered during the permit term. Two of the 22 occurrences are located in Santa Teresa County Park and Anderson Lake County Park and will be incorporated into the Reserve System.

The Implementing Entity will manage and monitor the 22 occurrences so that each maintains a minimum occurrence size of 2,000 individuals as recommended by the Recovery Plan for Serpentine Soil Species of the San Francisco Bay Area (U.S. Fish and Wildlife Service 1998c). The Recovery Plan's conservation strategy for Mt. Hamilton thistle recommends preserving a total of

23 populations, 55% of which should be in the “San José area” (13 populations) and 35% of which should be in “northeastern Santa Clara County and northwestern Stanislaus Counties” (eight populations). The Habitat Plan will protect and manage 22 occurrences of Mt. Hamilton thistle in perpetuity, exceeding the Recovery Plan conservation recommendations for populations in and around Santa Clara County. As such, implementation of the Plan will not cause jeopardy to, or preclude recovery of, Mt. Hamilton thistle.

Mt. Hamilton thistle is expected to benefit from acquisition and enhancement of the grassland natural communities, as these land cover types include the serpentine seeps and streams that serve as primary habitat and contain known or undiscovered occurrences (see Section 5.3.3 *Grassland Conservation and Management)*.

Acquisition of Modeled Habitat

There are 487 acres of primary modeled habitat for Mt. Hamilton thistle within the study area. A total of 204 acres (42%) of modeled habitat are located in Type 1, 2, or 3 open space with 55 acres (11%) permanently protected as Type 1 open space. The Plan will acquire a minimum of 150 acres of modeled habitat for the Reserve System. In addition, 60 acres of primary modeled habitat will be added to the Reserve system from existing open space. These acquisitions and additions will increase the proportion of protected modeled habitat in the study area to about 54% in Type 1 open space and 73% in Type 1, 2, or 3 open space (**Table 5-17**).

Mt. Hamilton thistle is one of eight Covered Species addressed in the Recovery Plan for Serpentine Soil Species of the Bay Area (U.S. Fish and Wildlife Service 1998c). At the time the Recovery Plan was written, known occurrences of Mt. Hamilton thistle were distributed nearly evenly on the east and west side of U.S. 101. Since the writing the Recovery Plan, and during the writing of this Plan, many more occurrences have been identified. Most new occurrences are located on the serpentine areas in and around Coyote Ridge on the east side of U.S. 101. The occurrences on the east side of the valley follow a network of drainages unique to Coyote Ridge. These drainages do not occur on the west side of the valley. As such, the Plan will focus conservation efforts for Mt. Hamilton thistle on acquiring occurrences along Coyote Ridge on the eastside of the valley (J. Hillman pers. comm. and Hillman 2007). Acquisition will also be located in similar drainages that flow into San Felipe Creek. In addition, acquisition, as well as enhancement, will occur in the Santa Cruz Mountains between Calero County Park and Almaden Quicksilver County Park and on Tulare Hill.

Occurrence Acquisition

Regardless of the level of impact, 22 known occurrences in the permit area will be acquired and incorporated into the Reserve System (LAND-P6). An effort will be made to acquire sites in the study area on both sides of Coyote Valley to ensure geographic diversity in protected occurrences in accordance with recommendations made in the Serpentine Recovery Plan (U.S. Fish and Wildlife Service 1998c). Target acquisitions include known occurrences along Coyote Ridge (an estimated 9 of 22 occurrences). Two other occurrences in Santa Teresa and Anderson Lake County parks will be acquired, enhanced, and monitored.

There are size estimates for 36 of the known occurrences of this species, from as early as 1983 up to as recently as 2008. These estimates range from 1 to 4,500 individuals, and the total estimated size of all occurrences is 28,962 (California Natural Diversity Database 2009). Only 12 of the 22 occurrences to be protected in the Reserve System have size estimates, and these total 7,810 individuals. The total number to be protected is likely to be much larger than this estimate. In addition, since this is a short-lived, two-year perennial species that depends on local hydrology, these numbers are likely to fluctuate from year to year in response to annual fluctuations in rainfall and runoff into serpentine seeps.

As described in Chapter 4, the impact limit for this species could increase from 6 occurrences if no additional occurrences are discovered during the permit term to 8 occurrences if additional occurrences are discovered during the permit term. A minimum of 3 occurrences have to be acquired prior to any newly discovered occurrence being impacted during the permit term. In other words, a minimum of 21 occurrences will be acquired and protected in the Reserve System before a 7th occurrence is impacted and a minimum of 24 occurrences will be acquired and protected in the Reserve System before an 8th occurrence is impacted. "Minimums" are referenced here because the Implementing Entity will protect 22 occurrences, regardless of impacts. The timing of acquisition of 18 of the 22 occurrences are linked to impacts, while the remaining 4 occurrences will be acquired for recovery purposes only and thus acquisition timing of these 4 occurrences are not linked to impacts. The newly discovered and acquired occurrences must be in better condition than the impacted occurrences, according to the criteria in Section 5.3.1 *Land Acquisition and restoration Actions* subheading *Incorporating Covered Plant Species*. In addition, new occurrences must be acquired before the impacts occur and by Year 45 (the deadline for all Reserve System acquisition).

In order for an occurrence to count as protected under the Plan, there will be a buffer of at least 500 feet between the occurrence and adverse land uses, as described for Tiburon Indian paintbrush in Section 5.4.10 *Tiburon Indian Paintbrush*.

Management Techniques and Tools

To successfully manage existing occurrences of Mt. Hamilton thistle, targeted studies will be conducted to determine factors limiting the expansion of extant occurrences (STUDIES-5). Such studies will include examining the effects of livestock grazing on the species by experimentally excluding livestock and monitoring the effects on occurrences; control sites will be incorporated into these studies (STUDIES-16). Other studies may focus on various factors related to management and microsite needs of the species at all life stages from germination through maturity (STUDIES-5).

The targeted studies will be used to inform the target occurrence size for managed occurrences. The definition of an occurrence for this species depends on the location: an occurrence on the east side of Coyote Valley is defined as all occurrences in a discrete drainage, while an occurrence on the west side of Coyote Valley is defined as a specific occurrence point because the western occurrences are more likely to occur at isolated points rather than in a network of drainages (J. Hillman pers. comm.). Specific target occurrence size will be developed by Year 10 of implementation, based on empirical data collected on occurrences in the Reserve System and other best available science. The Implementing Entity, in coordination with the Wildlife Agencies, will determine the target occurrence size.

Because Mt. Hamilton thistle only occurs along creeks and drainages, the hydrologic systems that maintain these features are critical to the survival and occurrence growth of this species. Therefore, the Implementing Entity will manage and maintain the hydrologic systems (e.g., springs, streams, ponds) that support Mt. Hamilton thistle.

To help implement the Recovery Plan for this species (U.S. Fish and Wildlife Service 1998c), a permanent conservation seed bank for Mt. Hamilton thistle will be established in the same manner as described for Tiburon Indian paintbrush in Section 5.4.10 *Tiburon Indian Paintbrush* subheading *Management Techniques and Tools* (STUDIES-12).

Uncertainties and Threats

Very little precise information about the ecology and population biology of this species is available, including information on the species' reproductive biology and demography. Its highly restricted habitat requirements in serpentine seeps, springs and drainages are likely limiting factors in the species' distribution and abundance. The hydrologic systems that maintain this habitat will be managed and maintained by the Plan. It is also possible that invasive weeds and insects have adverse effects and pose significant threats to the species. Further research into these threats is necessary to successfully manage this species (STUDIES-5).

It is not clear whether grazing benefits or adversely affects Mt. Hamilton thistle. For this reason, grazing in or adjacent to Mt. Hamilton thistle occurrences will include experimental exclusions and control sites, where feasible, to evaluate impacts (STUDIES-16). Adaptive management decisions can then be developed on the basis of monitoring results.

To help implement the Recovery Plan for this species (U.S. Fish and Wildlife Service 1998c), a permanent conservation seed bank for Mt. Hamilton thistle will be established in the same manner as described for Tiburon Indian paintbrush in Section 5.4.10 *Tiburon Indian paintbrush* subheading *Management Techniques and Tools* (STUDIES-12).

5.4.13 Santa Clara Valley Dudleya

There are a total of 209 known occurrences of Santa Clara Valley dudleya, 207 of which are in the study area. Only 47 of the 209 known occurrences have population estimates (see Chapter 4, Section 4.6.8 *Serpentine Plants* for more information). Impacts are allowed to 11 known occurrences by covered activities (**Tables 4-6 and 5-16**) if additional occurrences are not discovered during the permit term.

Biological Goals and Objectives

The Implementing Entity will protect, maintain the viability of, and increase the number and size of populations of Santa Clara Valley dudleya by acquiring and enhancing a minimum of 55 occurrences in the permit area (**Table 5-16**), if no additional occurrences are discovered during the permit term. Eleven of the 55 occurrences are located in County parks and will be protected when these parks are added to the Reserve System.

Santa Clara Valley dudleya is expected to benefit from the acquisition and enhancement of those grasslands (see Section 5.3.3 *Grassland Conservation and Management*) and oak woodlands that include serpentine rock outcrops (see Section 5.3.5 *Oak and Conifer Woodland Conservation and Management*).

Occurrence Acquisition

Regardless of the level of impact, the Implementing Entity will acquire (through acquisition or conservation easement) lands that support 55 extant occurrences of Santa Clara Valley dudleya throughout its entire range in the permit area (LAND-P2). In accordance with the *Recovery Plan for Serpentine Soil Species of the San Francisco Bay Area* (U.S. Fish and Wildlife Service 1998c), occurrences will be distributed throughout the range of the species (north, central, and south). The Implementing Entity will stratify protection and acquire sites in the study area on both sides of Coyote Valley to ensure geographic diversity in protected occurrences. The majority of the known occurrences will be acquired, enhanced through improved management, and monitored along Coyote Ridge in Coyote-4, 5, and 6. The number of occurrences in parentheses after each location name will also be acquired: Santa Teresa Hills and Tulare Hill (4), west of Calero County Park (2), and north of Morgan Hill (1). Incorporation of portions of Santa Teresa, Calero, Anderson Lake and Almaden Quicksilver County parks into the Reserve System (**Table 5-5**) will protect 11 of the 55 occurrences and provide opportunities for improved management and monitoring. This will bring total protection of this species to 57 occurrences in Type 1 open space.

The Recovery Plan recommends the protection of one occurrence in the San Martin Area because this represented the southern extent of the species range known at the time. There are two extant occurrences of Santa Clara dudleya near San Martin. One is located on a highly-parcelized, privately-owned plot and is not practical for acquisition consideration. The other occurrence is, at the writing of this Plan, in the process of being protected by a conservation easement for mitigation associated with the Corde Valle Golf Course[35]. Since the finalization of the Recovery Plan, the species' known range expanded south of the San Martin area (i.e., to Mount Madonna County Park). In response to new information collected since the finalization of the Recovery Plan, the Implementing Entity will acquire at least one occurrence (either known or found during the permit term) of Santa Clara Valley dudleya in the southern end of its range in the study area. This could include either the southwest or southeast portion of the study area. Therefore, the Implementing Entity will not focus on acquiring occurrences in the San Martin area.

As described in Chapter 4, the impact limit for this species could increase from 11 occurrences, if no additional occurrences are discovered during the permit term, to 14 occurrences, if additional occurrences are discovered during the permit term. A minimum of 4 occurrences have to be acquired prior to any newly discovered occurrence being impacted during the permit term. In other words, a minimum of 48 occurrences will be acquired and protected in the Reserve System before a 12th occurrence is impacted, a minimum of 52 occurrences will be acquired and protected in the Reserve System before a 13th occurrence is impacted, and a minimum of 56 occurrences will be acquired and protected in the Reserve System before a 14th occurrence is impacted. "Minimums" are referenced here because the Implementing Entity will protect 55 occurrences, regardless of impacts. The timing of acquisition of 44 of the 55 occurrences are linked to impacts, while the remaining 11 occurrences will be acquired for recovery purposes only and thus acquisition timing of these 11 occurrences are not linked to impacts. The newly discovered and acquired occurrences must be in better condition than the impacted occurrences, according to the criteria in Section 5.3.1 *Land Acquisition and Restoration Actions* subheading *Incorporating Covered Plant Species*. In addition, new occurrences must be acquired before the impacts occur and by Year 45 (the deadline for all Reserve System acquisition).

In order for an occurrence to count as protected under the Plan, there will be a buffer of at least 500 feet between the occurrence and adverse land uses, as described for Tiburon Indian paintbrush in Section 5.4.10 *Tiburon Indian Paintbrush*.

[35] This will be considered a protected occurrence once a conservation easement holder is identified and the conservation easement recorded.

Management Techniques and Tools

To successfully manage existing occurrences of Santa Clara Valley dudleya, targeted studies will be conducted to determine the biological definition of a population and the relationship between known occurrences and genetically-defined populations. Studies will also be conducted to determine factors limiting the expansion of extant occurrences (STUDIES-5). Such studies may include examining the effects of livestock grazing on the species by experimentally excluding livestock and monitoring the effects on occurrences (STUDIES-16). Other studies may focus on various factors related to management and microsite needs of the species at all life stages from germination through maturity (STUDIES-5).

The targeted studies will be used to inform the target occurrence size for managed occurrences. For this species, the relationship between population and recorded occurrence is unclear. It is possible that multiple occurrences compromise a single population. A preliminary goal of 2,000 individuals per population will be implemented as recommended in the *Recovery Plan for Serpentine Soil Species of the San Francisco Bay Area* (U.S. Fish and Wildlife Service 1998c); if approved by the wildlife agencies, this number will be adjusted as necessary pending research carried out during Plan implementation to assure viable occurrences of this species.

To help implement the Recovery Plan for this species (U.S. Fish and Wildlife Service 1998c), a permanent conservation seed bank for Santa Clara Valley dudleya will be established in the same manner as described for Tiburon Indian paintbrush in Section 5.4.10 *Tiburon Indian Paintbrush* subheading *Management Techniques and Tools* (STUDIES-12).

Uncertainties and Threats

Santa Clara Valley dudleya is a relatively well-studied plant, and more information and research is available for this species than for most of the other covered species. However, outstanding questions remain regarding the definition of a population and management issues. Research will be conducted to better define a population for this species to understand the effects of grazing. Management research will be conducted on grazing effects on Santa Clara Valley dudleya as discussed above (STUDIES-16) and on other limiting factors (STUDIES-5).

5.4.14 Fragrant Fritillary

There are a total of 59 known occurrences of fragrant fritillary throughout its range. There are eight known occurrences in the study area. Thirty-five of the 59 known occurrences have population estimates (see Chapter 4, Section 4.6.8 *Serpentine Plants* for more details). One of these known occurrences is expected to be impacted by covered activities, if no additional occurrences are discovered during the permit term (**Tables 4-6 and 5-16**).

Biological Goals and Objectives

The Implementing Entity will protect, maintain the viability of, and increase the size of populations of fragrant fritillary by acquiring and enhancing a total of four occurrences in the permit area, if no additional occurrences are discovered during the permit term (**Table 5-16**). Of these four occurrences, two will be located in the Diablo Range and two in the Santa Cruz Mountains to protect occurrences of this species across its range and across different environmental gradients.

Fragrant fritillary is expected to benefit from acquisition and enhancement of natural communities that serve as its primary or secondary modeled habitat, may contain known or undiscovered occurrences, and/or provide suitable habitat for occurrence creation, including grasslands (see Section 5.3.3 *Grassland Conservation and Management*), chaparral and coastal scrub (see Section 5.3.4 *Chaparral and Northern Coastal Scrub Conservation and Management*), oak and conifer woodlands (see Section 5.3.5 *Oak and Conifer Woodland Conservation and Management*), and seasonal wetlands (see Section 5.3.7 *Wetland and Pond Conservation and Management*).

Acquisition of Modeled Habitat

There are 165,455 acres of fragrant fritillary modeled habitat (primary and secondary) within the study area. A total of 42,317 acres (26%) of modeled habitat are located on Type 1, 2, or 3 open space with 16,371 acres (10%) permanently protected as Type 1 open space. The Plan will acquire a minimum of 23,000 acres of modeled habitat for the Reserve System. In addition, 4,000 acres will be added to the Reserve System from existing open space. These acquisitions and additions will increase the proportion of protected modeled habitat in the study area about 26% in Type 1 open space and 39% in Type 1, 2, or 3 open space (**Table 5-17**). Land acquisition that would protect primary and secondary modeled habitat would occur in almost all Conservation Analysis Zones in the study area in which land acquisition would occur.

Occurrence Acquisition

Regardless of the level of impact, four known extant occurrences of fragrant fritillary will be acquired for the Reserve System. Of these four, two occurrences will be protected along Coyote Ridge southeast of Metcalf Canyon and northeast of Morgan Hill (LAND-P8). The third occurrence is located in Calero County Park and will be protected through the incorporation of a portion of the park into the Reserve System (**Table 5-5**). The fourth occurrence will be located in the Santa Cruz Range.

As described in Chapter 4, the impact limit for this species could increase from 1 occurrence, if no additional occurrences are discovered during the permit term, to 3 occurrences, if additional occurrences are discovered during the permit term. A minimum of 3 occurrences have to be acquired prior to any newly discovered occurrence being impacted during the permit term. In other words, a minimum of 6 occurrences will be acquired and protected in the Reserve System before a 2nd occurrence is impacted and a minimum of 9 occurrences will be acquired and protected in the Reserve System before a 3rd occurrence is impacted. "Minimums" are referenced here because the Implementing Entity will protect 4 occurrences, regardless of impacts. The timing of acquisition of 3 of the 4 occurrences are linked to impacts, while the remaining 1 occurrence will be acquired for recovery purposes only and thus acquisition timing of this 1 occurrence is not linked to impacts. The newly discovered and protected occurrences must be in better condition than the impacted occurrences, according to the criteria in Section 5.3.1 *Land Acquisition and Restoration Actions* subheading *Incorporating Covered Plant Species*. In addition, new occurrences must be acquired before the impacts occur and by Year 45 (the deadline for all Reserve System acquisition).

In order for an occurrence to count as protected under the Plan, there will be a buffer of at least 500 feet between the occurrence and adverse land uses, as described for Tiburon Indian paintbrush in Section 5.4.10 *Tiburon Indian Paintbrush*.

Management Techniques and Tools

To successfully manage newly acquired occurrences of fragrant fritillary, targeted studies will be conducted to determine factors that limit occurrence expansion as well as those necessary for establishment and maintenance of new occurrences (STUDIES-5). Such studies may include specific seed germination requirements and successful transplantation requirements to create or augment new occurrences. Other studies may examine various factors related to management and microsite needs of the species at all life stages from germination through maturity (STUDIES-5). Adaptive management decisions can then be developed on the basis of monitoring results.

The targeted studies will be used to inform the target occurrence size for each managed occurrence. The specific target occurrence size will be developed by Year 10 of implementation, based on empirical data collected on occurrences in the Reserve System and other best available science. The Implementing Entity, in coordination with the Wildlife Agencies, will determine the target occurrence size.

To help the long-term viability of this species, a permanent conservation seed bank for fragrant fritillary will be established in the same manner as described for Tiburon Indian paintbrush in Section 5.4.10 *Tiburon Indian Paintbrush* subheading *Management Techniques and Tools* (STUDIES-12).

Uncertainties and Threats

Very little precise information about the ecology of this species exists, including details of its life history stages, population dynamics, microhabitat requirements (e.g., edaphic factors), demography, and pollination biology. Directed studies to determine limiting factors on survival and reproduction will help to successfully maintain and increase the size of occurrences of fragrant fritillary in perpetuity (STUDIES-5).

The actual occurrence size and age structure of the extant occurrences of fragrant fritillary in the study area are currently unknown. A key management action will be to survey extant occurrences as they are added to the Reserve System and to monitor these occurrences regularly to quantify and track the occurrence structure over time (STUDIES-5). This information will also be used to determine the targeted viable occurrence size of managed occurrences.

It is not clear whether grazing benefits or adversely affects fragrant fritillary. For this reason, grazing in or adjacent to fragrant fritillary occurrences will include experimental exclusions and control sites, where feasible, to evaluate impacts (STUDIES-16). Adaptive management decisions can then be developed on the basis of monitoring results.

5.4.15 Loma Prieta Hoita

There are a total of 26 known occurrences of Loma Prieta hoita throughout its range. There are 14 known occurrences in the study area. Only 18 of the 26 occurrences have population estimates (see Chapter 4, Section 4.6.9 *Non-Serpentine Plants* for more details). No impacts are allowed to these occurrences by covered activities (**Tables 4-6 and 5-16**).

Biological Goals and Objectives

The Implementing Entity will protect, maintain the viability of, and increase the number and size of populations of Loma Prieta hoita by acquiring and enhancing four extant occurrences within the study area (**Table 5-16**), if no additional occurrences are found during the permit term. Of the four occurrences, three are currently located in County parks. Loma Prieta hoita is expected to benefit from acquisition and enhancement of natural communities that serve as primary or secondary modeled habitat and/or contain known or undiscovered occurrences, including chaparral and coastal scrub (see Section 5.3.4 *Chaparral and Northern Coastal Scrub Conservation and Management*), oak and conifer woodlands (see Section 5.3.5 *Oak and Conifer Woodland Conservation and Management*), and mixed riparian forest and woodland (see Section 5.3.6 *Riverine and Riparian Forest and Scrub Conservation and Management*).

Acquisition of Modeled Habitat

There are 121,871 acres of Loma Prieta hoita modeled habitat (primary and secondary) within the study area. A total of 38,667acres (32%) of modeled habitat are located on Type 1, 2, or 3 open space with 17,276acres (14%) permanently protected as Type 1 open space. The Plan will acquire a minimum of 10,000 acres of modeled habitat for the Reserve System. In addition, 4,100 acres of modeled habitat will be added to the Reserve System from existing open space. These additions and acquisitions will increase the proportion of protected modeled habitat in the study area to about 26% in Type 1 open space and 40% in Type 1, 2, or 3 open space (**Table 5-17**).

Occurrence Acquisition

Regardless of impact, 4 occurrences will be acquired or added to the Reserve System. Of these, three occurrences will be permanently protected by inclusion of portions of Santa Teresa, Almaden Quicksilver and Calero County parks (**Table 5-5** and **Figure 5-4**), and a fourth occurrence will be acquired on the east side of the Santa Clara Valley, just east of U.S. 101, south of Motorcycle Park. It does not have a size estimate (California Natural Diversity Database 2009).

As described in Chapter 4, the impact limit for this species could increase from 0 occurrences if no additional occurrences are discovered during the permit term to 2 occurrences if additional occurrences are discovered during the permit term. A minimum of two occurrences have to be acquired prior to any newly discovered occurrence being impacted during the permit term. In other words, a minimum of 2 occurrences will be acquired and protected in the Reserve System before the 1st occurrence is impacted and a minimum of 4 occurrences will be acquired and protected in the Reserve System before the 2nd occurrence is impacted. “Minimums” are referenced here because the Implementing Entity will protect four occurrences, regardless of impacts. The timing of these recovery efforts are not linked to impacts. The newly discovered and protected occurrences must be in better condition than the impacted occurrences, according to the criteria in Section 5.3.1 *Land Acquisition and Restoration Actions* subheading *Incorporating Covered Plant Species*. In addition, new occurrences must be acquired before the impacts occur and by Year 45 (the deadline for all Reserve System acquisition).

In order for an occurrence to count as protected under the Plan, there will be a buffer of at least 500 feet between the occurrence and adverse land uses, as described for Tiburon Indian paintbrush in Section 5.4.10 *Tiburon Indian Paintbrush*.

Management Techniques and Tools

To successfully manage existing occurrences of Loma Prieta hoita, targeted studies will be conducted to determine factors limiting the expansion of extant occurrences (STUDIES-5). Other studies may focus on factors related to management and microsite needs of the species at all life stages from germination through maturity (STUDIES-5). Adaptive management decisions can then be developed on the basis of monitoring results.

The targeted studies will be used to inform the target occurrence size for managed occurrences. The specific target occurrence size will be developed by Year 10 of implementation, based on empirical data collected on occurrences in the Reserve System and other best available science. The Implementing Entity, in coordination with the Wildlife Agencies, will determine the target occurrence size.

A permanent conservation seed bank for Loma Prieta hoita will be established in the same manner as described for Tiburon Indian paintbrush in Section 5.4.10 *Tiburon Indian Paintbrush* subheading *Management Techniques and Tools* (STUDIES-12).

Uncertainties and Threats

Loma Prieta hoita has not been well studied, and little is known about its population biology or ecological effects and needs. Because management and conservation decisions for this species are limited in their potential efficacy, the Implementing Entity has little information with which to design and plan specific management and monitoring protocols. Accordingly, directed studies are needed to successfully establish and maintain new occurrences in perpetuity (STUDIES-5).

The actual occurrence size and age structure of the extant occurrences of Loma Prieta hoita in the study area are currently unknown. A key management action will be to survey and monitor the new occurrence when it is added to the Reserve System and at regular intervals thereafter to quantify and track the occurrence structure over time (STUDIES-5). This information will also be used to determine the targeted viable occurrence size of managed occurrences.

Threats to Loma Prieta hoita are thought to include cattle grazing and trampling, feral pig rooting, development, and vegetation clearing. Studies may be conducted to investigate the details of these threats and the best measures to mitigate them (STUDIES-5).

5.4.16 Smooth Lessingia

There are a total of 39 known occurrences of smooth lessingia throughout its range. All known occurrences are located in the study area. Only 22 of the 39 known occurrences have population estimates (see Chapter 4, Section 4.6.8 *Serpentine Plants* for more information). Impacts are allowed to six known occurrences by covered activities, if no additional occurrences are discovered during the permit term (**Tables 4-6 and 5-16**).

Biological Goals and Objectives

Regardless of impact, the Implementing Entity will protect, maintain the viability of, and increase the number and size of occurrences of smooth lessingia by protecting and enhancing a total of 24 occurrences in the permit area (**Table 5-16**) if no additional occurrences are discovered during the permit term. Twelve of the 24 protected occurrences must be naturally-occurring populations and will fulfill mitigation requirements for the impact of up to six occurrences. Five of these twelve natural occurrences will be protected through the incorporation of County Park lands into the Reserve System. To contribute to recovery, an additional 12 occurrences will be protected by the Implementing Entity through two possible methods, in the order of priority: (1) acquire land for the Reserve System that supports new or rediscovered historical occurrences by Year 45, or (2) create new occurrences within the Reserve System by Year 40.

Smooth lessingia is expected to benefit from acquisition and enhancement of grassland natural communities that serve as primary habitat, may contain known occurrences, and/or provide suitable for occurrence expansion (see Section 5.3.3 *Grassland Conservation and Management*).

Acquisition of Modeled Habitat

There are 10,491 acres of primary smooth lessingia modeled habitat within the study area. A total of 3,659 acres (35%) of modeled habitat are located on Type 1, 2, or 3 open space with 1,268 acres (12%) permanently protected as Type 1 open space. The Plan will acquire a minimum of 4,000 acres of modeled habitat, including seven new occurrences, for the Reserve System. In addition, 1,100 acres of modeled habitat will be added to the Reserve System from existing open space, including five known occurrences. These acquisitions and additions will increase the proportion of protected modeled habitat in the study area to about 61% as Type 1 open space and 73% as Type 1, 2 or 3 open space (**Table 5-17**).

Occurrence Acquisition

Regardless of impacts, five known occurrences will be acquired through the incorporation of portions of Santa Teresa, and Calero County parks into the Reserve System (**Table 5-5** and **Figure 5-4**) to improve management, habitat enhancement, and long-term monitoring. The Implementing Entity will also acquire seven additional natural occurrences of smooth lessingia (LAND-P7) regardless of impacts.

Only two of the protected occurrences have size estimates, which total 1,815. The seven additional new occurrences that would be acquired by Plan implementation are located on the west side of U.S. 101 in the Santa Cruz Mountains foothills, on serpentine areas between Tulare Hill and Mount Madonna County Park. The Implementing Entity will also protect an additional twelve new occurrences in the Reserve System to contribute to species recovery (LAND-P7; **Table 5-16**). If these twelve occurrences cannot be found or acquired in the Reserve System, then the Implementing Entity will create occurrences (i.e., if no occurrences are acquired, twelve occurrences will be created, if one occurrence is acquired, eleven occurrences will be created, etc.) as described below.

As described in Chapter 4, the impact limit for this species could increase from 6 occurrences, if no additional occurrences are discovered during the permit term, to 9 occurrences, if additional occurrences are discovered during the permit term (**Table 5-16**). A minimum of two occurrences have to be acquired prior to any newly discovered occurrence being impacted during the permit term. In other words, a minimum of 14 occurrences will be protected in the Reserve System before a seventh occurrence is impacted, a minimum of 16 occurrences will be protected in the Reserve System before a eighth occurrence is impacted, and a minimum of 18 occurrences will be protected in the Reserve System before a ninth occurrence is impacted. "Minimums" are referenced here because the Implementing Entity will protect 24 occurrences, regardless of impacts. The timing of acquisition of 12 of the 24 occurrences are linked to impacts (as described in Chapter 4), while the remaining 12 occurrences will be acquired to contribute to recovery and can be acquired at any time before Year 45. The newly discovered and protected occurrences must be in better condition than the impacted occurrences, according to the criteria in Section 5.3.1 *Land Acquisition and Restoration Actions* subheading *Incorporating Covered Plant Species*. In addition, new occurrences must be acquired before the impacts occur and by Year 45 (the deadline for all Reserve System acquisition).

In order for an occurrence to count as protected under the Plan, there will be a buffer of at least 500 feet between the occurrence and adverse land uses, as described for Tiburon Indian paintbrush in Section 5.4.10 *Tiburon Indian Paintbrush*.

Occurrence Creation

If 12 new occurrences of smooth lessingia are not acquired for the purposes of recovery, the Implementing Entity will create up to 12 occurrences of smooth lessingia (i.e., if no occurrences are acquired, 12 will be created; if one occurrence is acquired, 11 will be created, etc.). Creation is only considered as a conservation action, not mitigation.

Occurrence creation is expected to occur later in the permit term (but no later than by Year 40) because of the need to: (1) exhaust opportunities to discover new occurrences (which are the first priority), (2) assemble enough of the Reserve System to provide suitable habitat for occurrence creation, and (3) allow sufficient time to study optimum habitat conditions, target occurrence size and structure, and propagation techniques. The decision to focus conservation effort on occurrence creation will be made jointly with CDFG and USFWS. The Implementing Entity, in coordination with the Wildlife Agencies, will determine the target occurrence size and structure for created occurrences based on empirical data collected on occurrences in the Reserve System and other best available science.

Suitable habitat for created occurrences will be identified based on the habitat of known occurrences and any other available data at the time of acquisition (STUDIES-5). Suitable propagation and/or planting techniques will be researched and identified to create new occurrences of smooth lessingia from existing occurrences within Santa Clara County or adjacent watersheds (STUDIES-14). Biologically appropriate seed sampling techniques from existing occurrences, including sustainable harvest amounts, will also be determined through field and literature research (STUDIES-14). Additionally, if the number of propagules allow, field experiments will be conducted to test alternative techniques for occurrence establishment (STUDIES-15).

Management Techniques and Tools

Targeted studies will be used to inform the target occurrence size for managed occurrences. A preliminary goal of 2,000 individuals per occurrence will be implemented as recommended in the *Recovery Plan for Serpentine Soil Species of the San Francisco Bay Area* (U.S. Fish and Wildlife Service 1998c); if approved by the wildlife agencies, this number will be adjusted as necessary pending research carried out during Plan implementation to assure viable occurrences of this species.

Targeted studies will be conducted to determine factors limiting the expansion of extant occurrences (STUDIES-5). Such studies will include examining the effects of livestock grazing on the species by experimentally excluding livestock and monitoring the effects on occurrences (STUDIES-16). Other studies may focus on various factors related to management and microsite needs of the species at all life stages from germination through maturity (STUDIES-5).

To help implement the Recovery Plan for this species (U.S. Fish and Wildlife Service 1998c), a permanent conservation seed bank for smooth lessingia will be established in the same manner as described for Tiburon Indian paintbrush in Section 5.4.10 *Tiburon Indian Paintbrush* subheading *Management Techniques and Tools* (STUDIES-12).

Uncertainties and Threats

Very little information about the ecology and general habitat requirements of this species exists, including details of its life history stages, population dynamics, microhabitat requirements, demography, and pollination biology. Accordingly, directed studies are needed to successfully establish and maintain new occurrences in perpetuity (STUDIES-5). The management needs of the species also need investigation.

The actual size of the extant occurrences of smooth lessingia are mostly unknown. A key management action will be to survey extant occurrences as they are added to the Reserve System and monitor these occurrences regularly to quantify and track the occurrence structure over time (STUDIES-5).

Threats to smooth lessingia are thought to include cattle grazing, foot traffic (trampling), competition from invasive nonnative plants, and road and trail maintenance. Studies may be conducted to investigate the details of these threats and the best measures to mitigate them (STUDIES-5). It is not clear whether grazing benefits or adversely affects smooth lessingia. For this reason, grazing in or adjacent to smooth lessingia occurrences will include experimental exclusions and control sites, where feasible, to evaluate impacts (STUDIES-16). Adaptive management decisions can then be developed on the basis of monitoring results.

5.4.17 Metcalf Canyon Jewelflower

There are 11 known occurrences of Metcalf Canyon jewelflower throughout its range, 10 of which are in the study area. Only four of the 10 known occurrences have population estimates (see Chapter 4, Section 4.6.8 *Serpentine Plants* for more information). Impacts are allowed to two of the known occurrences by covered activities (**Tables 4-6 and 5-16**).

Biological Goals and Objectives

The Implementing Entity will protect, maintain the viability of, and increase the number and size of populations of Metcalf Canyon jewelflower by protecting a total of 13 occurrences in the permit area. To do this, the Implementing Entity will acquire and enhance at least three known occurrences in the permit area (**Table 5-16**). The Implementing Entity will also protect 10 new occurrences through two possible methods, in order of priority: (1) acquire land for the Reserve System that supports new or rediscovered historical occurrences by Year 45, or (2) create new occurrences within the Reserve System by Year 40.

Metcalf Canyon Jewelflower is expected to benefit from acquisition and enhancement of grassland natural communities that serve as its primary habitat, contain known occurrences, and/or provide suitable habitat for occurrence creation (see Section 5.3.3 *Grassland Conservation and Management*).

Acquisition of Modeled Habitat

There are 8,105 acres of primary modeled habitat for Metcalf Canyon jewelflower within the study area. A total of 2,843 acres (35%) of modeled habitat are located on Type 1, 2, or 3 open space with 984 acres (12%) permanently protected as Type 1 open space. The Plan proposes to acquire a minimum of 3,200 acres of modeled habitat for the Reserve System. In addition, 1,000 acres of modeled habitat will be added to the Reserve System from existing open space. These acquisitions and additions will increase the proportion of protected modeled habitat in the study area to about 64% as Type 1 open space and 75% as Type 1, 2, or 3 open space (**Table 5-17**).

Land acquired for the Reserve System will protect suitable habitat for Metcalf Canyon jewelflower on the north side of Tulare Hill on the west side of Coyote Valley (LAND-P4). Suitable habitat in this area includes serpentine grasslands and serpentine outcrops and road cuts that have little soil development and are surrounded by grasslands. Target areas include Coyote Ridge near Metcalf Canyon where 68 occurrences of an unidentified jewelflower have been found (Arcadis 2008). It is unclear how many of these are Metcalf Canyon jewelflower but due to the proximity of known occurrences, many are likely to be this subspecies (the other likely candidate is most beautiful jewelflower).

Occurrence Acquisition

Regardless of the level of impact, the Implementing Entity will acquire at least three known extant occurrences of Metcalf Canyon jewelflower (LAND-P3). Acquisition of the three known occurrence must occur prior to the first impact. The Implementing Entity will also identify and protect an additional 10 new occurrences in the Reserve System to contribute to species recovery by Year 45 (the deadline for all Reserve System acquisition). If 10 new occurrences cannot be found and acquired in the Reserve System, then the Implementing Entity will create occurrences (i.e., if no occurrences are acquired, 10 will be created; if one occurrence is acquired, nine will be created, etc.) as described in the section below.

The *Recovery Plan for Serpentine Soil Species of the San Francisco Bay Area* (U.S. Fish and Wildlife Service 1998c) calls for the acquisition of nine natural occurrences of Metcalf Canyon jewelflower to meet recovery criteria. At the time the Recovery Plan was written there were 13 known, extant occurrences of Metcalf Canyon jewelflower in the study area. Currently, there are 10 known, extant occurrences within the study area. Several of these occurrences are located on private lands that are highly parcelized and urbanized, making them low-priority targets for conservation.

The Habitat Plan will protect the highest quality natural occurrences. In combination with the one existing occurrence protected in Type 1 open space, there will be four protected natural occurrences in the study area prior to the first impact to the species or by Year 45 of the Plan, whichever comes first. There are several “jewelflower” occurrences that have yet to be determined to be Metcalf Canyon jewelflower or most beautiful jewelflower. Some of these occurrences are likely to be Metcalf Canyon jewelflower. Acquisition of these or other natural occurrences would be prioritized to meet the requirement to acquire or create ten more occurrences to contribute to species recovery.

In order for an occurrence to count as protected under the Plan, there will be a buffer of at least 500 feet between the occurrence and adverse land uses, as described for Tiburon Indian paintbrush in Section 5.4.10 *Tiburon Indian Paintbrush*.

Occurrence Creation

If new occurrences of Metcalf Canyon jewelflower are not found and preserved, the Implementing Entity will create up to 10 occurrences of Metcalf Canyon jewelflower (i.e., if no occurrences are acquired, 10 will be created; if one existing occurrence is acquired, nine will be created, etc.). Creation is only considered as a conservation action, not mitigation.

Occurrence creation is expected to occur later in the permit term (but no later than by Year 40) because of the need to: (1) exhaust opportunities to discover new occurrences (which are the first priority), (2) assemble enough of the Reserve System to provide suitable habitat for occurrence creation, and (3) allow sufficient time to study optimum habitat conditions, target occurrence size and structure, and propagation techniques. The decision to focus conservation effort on occurrence creation will be made jointly with CDFG and USFWS. The Implementing Entity, in coordination with the Wildlife Agencies, will determine the target occurrence size and structure for created occurrences based on empirical data collected on occurrences in the Reserve System and other best available science.

Targeted studies and current research will be used to inform new occurrence establishment. Suitable habitat for created occurrences will be identified based on the habitat of known occurrences and any other available data at the time of acquisition (STUDIES-5). This will involve identifying suitable locations in the Reserve System and researching and identifying biologically appropriate and viable propagation or planting techniques for this species (STUDIES-13, STUDIES-14). It will also entail conducting field and literature research to determine the biologically appropriate seed sampling techniques and harvest numbers for acquisition of seed from existing occurrences (STUDIES-14). In addition, field experiments will be conducted (if the number of propagules allows) to test alternative techniques for occurrence establishment (STUDIES-15). Extensive research is being done on the propagation needs and responses of this species by Justen Whittall and co-investigators at Santa Clara University (Whittall 2008, 2011); preliminary results indicate that successful occurrence creation is feasible. In addition, their field surveys suggest that sites for 10 occurrences should be available (J. Whittall pers. comm.; Whittall 2011). Their results and expertise, along with other scientific data available during Plan implementation, will be consulted during Plan implementation.

The Recovery Plan (U.S. Fish and Wildlife Service 1998c) recommends that protected populations be distributed throughout the range of the species, including at least 25% west of U.S. 101 and 75% in the Metcalf Canyon area, east of U.S. 101. The Implementing Entity will consider these guidelines as associated with protection and creation efforts for this Plan unless best available science indicates that a different distribution would be more beneficial to the conservation of the species. There are currently no known occurrences west of U.S. 101.

Management Techniques and Tools

To successfully manage and create new occurrences of Metcalf Canyon jewelflower, targeted studies will be conducted to determine factors that limit occurrence expansion, as well as those necessary for establishment and maintenance of new occurrences (STUDIES-5). Such studies may include specific seed germination requirements and successful transplantation requirements to create or augment new occurrences. Other studies may examine factors related to management and microsite needs of the species at all life stages from germination through maturity (STUDIES-5).

The targeted studies will be used to inform the target occurrence size for managed occurrences. A preliminary goal of 2,000 individuals per occurrence will be implemented as recommended in the *Recovery Plan for Serpentine Soil Species of the San Francisco Bay Area* (U.S. Fish and Wildlife Service 1998c); if approved by the Wildlife Agencies, this number will be adjusted as necessary pending research carried out during Plan implementation to assure viable occurrences of this species.

To help implement the Recovery Plan for this species (U.S. Fish and Wildlife Service 1998c), a permanent conservation seed bank for Metcalf Canyon jewelflower will be established in the same manner as described for Tiburon Indian paintbrush in Section 5.4.10 *Tiburon Indian Paintbrush* subheading *Management Techniques and Tools* (STUDIES-12).

Uncertainties and Threats

Metcalf Canyon jewelflower has not been well studied, and little is known about its population biology or ecological effects and needs. Because management and conservation decisions for this species are limited in their potential efficacy, the Implementing Entity has little information with which to design and plan specific management and monitoring protocols. Accordingly, directed studies are needed to successfully establish and maintain new occurrences in perpetuity (STUDIES-5).

The actual size and age structure of the extant occurrences of Metcalf Canyon jewelflower in the study area are currently unknown. A key management action will be to survey extant occurrences as they are added to the Reserve System and regularly monitor these occurrences, as well as the newly created occurrence, to quantify and track occurrence structure over time (STUDIES-5).

Threats to Metcalf Canyon jewelflower are thought to include cattle grazing, urban development, off-road motorcycles, garbage dumping, and road construction and maintenance. Studies may be conducted to investigate the details of these threats and the best measures to mitigate them (STUDIES-5).

5.4.18 Most Beautiful Jewelflower

There are a total of 86 most beautiful jewelflower known occurrences throughout its range. There are 39 known occurrences within the study area. Only 40 of the 86 known occurrences have population estimates (see Chapter 4, Section 4.6.8 *Serpentine Plants* for more information). Impacts to six known occurrences are allowed by covered activities (**Tables 4-6 and 5-16**) if no additional occurrences are discovered during the permit term.

Biological Goals and Objectives

The Implementing Entity will protect, maintain the viability of, and increase the number and size of populations of most beautiful jewelflower by acquiring and enhancing 17 known extant occurrences in the permit area, if no additional occurrences are discovered during the permit term (**Table 5-16**). This includes acquisition of nine known occurrences for the Reserve System and the addition of eight known occurrences when portions of Alamaden Quicksilver, Calero, and Santa Teresa County parks are added into the Reserve System.

Most beautiful jewelflower is expected to benefit from acquisition and enhancement of natural communities that serve as its primary or secondary habitat and/or contain known extant occurrences, including grasslands (see Section 5.3.3 *Grassland Conservation and Management*) and chaparral and coastal scrub (see Section 5.3.4 *Chaparral and Northern Coastal Scrub Conservation and Management*).

Acquisition of Modeled Habitat

There are 14,362 acres of most beautiful jewelflower modeled habitat (primary and secondary) within the study area. A total of 5,042 acres (35%) of modeled habitat are located on Type 1, 2, or 3 open space with 1,500 acres (10%) permanently protected as Type 1 open space. The Plan proposes to acquire a minimum of 4,000acres of modeled habitat for the Reserve System. In addition, 1,700 acres of modeled habitat will be added to the Reserve System from existing open space. These acquisitions and addition will increase the proportion of protected modeled habitat in the study area to about 50% as Type 1 open space and 63% as Type 1, 2, or 3 open space (**Table 5-17**).

Land acquired for the Reserve System will protect suitable habitat along Coyote Ridge, in the Santa Teresa Hills, and west of Chesbro Reservoir, as well as, near Morgan Hill and in the southern end of the study area in the Santa Cruz Mountain foothills. Target areas include Coyote Ridge near Metcalf Canyon where 68 occurrences of an unidentified jewelflower have been found (Arcadis 2008). It is unclear how many of these are most beautiful jewelflower but due to the proximity of known occurrences, many are likely to be this subspecies (the other likely candidate is Metcalf Canyon jewelflower).

Occurrence Acquisition

Regardless of the level of impact, 17 occurrences will be protected in the Reserve System (**Table 5-16**). Eight occurrences will be incorporated into the Reserve System to improve management and monitoring, and expand each occurrence, if biologically feasible, when portions of Alamaden Quicksilver, Calero, and Santa Teresa County parks are added to the Reserve System. In addition, the Implementing Entity will acquire nine occurrences of most beautiful jewelflower (LAND-P5).

As described in Chapter 4, the impact limit for this species could increase from 6 occurrences, if no additional occurrences are discovered during the permit term, to 8 occurrences, if additional occurrences are discovered during the permit term. A minimum of 2 occurrences have to be acquired prior to any newly discovered occurrence being impacted during the permit term. In other words, a minimum of 14 occurrences will be acquired and protected in the Reserve System before the 7th occurrence is impacted and a minimum of 16 occurrences will be acquired and protected in the Reserve System before the 8th occurrence is impacted. "Minimums" are referenced here because the Implementing Entity will protect 17 occurrences, regardless of impacts. The timing of acquisition of 12 of the 17 occurrences are linked to impacts, while the remaining 5 occurrences will be acquired for recovery purposes only and thus acquisition timing of these 5 occurrences are not linked to impacts. The newly discovered and protected occurrences must be in better condition than the impacted occurrences, according to the criteria in Section 5.3.1 *Land Acquisition and Restoration Actions* subheading *Incorporating Covered Plant Species*. In addition, new occurrences must be acquired before the impacts occur and by Year 45 (the deadline for all Reserve System acquisition).

There is a high potential to acquire additional natural populations under the Plan. As stated in section above, there are several "jewelflower" occurrences that have yet to be determined to be Metcalf Canyon jewelflower or most beautiful jewelflower. Some of these occurrences are likely to be most beautiful jewelflower. In order for an occurrence to count as protected under the Plan, there will be a buffer of at least 500 feet between the occurrence and adverse land uses, as described for Tiburon Indian paintbrush in Section 5.4.10 *Tiburon Indian Paintbrush*.

Management Techniques and Tools

To successfully manage occurrences of most beautiful jewelflower, targeted studies will be conducted to determine factors that limit occurrence expansion

(STUDIES-5). Such studies may examine factors related to management and microsite needs of the species at all life stages from germination through maturity (STUDIES-5). Adaptive management decisions can then be developed on the basis of monitoring results to mitigate, minimize, or eliminate limiting factors.

The targeted studies will be used to inform the target size for managed occurrences. A preliminary goal of 2,000 individuals per occurrence will be implemented as recommended in the *Recovery Plan for Serpentine Soil Species of the San Francisco Bay Area* (U.S. Fish and Wildlife Service 1998c); if approved by the Wildlife Agencies, this number will be adjusted as necessary pending research carried out during Plan implementation to assure viable occurrences of this species.

To help implement the Recovery Plan for this species (U.S. Fish and Wildlife Service 1998c), a permanent conservation seed bank for most beautiful jewelflower will be established in the same manner as described for Tiburon Indian paintbrush in Section 5.4.10 *Tiburon Indian Paintbrush* subheading *Management Techniques and Tools* (STUDIES-12).

Uncertainties and Threats

Most beautiful jewelflower has been studied; however, little is known about its reproductive biology or demography. Herbivory and its impacts on the species are also poorly understood. Because management and conservation decisions for this species are limited in their potential efficacy, the Implementing Entity has little information with which to design and plan specific management and monitoring protocols. Accordingly, directed studies are needed to successfully establish and maintain new occurrences in perpetuity (STUDIES-5).

The age structure and occurrence trends of the extant occurrences of most beautiful jewelflower in the study area are currently unknown. An important management action will be to survey extant occurrences as they are added to the Reserve System and regularly monitor these occurrences to quantify and track the occurrence structure over time (STUDIES-5).

Threats to most beautiful jewelflower are thought to include cattle grazing, competition from invasive nonnative species (notably yellow star-thistle), habitat loss from residential development and road construction, rooting by feral pigs, and disturbance from landfill operations. Studies may be conducted to investigate the details of these threats and the best measures to mitigate them (STUDIES-5).

Table 5-1a. Biological Goals, Objectives and Conservation Actions: Landscape Level

Biological Goals and Objectives	Conservation Actions[1,2]	Monitoring Action
Goal 1a. Protect and maintain natural and semi-natural landscapes.[1]		
Objective 1a.1. Establish a reserve system of at least 46,496 acres and 100 stream miles within the study area (see Figure 5-05 for acquisition target areas by Conservation Analysis Zones).[2, 3]	LAND-L1. Acquire in fee title or obtain easements on 100 stream miles within the study area.	Compliance monitoring and annual reports
	LAND-L2a. Acquire in fee title or obtain easements on at least 33,205 acres of land for the Reserve System.	Compliance monitoring and annual reports
	LAND-L2b. Incorporate 13,291 acres of existing open space into the Reserve System.	Compliance monitoring and annual reports
Objective 1a.2. Protect streams (100 miles), ponds (50 acres) freshwater wetlands (10 acres), and seasonal wetlands (5 acres) within the Reserve System.	LAND-L3. Acquire in fee title or obtain easements on streams (100 miles), ponds (50 acres), freshwater wetlands (10 acres), and seasonal wetlands (5 acres) in all watersheds of the study area.	Compliance monitoring and annual reports
Goal 1b. Protect and maintain ecological (natural) processes.		
Objective 1b.1. Protect a range of environmental gradients (such as slope, elevation, aspect, rainfall) across a diversity of natural communities within the Reserve System.[2, 3]	LAND-L2c. Acquire in fee title or obtain easements on 33,205 acres of land for the Reserve System that includes the full range of topographic and geographic diversity in the study area.	Compliance monitoring and annual reports
	LAND-L2d. Incorporate 13,291 acres of existing open space into the Reserve System that includes the full range of topographic and geographic diversity in the study area.	Compliance monitoring and annual reports
Goal 2. Maintain or improve opportunities for movement and genetic exchange of native organisms within and between natural communities inside and connecting to areas outside of the study area.[4]		
Objective 2.1. Determine wildlife movement across Coyote Creek downstream of Anderson Reservoir, Pacheco Creek (SR 152), and the Pajaro River when adequate monitoring data exist on wildlife movement in the three focal areas or by year 10 of implementation, whichever comes first.	STUDIES-1. Conduct feasibility study to determine wildlife movement across Coyote Creek downstream of Anderson Reservoir, Pacheco Creek (SR 152), and the Pajaro River.	Analyze and quantify movement of indicator species to determine whether linkages are functioning as intended.
Objective 2.2. Protect and enhance important habitat linkages for covered species and other native species within the Reserve System and protect connectivity to habitat outside the study area (Figure 5-6 and Table 5-9).[2]	LAND-L4. Acquire and enhance natural and semi-natural landscapes between the Santa Teresa Hills and Metcalf Canyon to the south that will contribute to providing connectivity between the Santa Cruz Mountains and the Diablo Range to promote the movement of covered and other native species at many spatial scales (Linkage 10 in Table 5-9 and Figure 5-6).	Compliance monitoring for land acquisition. Analyze and quantify movement of indicator species to determine whether linkages are functioning as intended.
	LAND-L5. Acquire in fee title or obtain easements on 2,900 acres of serpentine grassland along Coyote Ridge to link existing protected areas and to create a large core reserve for serpentine grassland species to move within (Linkage 6 in Table 5-9 and Figure 5-6). These acreages are inclusive of, not in addition to, acquisition targets set in LAND-G3.	Compliance monitoring for land acquisition. Analyze and quantify movement of indicator species to determine whether linkages are functioning as intended.
	LAND-L6. Acquire in fee title or obtain easements on at least 3,000 acres of grassland, chaparral & coastal scrub, and oak woodland natural communities south of Henry W. Coe State Park to link this core reserve with extensive wetlands surrounding San Felipe Lake in San Benito County (Linkage 14 in Table 5-9 and Figure 5-6).	Compliance monitoring for land acquisition. Analyze and quantify movement of indicator species to determine whether linkages are functioning as intended.

Table 5-1a. Continued

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Biological Goals and Objectives	Conservation Actions[1,2]	Monitoring Action
	LAND- L7. Acquire in fee title or obtain easements on at least 2,300 acres of grassland, chaparral & coastal scrub, and oak woodland natural communities in the NE corner of the study area to link the core reserve that includes Joseph Grant County Park with SFPUC lands and other protected lands in Alameda County (Linkage 4 in Table 5-9 and Figure 5-6).	Compliance monitoring for land acquisition. Analyze and quantify movement of indicator species to determine whether linkages are functioning as intended.
	LAND-L8. Acquire in fee title or obtain easements on at least 500 acres of grassland, chaparral & coastal scrub, and oak woodland natural communities to connect Almaden Quicksilver County Park with protected open space to the east near Calero Lake (Linkage 9 in Table 5-9 and Figure 5-6).	Compliance monitoring for land acquisition. Analyze and quantify movement of indicator species to determine whether linkages are functioning as intended.
	LAND-L9. Acquire in fee title or obtain easements on 2,000 acres of conifer woodland, riparian forest & scrub, oak woodland, and grassland natural communities, in the portion of the Pescadero Watershed that is in the study area and along the Pajaro River, to maintain wildlife connections between the Santa Cruz Mountains and the Gabilan Range outside the study area (Linkages 18, 19, and 20 in Table 5-9 and Figure 5-6).	Compliance monitoring for land acquisition. Analyze and quantify movement of indicator species to determine whether linkages are functioning as intended.
	LAND-L10. Acquire in fee title or obtain easements on serpentine grassland along Coyote Ridge to protect the connection between Silver Creek and Kirby Canyon (Linkage 6 in Table 5-9 and Figure 5-6) as part of the acquisition targets set in LAND-G3.	Compliance monitoring for land acquisition. Analyze and quantify movement of indicator species to determine whether linkages are functioning as intended.
Objective 2.3. Increase the permeability of Highway 152 for species movement across Pacheco Creek and Highway 152 from the Highway 152/156 interchange east to the Santa Clara/Merced county line with structures that have the potential to most benefit movement of a variety of native species by year 20 (Linkage 15 in Figure 5-6 and Table 5-9).[6,7]	LM-1. Remove fences and private roads in areas where they are no longer needed and where their removal could increase the permeability of the study area for wildlife.	Compliance monitoring for infrastructure/structure removal, replacement, or installation. Monitor wildlife movement (or plant distribution if applicable) in target areas. Monitor movement of indicator species for connectivity.
	LM-2. When replacing small culverts ensure that the culvert has a natural bottom and is large enough for larger mammals such as deer and mountain lions to pass, if feasible. Culverts must provide direct movement from one side of the road to the other and ensure that the culvert is visible to the target species (i.e., do not obscure entrance with vegetation). Install fencing or other features that will direct wildlife towards the culvert or other safe crossing within the first 20 years of implementation.	Compliance monitoring for infrastructure/structure removal, replacement, or installation. Monitor wildlife movement (or plant distribution if applicable) in target areas. Monitor movement of indicator species for connectivity.
	LM-3. Where structurally possible, replace culverts with free span bridges to ensure free movement for wildlife under roadways.	Compliance monitoring for infrastructure/structure removal, replacement, or installation. Monitor wildlife movement (or plant distribution if applicable) in target areas. Monitor movement of indicator species for connectivity.
	LM-4. Ensure that median barrier removal and/or median perforations are considered as alternatives during project design.	Compliance monitoring for infrastructure/structure removal, replacement, or installation.

Table 5-1a. Continued

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Biological Goals and Objectives	Conservation Actions[1,2]	Monitoring Action
	LM-5. Remove median barriers or perforate sections of median barriers along roadways to improve successful wildlife crossings and install fencing or other features to direct wildlife to those open sections within first 20 years of implementation. Use feasibility study to determine location and length of barrier removal.	Compliance monitoring for infrastructure/structure removal, replacement, or installation. Monitor wildlife movement (or plant distribution if applicable) in target areas. Monitor movement of indicator species for connectivity.
Objective 2.4. Increase the permeability for species movement across Santa Clara Valley between the Diablo Range and the Santa Cruz Mountains and between Coyote Ridge and Diablo Range to the Santa Cruz Mountains via Coyote Valley, Tulare Hill, or Fisher Creek with structures that have the potential to most benefit movement of a variety of covered and other native species by year 20 (Linkages 8 and 10 in Figure 5-6 and Table 5-9).[6]	LM-1. Remove fences and private roads in areas where they are no longer needed and where their removal could increase the permeability of the study area for wildlife.	Compliance monitoring for infrastructure/structure removal, replacement, or installation. Monitor wildlife movement (or plant distribution if applicable) in target areas. Monitor movement of indicator species for connectivity.
	LM-2. When replacing small culverts ensure that the culvert has a natural bottom and is large enough for larger mammals such as deer and mountain lions to pass, if feasible. Culverts must provide direct movement from one side of the road to the other and ensure that the culvert is visible to the target species (i.e., do not obscure entrance with vegetation). Install fencing or other features that will direct wildlife towards the culvert or other safe crossing within the first 20 years of implementation.	Compliance monitoring for infrastructure/structure removal, replacement, or installation. Monitor wildlife movement (or plant distribution if applicable) in target areas. Monitor movement of indicator species for connectivity.
	LM-3. Where structurally possible, replace culverts with free span bridges to ensure free movement for wildlife under roadways.	Compliance monitoring for infrastructure/structure removal, replacement, or installation. Monitor wildlife movement (or plant distribution if applicable) in target areas. Monitor movement of indicator species for connectivity.
	LM-4. Ensure that median barrier removal and/or median perforations are considered as alternatives during project design.	Compliance monitoring for infrastructure/structure removal, replacement, or installation. Monitor wildlife movement (or plant distribution if applicable) in target areas. Monitor movement of indicator species for connectivity.
	LM-5. Remove median barriers or perforate sections of median barriers along roadways to improve successful wildlife crossings and install fencing or other features to direct wildlife to those open sections within first 20 years of implementation. Use feasibility study to determine location and length of barrier removal.	Compliance monitoring for infrastructure/structure removal, replacement, or installation. Monitor wildlife movement (or plant distribution if applicable) in target areas. Monitor movement of indicator species for connectivity.
Objective 2.5 (not used)		
Objective 2.6. Increase the permeability for species movement from the Santa Cruz Mountains to the Pajaro River with structures that have the potential to most benefit movement of a variety of covered and other native species by year 20 (Linkage 18, 19, and 20 in Figure 5-6 and Table 5-9).[6]	LM-1. Remove fences and private roads in areas where they are no longer needed and where their removal could increase the permeability of the study area for wildlife.	Compliance monitoring for infrastructure/structure removal, replacement, or installation. Monitor wildlife movement (or plant distribution if applicable) in target areas. Monitor movement of indicator species for connectivity.

Table 5-1a. Continued

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Biological Goals and Objectives	Conservation Actions[1,2]	Monitoring Action
	LM-2. When replacing small culverts ensure that the culvert has a natural bottom and is large enough for larger mammals such as deer and mountain lions to pass, if feasible. Culverts must provide direct movement from one side of the road to the other and ensure that the culvert is visible to the target species (i.e., do not obscure entrance with vegetation). Install fencing or other features that will direct wildlife towards the culvert or other safe crossing within the first 20 years of implementation.	Compliance monitoring for infrastructure/structure removal, replacement, or installation. Monitor wildlife movement (or plant distribution if applicable) in target areas. Monitor movement of indicator species for connectivity.
	LM-3. Where structurally possible, replace culverts with free span bridges to ensure free movement for wildlife under roadways.	Compliance monitoring for infrastructure/structure removal, replacement, or installation. Monitor wildlife movement (or plant distribution if applicable) in target areas. Monitor movement of indicator species for connectivity.
	LM-4. Ensure that median barrier removal and/or median perforations are considered as alternatives during project design.	Compliance monitoring for infrastructure/structure removal, replacement, or installation. Monitor wildlife movement (or plant distribution if applicable) in target areas. Monitor movement of indicator species for connectivity.
	LM-5. Remove median barriers or perforate sections of median barriers along roadways to improve successful wildlife crossings and install fencing or other features to direct wildlife to those open sections within first 20 years of implementation. Use feasibility study to determine location and length of barrier removal.	Compliance monitoring for infrastructure/structure removal, replacement, or installation. Monitor wildlife movement (or plant distribution if applicable) in target areas. Monitor movement of indicator species for connectivity.
Objective 2.7. Increase the permeability for species movement from Highway 152 to the confluence with the Pajaro River with structures that have the potential to most benefit movement of a variety of covered and other native species by year 20 (Linkages 12 in Figure 5-6 and Table 5-9).[6]	LM-1. Remove fences and private roads in areas where they are no longer needed and where their removal could increase the permeability of the study area for wildlife.	Compliance monitoring for infrastructure/structure removal, replacement, or installation. Monitor wildlife movement (or plant distribution if applicable) in target areas. Monitor movement of indicator species for connectivity.
	LM-2. When replacing small culverts ensure that the culvert has a natural bottom and is large enough for larger mammals such as deer and mountain lions to pass, if feasible. Culverts must provide direct movement from one side of the road to the other and ensure that the culvert is visible to the target species (i.e., do not obscure entrance with vegetation). Install fencing or other features that will direct wildlife towards the culvert or other safe crossing within the first 20 years of implementation.	Compliance monitoring for infrastructure/structure removal, replacement, or installation. Monitor wildlife movement (or plant distribution if applicable) in target areas. Monitor movement of indicator species for connectivity.

Table 5-1a. Continued

Biological Goals and Objectives	Conservation Actions[1,2]	Monitoring Action
	LM-3. Where structurally possible, replace culverts with free span bridges to ensure free movement for wildlife under roadways.	Compliance monitoring for infrastructure/structure removal, replacement, or installation. Monitor wildlife movement (or plant distribution if applicable) in target areas. Monitor movement of indicator species for connectivity.
	LM-4. Ensure that median barrier removal and/or median perforations are considered as alternatives during project design.	Compliance monitoring for infrastructure/structure removal, replacement, or installation. Monitor wildlife movement (or plant distribution if applicable) in target areas. Monitor movement of indicator species for connectivity.
	LM-5. Remove median barriers or perforate sections of median barriers along roadways to improve successful wildlife crossings and install fencing or other features to direct wildlife to those open sections within first 20 years of implementation. Use feasibility study to determine location and length of barrier removal.	Compliance monitoring for infrastructure/structure removal, replacement, or installation. Monitor wildlife movement (or plant distribution if applicable) in target areas. Monitor movement of indicator species for connectivity.
Goal 3. Enhance or restore representative natural and semi-natural landscapes to maintain or increase native biological diversity.		
Objective 3.1. To increase the total area of quality habitat for covered and other native species and to improve hydrologic function, enhance 33,205 acres of terrestrial and aquatic land cover types and 100 miles of streams, and restore 1 mile of stream and restore or create 90 acres of aquatic land cover types within the Reserve System. If all predicted impacts occur, restore 10.4 miles of streams and restore or create 501 acres of aquatic land cover types within the Reserve System.[3]	LM-6. Enhance or restore an estimated 17,440 acres of grassland, 2,500 acres of chaparral and northern coastal scrub, 12,900 acres of oak woodland, 290 acres of riparian forest and scrub, and 10 acres of conifer woodland within the Reserve System.	Compliance monitoring with additional monitoring for effectiveness of restoration/enhancement/creation developed at natural community level.
	LM-7a. Restore a minimum of 1.0 miles of stream, 50 acres of riparian forest and scrub, and 20 acres of freshwater marsh, and create 20 acres of ponds to contribute to species recovery.	Compliance monitoring. Monitor baseline hydrologic function against future changes.
	LM-7b. If all predicted impacts occur, restore 10.4 miles of streams, 339 acres of riparian forest and scrub, 45 acres of freshwater marsh, and 30 acres of seasonal wetlands, and create 72 acres of ponds within all watersheds of the study area to maintain and when necessary improve stream hydrologic functions.	Compliance monitoring. Monitor baseline hydrologic function against future changes.
Objective 3.2a. Ensure natural fire disturbance regimes required for natural community regeneration and structural diversity, and covered species germination and recruitment occur within the Reserve System or implement management actions that mimic those natural disturbances through development of a fire management component of each reserve unit management plan.[3,8]	LM-8. Negotiate with Cal Fire and other local fire-fighting agencies the use of management response measures for all fire events and fire-dependent ecosystems that minimize impacts to natural communities and covered species while protecting human life and property. All burns will be responded to, and prescribed burns will be conducted, with minimum impact suppression tactics. Burn response will take into consideration ignition location and method, seasonality, weather and availability of suppression forces.	Compliance monitoring including effects of burning monitored as part of natural community enhancement. For management actions that mimic natural fire regimes, compare post-fire vegetation to baseline conditions at periodic intervals to assess the effect of various fire frequencies and intensities at promoting native plants and reducing non-native plants. Monitor target covered species response.
	LM-9. In identified “no burn” areas implement the biologically appropriate management actions that mimic the natural effects of fire (e.g., mowing, grazing, hand pulling) to subsequently improve habitat for native vegetation.	Analyze and quantify effectiveness of burning vs. other management actions in increasing diversity and quantity of native vegetation. Monitor target covered species response, if applicable.

Table 5-1a. Continued

Biological Goals and Objectives	Conservation Actions[1,2]	Monitoring Action
Objective 3.2b. Ensure natural flooding disturbance regimes required for natural community regeneration and structural diversity, and covered species germination and recruitment occur within the Reserve System or implement management actions that mimic those natural disturbances through adoption of the SCVWD Natural Flood Protection Plan (2000).[3]	LM-10. Integrate adopted policies for natural flood protection (i.e., Ordinance O6-1, *Clean, Safe Creeks and Natural Flood Protection Plan*, *Coyote Watershed Stream Stewardship Plan*) into flood protection projects to protect habitat for covered fish, amphibians, and reptiles.	Compliance monitoring
Objective 3.3. Eradicate or reduce the cover, biomass, and distribution of existing target, non-native invasive plants and reduce the number and distribution of non-native, invasive animals to enhance natural communities and covered species habitat within the Reserve System.[3]	LM-11. Graze, mow, hand-pull, to reduce non-native invasive plant species, both terrestrial and aquatic, to a level where native plants can reestablish and remain dominant within the Reserve System.	Monitor status of non-native invasive plants in target eradication areas and assess efficacy of various techniques. Monitor covered species response.
	LM-12. Eradicate or reduce nonnative pig disturbance within the Reserve System through trapping, hunting, or other control methods. Success criteria is achieved through ensuring disturbances by nonnative pigs do not impair the ability of the Reserve System from meeting the biological goals and objectives.	Analyze and quantify numbers of pigs eradicated and evidence of remaining population (e.g., pig observations or signs of damage).
	LM-13. Eradicate or reduce nonnative predators (bullfrogs, invasive fish, feral cats) within the Reserve System through habitat manipulation (e.g., periodic draining of ponds), trapping, hand capturing, electroshocking or other control methods to achieve targets identified in reserve unit management plans.	Monitor response of nonnative predators to habitat manipulation and assess efficacy of various techniques.
	LM-14. Selectively apply herbicides or other treatments to invasive plants.	Monitor status of non-native invasive plants in target eradication areas and assess efficacy of various techniques. Monitor covered species response.
	STUDIES-2. Experimentally manage oak woodlands to reduce seedling mortality, increase seedling and sapling survival and determine factors relevant to regeneration, including browsing by mammals, birds, and insects.	Monitor research results.

Notes:

[1] Habitat enhancement, monitoring, and adaptive management program, will continue in perpetuity. Restoration and creation must occur in rough step with impacts as required by the Stay-Ahead provision (see Chapter 8, Section 8.6.1). All habitat restoration will be completed by Year 40.

[2] Land acquisition must occur in rough step with impacts as required by the Stay-Ahead provision (see Chapter 8, Section 8.6.1). All land acquisition must be complete by Year 45. Land acquisition requiring restoration or creation of habitat for Covered Species must be complete by Year 40.

[3] See Tables 5-4 and Figure 5-4. Existing open space requirements for the Reserve System may be substituted with new acquisition in addition to the minimum of 33,205 acres of new acquisition required by the Plan.

[4] Excerpted from NCCP Act and revised for the Plan.

[6] Specific locations and structures will be identified as part of a feasibility study.

[7] Design will be based on the best available science and be consistent with Condition 6 described in Chapter 6, Section 6.4.4, subheading *Condition 6 Design and Construction Requirements for Covered*

[8] Fire management will be incorporated into the reserve unit management plans within 5 years of the first acquisition of the land for the reserve unit.

Table 5-1b. Biological Goals, Objectives, and Conservation Actions: Natural Community Level

Biological Goals and Objectives	Conservation Actions	Monitoring Action
Grassland		
Goal 4. Maintain and enhance grassland communities that benefit covered species and promote native biodiversity.		
Objective 4.1. Protect 4,130 acres of serpentine grassland containing the full range of serpentine grassland associations and species including serpentine seeps and serpentine rock outcrops as part of the Reserve System within the study area.[1]	LAND-G1. Acquire 4,130 acres of serpentine grassland by fee title or conservation easement with the full range of serpentine grassland associations and vegetation diversity found throughout the study area. This includes 4,000 acres of serpentine bunchgrass grassland, 120 of serpentine rock outcrops/barrens, and 10 acres of serpentine seeps.	Compliance monitoring and annual reporting. Assess habitat quality of acquired land and prioritize areas for management.
Objective 4.2. Protect 13,300 acres of annual grassland in a diversity of soils types and other environmental gradients including areas suitable for enhancing native species, provide a matrix of pond, wetland, and upland habitat, and those containing native grassland as part of the Reserve System within the study area.[1]	LAND-G2. Acquire 13,300 acres of annual grassland by fee title or conservation easement as part of the Reserve System. Target areas on both sides of Santa Clara Valley with a high concentration of ponds occupied by covered species or native species and/or other ponds capable of being restored. Acquisition of native grassland will be given priority.	Compliance monitoring and annual reporting. Assess habitat quality of acquired land and prioritize areas for management.
Objective 4.3a. Reduce cover and biomass of non-native plants.[2]	GRASS-1. Continue or introduce livestock and native herbivore (e.g., elk) grazing in a variety of grazing regimes.	Monitor effects of various grazing regimes on reducing nonnative plants and increasing diversity and biomass of native plants. In oak woodlands, monitor effects of various grazing regimes on oak woodland regeneration and recruitment. Monitor target covered species responses.
	GRASS-2. Conduct prescribed burns. Use targeted studies to inform methods, timing, location, and frequency.	Monitor effects of burning on reducing nonnative plants and increasing diversity and biomass of native plants. Monitor target covered species responses.
	GRASS-3. Conduct mowing in selected areas to mimic grazing where use of livestock is impractical.	Monitor effects of mowing on reducing nonnative plants and increasing diversity and biomass of native plants. Monitor target covered species response.
	GRASS-4. Conduct selected seeding of native forbs and grasses in the Reserve System.	Monitor success of seeding efforts in promoting native forbs and grasses. Monitor target covered species responses.
	LM-8. Negotiate with Cal Fire and other local fire-fighting agencies the use of management response measures for all fire events and fire-dependent ecosystems that minimize impacts to natural communities and covered species while protecting human life and property. All burns will be responded to, and prescribed burns will be conducted, with minimum impact suppression tactics. Burn response will take into consideration ignition location and method, seasonality, weather and availability of suppression forces.	Compare post-fire vegetation to baseline conditions at periodic intervals to assess the effect of various fire frequencies and intensities at promoting native plants and reducing non-native plants. Monitor target covered species response.
	LM-9. In identified "no burn" areas implement the biologically appropriate management actions that mimic the natural effects of fire (e.g., mowing, grazing, hand pulling) to subsequently improve habitat for native vegetation.	Analyze and quantify effectiveness of burning vs. other management actions in increasing diversity and quantity of native vegetation. Monitor target covered species response, if applicable.
	LM-11. Graze, mow, hand-pull, to reduce non-native invasive plant species, both terrestrial and aquatic, to a level where native plants can reestablish and remain dominant within the Reserve System.	Monitor status of non-native invasive plants in target eradication areas and assess efficacy of various techniques. Monitor covered species response.
	LM-14. Selectively apply herbicides or other treatments to invasive plants.	Monitor status of non-native invasive plants in target eradication areas and assess efficacy of various techniques. Monitor covered species response.

Table 5-1b. Continued

Biological Goals and Objectives	Conservation Actions	Monitoring Action
Objective 4.3b. Decrease nitrogen deposition in serpentine grasslands to reduce non-native, invasive plant growth.	GRASS-1. Continue or introduce livestock and native herbivore (e.g., elk) grazing in a variety of grazing regimes.	Monitor effects of various grazing regimes on reducing nonnative plants and increasing diversity and biomass of native plants. In oak woodlands, monitor effects of various grazing regimes on oak woodland regeneration and recruitment. Monitor target covered species responses.
	GRASS-2. Conduct prescribed burns. Use targeted studies to inform methods, timing, location, and frequency.	Monitor effects of burning on reducing nonnative plants and increasing diversity and biomass of native plants. Monitor target covered species responses.
	GRASS-3. Conduct mowing in selected areas to mimic grazing where use of livestock is impractical.	Monitor effects of mowing on reducing nonnative plants and increasing diversity and biomass of native plants. Monitor target covered species response.
	GRASS-4. Conduct selected seeding of native forbs and grasses in the Reserve System.	Monitor success of seeding efforts in promoting native forbs and grasses. Monitor target covered species responses.
	LM-8. Negotiate with Cal Fire and other local fire-fighting agencies the use of management response measures for all fire events and fire-dependent ecosystems that minimize impacts to natural communities and covered species while protecting human life and property. All burns will be responded to, and prescribed burns will be conducted, with minimum impact suppression tactics. Burn response will take into consideration ignition location and method, seasonality, weather and availability of suppression forces.	Compare post-fire vegetation to baseline conditions at periodic intervals to assess the effect of various fire frequencies and intensities at promoting native plants and reducing non-native plants. Monitor target covered species response.
Objective 4.3c. Increase the diversity of native plants within the Reserve System.[2]	GRASS-1. Continue or introduce livestock and native herbivore (e.g., elk) grazing in a variety of grazing regimes.	Monitor effects of various grazing regimes on reducing nonnative plants and increasing diversity and biomass of native plants. In oak woodlands, monitor effects of various grazing regimes on oak woodland regeneration and recruitment. Monitor target covered species responses.
	GRASS-2. Conduct prescribed burns. Use targeted studies to inform methods, timing, location, and frequency.	Monitor effects of burning on reducing nonnative plants and increasing diversity and biomass of native plants. Monitor target covered species responses.
	GRASS-3. Conduct mowing in selected areas to mimic grazing where use of livestock is impractical.	Monitor effects of mowing on reducing nonnative plants and increasing diversity and biomass of native plants. Monitor target covered species response.
	GRASS-4. Conduct selected seeding of native forbs and grasses in the Reserve System.	Monitor success of seeding efforts in promoting native forbs and grasses. Monitor target covered species responses.
	LM-8. Negotiate with Cal Fire and other local fire-fighting agencies the use of management response measures for all fire events and fire-dependent ecosystems that minimize impacts to natural communities and covered species while protecting human life and property. All burns will be responded to, and prescribed burns will be conducted, with minimum impact suppression tactics. Burn response will take into consideration ignition location and method, seasonality, weather and availability of suppression forces.	Compare post-fire vegetation to baseline conditions at periodic intervals to assess the effect of various fire frequencies and intensities at promoting native plants. Monitor target covered species response.
	LM-9. In identified "no burn" areas implement the biologically appropriate management actions that mimic the natural effects of fire (e.g., mowing, grazing, hand pulling) to subsequently improve habitat for native vegetation.	Analyze and quantify effectiveness of burning vs. other management actions in increasing diversity and quantity of native vegetation. Monitor target covered species response, if applicable.

Table 5-1b. Continued

Biological Goals and Objectives	Conservation Actions	Monitoring Action
Objective 4.4. Increase the distribution and availability of California ground squirrels to increase the prey base for San Joaquin kit fox and to increase burrow availability within grassland for California tiger salamander, California red-legged frog, western burrowing owl, San Joaquin kit fox, and other native species within the Reserve System.[2]	GRASS-5. Prohibit use of rodenticides within the Reserve System, except when needed to protect the integrity of structures, such as levees, stock ponds and dams.	Monitor population trend of California ground squirrels. Track changes in burrowing mammal colony size over time.
	GRASS-6. Introduce livestock grazing where it is not currently used, and where conflicts with covered activities are minimized, to reduce vegetative cover and biomass that currently excludes ground squirrel and encourage ground squirrel colonization of new areas within the Reserve System.	Monitor population trend of California ground squirrels. Analyze and quantify changes in burrowing mammal colony size over time.
Chaparral and Northern Coastal Scrub		
Goal 5. Maintain and enhance functional chaparral and northern coastal scrub communities to benefit covered species and promote native biodiversity.		
Objective 5.1. Protect 2,500 acres of chaparral and northern coastal scrub containing the full range of chaparral and northern coastal scrub community associations and manage it as part of the Reserve System within the study area.[1]	LAND-C1. Acquire 400 acres of northern mixed chaparral/chamise chaparral by fee title or conservation easement.	Compliance monitoring and annual reporting. Assess habitat quality of acquired land and prioritize areas for management.
	LAND-C2. Acquire 700 acres of mixed serpentine chaparral by fee title or conservation easement.	Compliance monitoring and annual reporting. Assess habitat quality of acquired land and prioritize areas for management.
	LAND-C3. Acquire 1,400 acres of northern coastal scrub/Diablan sage scrub by fee title or conservation easement.	Compliance monitoring and annual reporting. Assess habitat quality of acquired land and prioritize areas for management.
Objective 5.2. Enhance all acquired chaparral and northern coastal scrub land cover types by promoting regeneration and succession to sustain the natural processes and native species diversity found in these communities within the Reserve System.[2]	STUDIES-2. Determine factors relevant to the health and regeneration of native chaparral/scrub species. Targeted studies will be imitated within first 10 years of plan implementation. Use results of targeted studies to revise and improve management actions.	Conduct targeted research that identifies key factors affecting regeneration and succession of chaparral/scrub.
	CHAP-1. Conduct prescribed burns in chaparral and northern coastal scrub to maintain canopy gaps and promote regeneration. Use targeted studies to inform locations and frequency.	Monitor effects of burning on promoting canopy gaps, regeneration, and succession in chaparral and northern coastal scrub.
	CHAP-2. Mechanically thin chaparral and northern coastal scrub to promote structural diversity. Use targeted studies to inform location and frequency.	Monitor effects of mechanical thinning on promoting canopy gaps, regeneration, and succession in chaparral and northern coastal scrub.
	CHAP-3. Identify areas in the Santa Cruz Mountains and eastern mountains where adjacent natural communities (e.g. grassland, oak woodland, conifer forests) are encroaching on chaparral and scrub land cover and, if appropriate, work to reduce the spread through manual reduction.	Analyze and quantify spread of adjacent natural communities into chaparral and scrub land cover types. Study spread rate after manual reduction.
	LM-8. Negotiate with Cal Fire and other local fire-fighting agencies the use of management response measures for all fire events and fire-dependent ecosystems that minimize impacts to natural communities and covered species while protecting human life and property. All burns will be responded to, and prescribed burns will be conducted, with minimum impact suppression tactics. Burn response will take into consideration ignition location and method, seasonality, weather and availability of suppression forces.	Compare post-fire vegetation to baseline conditions at periodic intervals to assess the effect of various fire frequencies and intensities at promoting native plants and reducing non-native plants. Monitor target covered species response.

Table 5-1b. Continued

Biological Goals and Objectives	Conservation Actions	Monitoring Action
Oak and Conifer Woodland		
Goal 6. Maintain and enhance functional oak woodland communities to benefit covered species and promote native biodiversity.		
Objective 6.1. Protect 1,700 acres of valley oak woodland, 7,100 acres of mixed oak woodland and forest, 2,900 acres of coast live oak woodland and forest, 1,100 acres of blue oak woodland, 80 acres of foothill pine-oak woodland, and 20 acres of mixed evergreen forest, containing the full range of oak woodland associations and species, and that provide a matrix of pond, wetland, and upland habitat as part of the Reserve System within the study area.[1]	LAND-OC1. Acquire in fee title or obtain conservation easements on 7,100 acres of mixed oak woodland and forest, including land in both the Santa Cruz Mountains and the Diablo Range. Target areas with a high concentration of ponds occupied by covered species or native species and/or other ponds capable of being restored.	Compliance monitoring and annual reporting. Assess habitat quality of acquired land and prioritize areas for management.
	LAND-OC2. Acquire 2,900 acres of coast live oak woodland and forest by fee title or conservation easement, including land in both the Santa Cruz Mountains and the Diablo Range. Target areas with a high concentration of ponds occupied by covered species or native species and/or other ponds capable of being restored.	Compliance monitoring and annual reporting. Assess habitat quality of acquired land and prioritize areas for management.
	LAND-OC3. Acquire 1,100 acres of blue oak woodland and 1,700 acres of valley oak woodland by fee title or conservation easement including land in both the Santa Cruz Mountains and the Diablo Range. Target areas with a high concentration of ponds occupied by covered species or native species and/or other ponds capable of being restored.	Compliance monitoring and annual reporting. Assess habitat quality of acquired land and prioritize areas for management.
	LAND-OC4. Acquire 80 acres of foothill pine-oak woodland and forest by fee title or conservation easement, including land in both the Santa Cruz Mountains and Diablo Range. Target areas with a high concentration of ponds occupied by covered species or native species and/or other ponds capable of being restored.	Compliance monitoring and annual reporting. Assess habitat quality of acquired land and prioritize areas for management.
	LAND-OC5. Acquire 20 acres of mixed evergreen forest by fee title or conservation easement including land in both the Santa Cruz Mountains and Diablo Range. Target areas with a high concentration of ponds occupied by covered species or native species and/or other ponds capable of being restored.	Compliance monitoring and annual reporting. Assess habitat quality of acquired land and prioritize areas for management.
Objective 6.2a. Enhance all acquired oak woodland land cover types by reducing invasive plant and animal species.[2]	LM-12. Eradicate or reduce nonnative pig disturbance within the Reserve System through trapping, hunting, or other control methods. Success criteria is achieved through ensuring disturbances by nonnative pigs do not impair the ability of the Reserve System from meeting the biological goals and objectives.	Monitor effectiveness of pig removal efforts and response of oak woodlands once pigs are removed.
	LM-14. Selectively apply herbicides or other treatments to invasive plants.	Monitor status of non-native invasive plants in target eradication areas and assess efficacy of various techniques. Monitor covered species response.
	OAK-1. Conduct prescribed burns in low-density oak woodlands to enhance the community and to reduce non-native, invasive grass cover beneath oaks and encourage growth of a native understory and oak seedlings.	Monitor effects of burning on promoting regeneration and recruitment of oak woodlands and understory land cover. Monitor covered species response.
	GRASS-1. Continue or introduce livestock and native herbivore (e.g., elk) grazing in a variety of grazing regimes.	Monitor effects of various grazing regimes on reducing nonnative plants and increasing diversity and biomass of native plants. In oak woodlands, monitor effects of various grazing regimes on oak woodland regeneration and recruitment. Monitor target covered species responses.

Table 5-1b. Continued

Biological Goals and Objectives	Conservation Actions	Monitoring Action
Objective 6.2b. Promote regeneration and recruitment of all acquired oak woodland land cover types by promoting regeneration and recruitment of component species.[2]	OAK-1. Conduct prescribed burns in low-density oak woodlands to enhance the community and to reduce non-native, invasive grass cover beneath oaks and encourage growth of a native understory and oak seedlings.	Monitor effects of burning on promoting regeneration and recruitment of oak woodlands and understory land cover. Monitor covered species response.
	GRASS-1. Continue or introduce livestock and native herbivore (e.g., elk) grazing in a variety of grazing regimes.	Monitor effects of various grazing regimes on reducing nonnative plants and increasing diversity and biomass of native plants. In oak woodlands, monitor effects of various grazing regimes on oak woodland regeneration and recruitment. Monitor target covered species responses.
Objective 6.2c. Enhance all acquired oak woodland and cover types by sustaining the natural processes found in these communities.[2]	STUDIES-3. Experimentally manage oak woodlands to reduce seedling mortality, increase seedling and sapling survival and determine factors relevant to regeneration, including browsing by mammals, birds, and insects.	Conduct targeted research that identifies key factors affecting seedling mortality, seedling and sapling survival and factors relevant to oak woodland regeneration.
	GRASS-1. Continue or introduce livestock and native herbivore (e.g., elk) grazing in a variety of grazing regimes.	Monitor effects of various grazing regimes on reducing nonnative plants and increasing diversity and biomass of native plants. In oak woodlands, monitor effects of various grazing regimes on oak woodland regeneration and recruitment. Monitor target covered species responses.
	OAK-1. Conduct prescribed burns in low-density oak woodlands to enhance the community and to reduce non-native, invasive grass cover beneath oaks and encourage growth of a native understory and oak seedlings.	Monitor effects of burning on promoting regeneration and recruitment of oak woodlands and understory land cover. Monitor covered species response.
Goal 7. Maintain and enhance functional conifer woodland communities to benefit covered species and promote native biodiversity.		
Objective 7.1. Protect 10 acres of redwood forest as part of the Reserve System within the study area.[1]	LAND-OC6. Acquire 10 acres of redwood forest by fee title or conservation easement.	Compliance monitoring and annual reporting. Assess habitat quality of acquired land and prioritize areas for management.
Objective 7.2. Enhance all acquired conifer woodland communities by promoting ecologically appropriate structure, density, and species composition to preserve and sustain the natural processes and native species diversity found in these communities.[3]	STUDIES-4. Experimentally manage redwood forest to determine factors relevant to regeneration and maintenance; possibly including prescribed burning, selective thinning, and other management actions to meet this objective.	Conduct targeted research in redwood forest, ponderosa pine woodland, and knobcone pine woodland to guide management actions and other factors relevant to regeneration and maintenance.
	OAK-2. Conduct prescribed burns in redwood forest to maintain or enhance native species diversity in the mid-canopy and understory.	Monitor effects of burning on promoting native species diversity.
	OAK-3. Mechanically thin the understory of redwood forest in target areas to promote a healthy understory/canopy.	Monitor effects of mechanical thinning on regeneration and succession in the understory and canopy of conifer woodlands. Monitor target covered species response, if applicable.

Table 5-1b. Continued

Biological Goals and Objectives	Conservation Actions	Monitoring Action
Riverine and Riparian Forest and Scrub		
Goal 8. Improve the quality of streams and the hydrologic and geomorphic processes that support them to maintain a functional aquatic and riparian community to benefit covered species and promote native biodiversity.		
Objective 8.1. Protect 100 miles of streams to promote habitat function, wildlife movement, and stream temperature moderation as part of the Reserve System within the study area.[1, 3]	STREAM-1. Exclude livestock access to target stream segments (e.g., Pacheco Creek, floodplain of Coyote Creek) using exclusion fencing, off-channel water sources, and other potential actions.	Conduct pre- and post-treatment monitoring to document vegetation and covered-species response to exclusion.
	LAND-R1. Extend the Uvas Creek Park Preserve 1.6 miles upstream to Hecker Pass Highway and setback expected development adjacent to this stream segment by a minimum of 100 feet to protect the Uvas Creek Corridor consistent with Goals 5-5, 5-7, and 5-8 of the approved City of Gilroy Hecker Pass Specific Plan. Target acquisitions will to contribute to the protection of a total of 800 acres of riparian woodland and forest in the Uvas, Llagas, and Pacheco watersheds.	Compliance monitoring and annual reporting. Assess habitat quality of acquired land and prioritize areas for management.
Objective 8.2. If all impacts occur, restore 10.4 stream miles on acquired fish bearing stream, as identified in Figure 3-12, within the Reserve System.[2]	STREAM-1. Exclude livestock access to target stream segments (e.g., Pacheco Creek, floodplain of Coyote Creek) using exclusion fencing, off-channel water sources, and other potential actions.	Conduct pre- and post-treatment monitoring to document vegetation and covered-species response to exclusion.
	STREAM-2. Plant and/or seed in native understory and overstory riparian vegetation within 15 feet of the edge of the low-flow channel to create structural diversity, provide overhead cover, and moderate water temperature at all riparian restoration sites.	Monitor the efficacy of seeding efforts with respect to structural diversity, overhead cover, and water temperature compared to designated reference locations. Indicator species will be selected and success criteria developed for large-scale restoration projects from the reference locations.
	STREAM-3. Plant and/or seed in native riparian vegetation in gaps in existing riparian corridors, or re-establish severally degraded or historic riparian corridors, to promote continuity within conservation lands.	STREAM-4. Plant and/or seed in native riparian vegetation in gaps in existing riparian corridors to promote continuity.
	LM-11. Graze, mow, hand-pull, to reduce non-native invasive plant species, both terrestrial and aquatic, to a level where native plants can reestablish and remain dominant within the Reserve System.	Monitor status of non-native invasive plants in target eradication areas and assess efficacy of various techniques. Monitor covered species response.
Objective 8.3. Enhance all miles of streams within the Reserve System to promote natural community functions, and habitat heterogeneity and connectivity.[2]	STREAM-4. Replace concrete, earthen or other engineered channels as part of the 10.4 miles of stream restoration to restore floodplain connectivity. Location and length will be determine by site-specific conditions.	Compliance monitoring and annual reporting. Assess habitat quality of acquired land and prioritize areas for management.
	STREAM-5. Replace confined channels to restore floodplain connectivity and commensurate functions as part of the 10.4 miles of stream restoration. Location and length will be determine by site-specific conditions.	Conduct pre- and post-treatment monitoring of community function (performance of ecological processes); habitat composition, structure and pattern; and connectivity as part of a targeted study.
	STREAM-6. Manage watershed-wide fine sediment inputs by conditioning controls on runoff from all development projects (see Condition 3) to improve riverine habitat functions and geomorphic processes.	Conduct annual spot checks on new developments to determine whether sediment run-off provisions are consistent with the Conditions outlined in this Plan.

Table 5-1b. Continued

Biological Goals and Objectives	Conservation Actions	Monitoring Action
Goal 9. Maintain a functional riparian forest and scrub community at a variety of successional stages and improve these communities to benefit covered species and promote native biodiversity.		
Objective 9.1. Protect a minimum of 250 acres of large (at least 10 acres), contiguous stands of willow riparian forest and scrub or mixed riparian forest and woodland within the 100-year floodplain to maximize the width of native vegetation below dams to promote habitat function, wildlife movement, and stream temperature moderation as part of the Reserve System within the study area. Up to 578 acres of riparian forest and scrub will be protected if all estimated impacts occur.[1]	LAND-R2. Acquire in fee title or obtain conservation easements on lands that protect at least 250 acres and up to 578 acres of existing willow riparian forest and scrub or mixed riparian forest and woodland, including areas that provide key connectivity between existing riparian habitats in upper Coyote Creek, San Felipe Creek, Uvas Creek, Tar Creek, Little Arthur Creek, and Pacheco Creek.	Compliance monitoring and annual reporting. Assess habitat quality of acquired land and prioritize areas for management.
	STREAM-1. Exclude livestock access to target stream segments (e.g., Pacheco Creek, floodplain of Coyote Creek) using exclusion fencing, off-channel water sources, and other potential actions.	Conduct pre- and post-treatment monitoring to document vegetation and covered-species response to exclusion.
Objective 9.2. Protect a minimum of 40 acres of large (at least 10 acres), contiguous stands of Central California sycamore alluvial woodland within the 100-year floodplain to maximize the width of native vegetation below dams to promote habitat function, wildlife movement, and stream temperature moderation as part of the Reserve System within the study area.[1]	LAND-R3. Acquire in fee title or obtain conservation easements on lands that protect at least 40 acres of existing Central California sycamore alluvial woodland to ensure that this very rare and threatened land cover type is preserved in the study area.	Compliance monitoring and annual reporting. Assess habitat quality of acquired land and prioritize areas for management.
	STREAM-1. Exclude livestock access to target stream segments (e.g., Pacheco Creek, floodplain of Coyote Creek) using exclusion fencing, off-channel water sources, and other potential actions.	Conduct pre- and post-treatment monitoring to document vegetation and covered-species response to exclusion.
Objective 9.3. Restore an acre of high-quality willow riparian forest and scrub and mixed riparian forest and woodland and two acres of Central California sycamore alluvial woodland at a variety of successional stages within the Reserve System for every acre removed by covered activities (up to 339 acres of willow and mixed riparian forest and up to 14 acres of sycamore woodland if all impacts occur).[2]	STREAM-2. Plant and/or seed in native understory and overstory riparian vegetation within 15 feet of the edge of the low-flow channel to create structural diversity, provide overhead cover, and moderate water temperature at all riparian restoration sites.	Monitor the efficacy of seeding efforts with respect to structural diversity, overhead cover, and water temperature compared to designated reference locations. Indicator species will be selected and success criteria developed for large-scale restoration projects from the reference locations.
	STREAM-3. Plant and/or seed in native riparian vegetation in gaps in existing riparian corridors, or re-establish severally degraded or historic riparian corridors, to promote continuity within conservation lands.	STREAM-4. Plant and/or seed in native riparian vegetation in gaps in existing riparian corridors to promote continuity.
Objective 9.4. Enhance all riparian forest and scrub at a variety of successional stages within the Reserve System.[2]	STREAM-1. Exclude livestock access to target stream segments (e.g., Pacheco Creek, floodplain of Coyote Creek) using exclusion fencing, off-channel water sources, and other potential actions.	Conduct pre- and post-treatment monitoring to document vegetation and covered-species response to exclusion.
Objective 9.5. Restore at least 50 acres of willow riparian forest and scrub and mixed riparian woodland to increase available habitat species and enhance connectivity within the Reserve System to contribute to species recoverey.[2]	STREAM-2. Plant and/or seed in native understory and overstory riparian vegetation within 15 feet of the edge of the low-flow channel to create structural diversity, provide overhead cover, and moderate water temperature at all riparian restoration sites.	Monitor the efficacy of seeding efforts with respect to structural diversity, overhead cover, and water temperature compared to designated reference locations. Indicator species will be selected and success criteria developed for large-scale restoration projects from the reference locations.
	STREAM-3. Plant and/or seed in native riparian vegetation in gaps in existing riparian corridors, or re-establish severally degraded or historic riparian corridors, to promote continuity within conservation lands.	STREAM-4. Plant and/or seed in native riparian vegetation in gaps in existing riparian corridors to promote continuity.

Table 5-1b. Continued

Biological Goals and Objectives	Conservation Actions	Monitoring Action
Wetland and Pond		
Goal 10. Maintain, enhance, and create or restore functional pond, freshwater perennial wetland, and seasonal wetland habitats that benefit covered species and promote native biodiversity.		
Objective 10.1. Protect a minimum of 10 acres total of perennial wetlands, 5 acres total of seasonal wetlands, and 50 total acres of ponds as part of the Reserve System within the study area to contribute to species recovery, regardless of impacts.[1] Aquatic habitat preserved for the purposes of the Plan must be adjacent to permanently protected upland habitat for covered species.	LAND-WP1a. Acquire in fee title or conservation easement 10 acres of perennial freshwater wetlands suitable for covered or native species in the Santa Cruz Mountains, Santa Clara Valley, and the Diablo Range.	Compliance monitoring and annual reporting. Assess habitat quality of acquired land and prioritize areas for management.
	LAND-WP2a. Acquire in fee title or conservation easement 5 acres of seasonal freshwater wetlands suitable for covered or native species and/or other seasonal wetlands capable of being enhanced or restored to support covered species in the Santa Cruz Mountains, Santa Clara Valley, and the Diablo Range.	Compliance monitoring and annual reporting. Assess habitat quality of acquired land and prioritize areas for management.
	LAND-WP3a. Acquire in fee title or conservation easement 50 acres of ponds suitable for covered or native species in the Santa Cruz Mountains, Santa Clara Valley, and the Diablo Range.	Compliance monitoring and annual reporting. Assess habitat quality of acquired land and prioritize areas for management.
Objective 10.2. Protect up to 50 acres of perennial wetlands, 30 acres of seasonal wetlands, and 104 acres of ponds as part of the Reserve System if all estimated impacts occur.[1] Aquatic habitat preserved for the purposes of the Plan must be adjacent to permanently protected upland habitat for covered species	LAND-WP1b. Acquire in fee title or conservation easement up to 50 acres of perennial freshwater wetlands suitable for covered or native species in the Santa Cruz Mountains, Santa Clara Valley, and the Diablo Range.	Compliance monitoring and annual reporting. Assess habitat quality of acquired land and prioritize areas for management.
	LAND-WP2b. Acquire in fee title or conservation easement up to 30 acres of seasonal freshwater wetlands suitable for covered or native species and/or other seasonal wetlands capable of being enhanced or restored to support covered species in the Santa Cruz Mountains, Santa Clara Valley, and the Diablo Range.	Compliance monitoring and annual reporting. Assess habitat quality of acquired land and prioritize areas for management.
	LAND-WP3b. Acquire in fee title or conservation easement up to 104 acres of ponds suitable for covered or native species in the Santa Cruz Mountains, Santa Clara Valley, and the Diablo Range.	Compliance monitoring and annual reporting. Assess habitat quality of acquired land and prioritize areas for management.
Objective 10.3. As determined by covered and native species needs, enhance all freshwater and seasonal wetlands and ponds by increasing native vegetative cover, biomass, and structural diversity in and around the margins within five years of pond or wetland acquisition within the Reserve System.[2]	POND-1. Install fencing that will reduce grazing pressure and exclude feral pigs on portions of ponds and wetlands and provide vegetated refuge sites for covered species. Fence installation will be carefully applied to avoid negative impacts on small mammal movement and upland habitat.	Monitor effectiveness of fencing to exclude livestock and feral pigs and compare vegetation inside of fencing to vegetation outside of fencing. Evaluate success of wetland and pond enhancement using established success criteria.
	POND-2. Install woody debris around perimeter and in submerged banks of ponds and wetlands to create basking habitat and cover for native juvenile amphibians and turtles. Materials imported from outside of the watershed shall be treated for chytrid and other potential pathogens prior to installation.	Analyze and quantify effectiveness of created basking site through routine monitoring in ponds with known western pond turtle occupancy.
	POND-3. Plant native emergent vegetation around the perimeter and in ponds and wetlands.	Monitor survivorship of planting, quantify vegetated perimeter of pond, describe habitat quality and periodically survey for species response from covered amphibians and reptiles. Evaluate success of wetland and pond enhancement using established success criteria.
	POND-4. Clear vegetation and/or remove sediment in a way that minimizes negative effects on covered species when vegetation and/or sediment restricts the ability of the aquatic environment from meeting the biological goals and objectives of the Plan.	Evaluate success of wetland and pond enhancement using established success criteria.

Table 5-1b. Continued

Biological Goals and Objectives	Conservation Actions	Monitoring Action
	LM-12. Eradicate or reduce nonnative pig disturbance within the Reserve System through trapping, hunting, or other control methods. Success criteria is achieved through ensuring disturbances by nonnative pigs do not impair the ability of the Reserve System from meeting the biological goals and objectives.	Analyze and quantify numbers of pigs eradicated and evidence of remaining population (e.g., pig observations or signs of damage).
Objective 10.4. Enhance all ponds by reducing the cover and biomass of non-native, invasive plants in the adjacent uplands between the functional perimeter of the ponds and within 0.5 miles. Pond enhancement will begin immediately after reserve unit management plans are completed or updated for each reserve unit.[2]	LM-11. Graze, mow, hand-pull, to reduce non-native invasive plant species, both terrestrial and aquatic, to a level where native plants can reestablish and remain dominant within the Reserve System.	Evaluate success of wetland and pond enhancement using established success criteria.
	LM-14. Selectively apply herbicides or other treatments to invasive plants.	Evaluate success of wetland and pond enhancement using established success criteria.
	STUDIES-5. Conduct targeted studies to determine factors limiting the expansion of the covered plant species, including but not limited to its management and micro-site needs, and implement measures to mitigate or eliminate these factors to promote occurrence expansion.	Monitor research results.
	POND-3. Plant native emergent vegetation around the perimeter and in ponds and wetlands.	Monitor survivorship of planting, quantify vegetated perimeter of pond, describe habitat quality and periodically survey for species response from covered amphibians and reptiles. Evaluate success of wetland and pond enhancement using established success criteria.
	POND-5. If biologically appropriate, graze or mechanically thin around pond perimeter to mimic grazing and promote native species.	Evaluate success of wetland and pond enhancement using established success criteria.
Objective 10.5. Enhance all ponds and wetlands within the Reserve System by eradicating or reducing density of exotic species by 95% that are detrimental to native pond and wetland biodiversity to increase number of ponds and wetlands occupied by covered species. Wetland and pond enhancement will begin immediately after reserve unit management plans are completed or updated for each reserve unit.[2]	LM-12. Eradicate or reduce nonnative pig disturbance within the Reserve System through trapping, hunting, or other control methods. Success criteria is achieved through ensuring disturbances by nonnative pigs do not impair the ability of the Reserve System from meeting the biological goals and objectives.	Analyze and quantify numbers of pigs eradicated and evidence of remaining population (e.g., pig observations or signs of damage).
	LM-13. Eradicate or reduce nonnative predators (bullfrogs, invasive fish, feral cats) within the Reserve System through habitat manipulation (e.g., periodic draining of ponds), trapping, hand capturing, electroshocking or other control methods to achieve targets identified in reserve unit management plans.	Monitor response of nonnative predators to habitat manipulation. Evaluate effect of predator abatement on native pond and wetland biodiversity. Determine presence of covered species.
	POND-1. Install fencing that will reduce grazing pressure and exclude feral pigs on portions of ponds and wetlands and provide vegetated refuge sites for covered species. Fence installation will be carefully applied to avoid negative impacts on small mammal movement and upland habitat.	Monitor effectiveness of fencing to exclude livestock and feral pigs and compare vegetation inside of fencing to vegetation outside of fencing. Evaluate success of wetland and pond enhancement using established success criteria.
Objective 10.6. Restore at least 20 acres of freshwater and seasonal wetlands to increase available habitat species and enhance connectivity among existing ponds and wetlands for covered species within the Reserve System to contribute to species recovery.[2]	POND-6. Restore 20 acres of perennial freshwater marsh within the Reserve System in suitable sites and those likely to support covered species.	Compliance monitoring. Monitor freshwater marsh and wetland restoration and assess whether success criteria are being met. Assess connectivity of restored complexes.
Objective 10.7. In addition to the restoration of wetlands described in **Objective 10.6**, restore up to 55 acres of perennial freshwater and seasonal wetlands in-kind within the Reserve System to increase available habitat and enhance connectivity among existing ponds and wetlands for covered species if all anticipated impacts occur.[2]	POND-7. In addition to the perennial freshwater marsh restoration described in **POND-6**, restore up to 25 acres of perennial freshwater marsh within the Reserve System in the Santa Cruz Mountains, Santa Clara Valley, and Diablo Range.	Compliance monitoring. Monitor freshwater marsh and wetland restoration and assess whether success criteria are being met. Assess connectivity of restored complexes.
	POND-8. Restore up to 30 acres of seasonal wetlands within the Reserve System in the Santa Cruz Mountains, Santa Clara Valley, and Diablo Range.	Compliance monitoring. Monitor freshwater marsh and wetland restoration and assess whether success criteria are being met. Assess connectivity of restored complexes.

Table 5-1b. Continued

Biological Goals and Objectives	Conservation Actions	Monitoring Action
Objective 10.8. Create at least 20 acres of ponds at 40 sites to increase available covered species habitat and enhance connectivity among existing ponds and wetlands within the Reserve System. [2]	POND-9. Create at least 20 acres of ponds at 40 sites, at least 10 sites in the Santa Cruz Mountains and 20 sites in the Diablo Range.	Compliance monitoring. Monitor pond construction and assess whether success criteria are being met.
Objective 10.9. In addition to the creation of ponds described in **Objective 10.8**, create up to 52 acres of ponds in-kind within the Reserve System to increase the amount available habitat and enhance connectivity among existing ponds and wetlands if all anticipated impacts occur.[2]	POND-10. In addition to the creation of ponds described in POND-9, create up to 52 acres of ponds in-kind within the Reserve System to increase the amount available habitat and enhance connectivity among existing ponds and wetlands if all anticipated impacts occur.3	Compliance monitoring. Monitor pond construction and assess whether success criteria are being met.

Notes:

[1] Land acquisition must occur in rough step with impacts as required by the Stay-Ahead provision (see Chapter 8, Section 8.6.1). All land acquisition must be complete by Year 45. Section 5.3 of the Plan provides more detail on areas targeted for acquisition for each natural community. Reserve lands will be managed in accordance with reserve unit management plans, completed within 5 years of the acquisition of the 1st parcel within the reserve unit. The conservation strategy for aquatic land cover types includes preservation/enhancement, restoration, and/or creation. See Tables 5-14 and 5-15 for details.

[2] Habitat enhancement, monitoring, and adaptive management program, will continue in perpetuity. Restoration and creation must occur in rough step with impacts as required by the Stay Ahead provision (see Chapter 8, Section 8.6.1). All habitat restoration will be completed by Year 40 unless otherwise noted in this table. Reserve lands will be managed in accordance with reserve unit management plans, completed within 5 years of the acquisition of the 1st parcel within the reserve unit. The conservation strategy for aquatic land cover types are three fold and include preservation/enhancement, restoration, and/or creation. See Tables 5-14 and 5-15 for details.

[3] Watershed-specific targets are established for certain stream reaches within each watershed.

Table 5-1c. Biological Goals, Objectives and Conservation Actions: Wildlife

Biological Goals and Objectives	Conservation Actions	Monitoring Action
Goal 11. Improve the viability of existing Bay checkerspot butterfly populations, increase the number of populations, and expand the geographic distribution to ensure the long-term persistence of the species in the study area.		
Objective 11.1. Protect 4,554 acres of modeled Bay Checkerspot butterfly habitat, including 4,000 acres of serpentine grasslands in core populations of Bay checkerspot buttery, to protect a range of slopes, aspects, and microhabitats as part of the Reserve System within the study area.[1]	LAND-G3. Acquire in fee title or obtain conservation easements on 4,000 acres of suitable serpentine grassland habitat along ridges for Bay checkerspot butterfly on Silver Creek Hills, Coyote Ridge, Pigeon Point, Tulare Hill, Santa Theresa Hills, areas west of Calero Reservoir, and the Kalanas, and Hale/Falcon Crest in fee title or conservation easement. Habitat acquisition on Coyote Ridge and Tulare Hill is top priority. For other sites totaling 554 acres, prioritize sites, threat, patch size, current occupancy and prevalence of cool microsites for Bay checkerspot butterflies.	Compliance monitoring and yearly reporting. Assess habitat quality of acquired land and prioritize areas for management according to threat, patch size, current occupancy and prevalence of cool microsites for Bay checkerspot butterflies.
	LAND-L5. Acquire in fee title or obtain easements on 2,900 acres of serpentine grassland along Coyote Ridge to link existing protected areas and to create a large core reserve for serpentine grassland species to move within (Linkage 6 in Table 5-9 and Figure 5-6). These acreages are inclusive of, not in addition to, acquisition targets set in LAND-G3.	Compliance monitoring for land acquisition. Analyze and quantify movement of indicator species to determine whether linkages are functioning as intended.
Objective 11.2. Increase the number of larval host plant populations and adult nectar sources and reduce the amount of thatch to a level that supports the long term viability of the Bay checkerspot butterfly on sites with degraded serpentine grassland within the Reserve System.[2]	GRASS-1. Continue or introduce livestock and native herbivore (e.g., elk) grazing in a variety of grazing regimes.	Monitor effects of various grazing regimes on increasing larval host plants and numbers of Bay checkerspot butterflies.
	GRASS-2. Conduct prescribed burns. Use targeted studies to inform methods, timing, location, and frequency.	Monitor effects of prescribed burns on increasing larval host plants and numbers of Bay checkerspot butterflies.
	GRASS-3. Conduct mowing in selected areas to mimic grazing where use of livestock is impractical.	Monitor effects of mowing on larval host plants, adult host plants, numbers of Bay checkerspot butterflies, and non-native invasive plant species.
Objective 11.3 Decrease nitrogen deposition in serpentine grassland to reduce non-native, invasive plant growth in the Reserve System.	GRASS-4. Conduct selected seeding of native forbs and grasses in the Reserve System.	Monitor effects of mowing on larval host plants, adult host plants, numbers of Bay checkerspot butterflies, and non-native invasive plant species.
	GRASS-7. Implementing Entity will initiate translocation efforts if natural colonization fails after five seasons in which core populations are at above-average population sizes. Through coordination with species experts and regulatory agencies translocate Bay checkerspot butterflies (eggs, larvae, or adults) from core populations into suitable but unoccupied sites if natural dispersal fails to reestablish population.	Monitor at periodic intervals the success of translocation efforts in establishing new populations of Bay checkerspot butterfly.
	LM-11. Graze, mow, hand-pull, to reduce non-native invasive plant species, both terrestrial and aquatic, to a level where native plants can reestablish and remain dominant within the Reserve System.	Monitor relationship between nonnative plant abundance and Bay checkerspot butterfly.

Table 5-1c. Continued

Biological Goals and Objectives	Conservation Actions	Monitoring Action
Goal 13. Increase the size and sustainability of the breeding population and increase the distribution of breeding and wintering burrowing owls in the study area and the expanded burrowing owl conservation area.		
Objective 13.1. Protect 21,310 acres of modeled western burrowing owl overwintering habitat (i.e., grassland, oak woodland, or barren land) and protect or manage 5,300 acres of nesting habitat (occupied or potential) on the valley floor and in the Diablo Range within the permit area. The geographic breakdown should be: 3,700 acres in the North San Jose/Baylands region, 800 acres in the Gilroy region, 530 acres in the Morgan Hill region, and 270 acres in the South San Jose region as shown in Figure 5-10. Prioritize sites that contain occupied burrowing owl breeding sites. Management agreements on non-reserve lands may be placed on up to 4,700 acres of the 5,300 acres of nesting habitat.	LAND-G6. Acquire, obtain easements, or retain management agreements on burrowing owl nesting habitat within 2 miles the San Jose Water Pollution Control Plant Bufferlands, north of Highway 237.	Compliance monitoring and yearly reporting. Monitor presence/absence of burrowing owl in target areas.
	LAND-G7. Acquire, obtain easements, or retain management agreements on burrowing owl nesting habitat within 2 miles of the San Jose International Airport or other important northern San Jose breeding sites.	Compliance monitoring and yearly reporting. Monitor presence/absence of burrowing owl in target areas.
	LAND-G8. Acquire or obtain easements on 21,310 acres of suitable overwintering habitat in the Diablo Range that support ground squirrel populations or could support them with improved management. This acreage is in addition to of the targets identified in LAND-G6 and LAND-G7.	Compliance monitoring and yearly reporting. Monitor presence/absence of burrowing owl in target areas.
Objective 13.2. Enhance through improved management 3,700 acres of burrowing owl nesting habitat in the North San Jose/Baylands burrowing owl conservation region, 800 acres in the Gilroy burrowing owl conservation region, 530 acres in the Morgan Hill burrowing owl conservation region, and 270 acres in the South San Jose burrowing owl conservation region to encourage expansion of burrowing owls within the permit area.[2]	GRASS-5. Prohibit use of rodenticides within the Reserve System, except when needed to protect the integrity of structures, such as levees, stock ponds and dams.	Monitor population trend (i.e., number, density, range) of California ground squirrels in target areas.
	GRASS-6. Introduce livestock grazing where it is not currently used, and where conflicts with covered activities are minimized, to reduce vegetative cover and biomass that currently excludes ground squirrel and encourage ground squirrel colonization of new areas within the Reserve System.	Identify candidate grassland sites within the Reserve System to provide expansion areas for ground squirrel colonies.
	GRASS-8. Implement vegetation management (i.e., graze/mow) that reduces vegetation height and density to optimal conditions for burrowing owls.	Monitor status of burrowing owl population and correlate species response to vegetation management.
	GRASS-9. Create and maintain artificial burrows to encourage colonization of sites where ground squirrels establishment is not feasible or during the interim before ground squirrel colonies naturally establish.	Monitor artificial burrow for occupancy twice annually, during the breeding season.
Objective 13.3. Establish a positive growth trend for burrowing owls in the permit area by Year 15 of the permit term and maintain the positive growth trend for each year thereafter.	LAND-G6. Acquire, obtain easements, or retain management agreements on burrowing owl nesting habitat within 2 miles the San Jose Water Pollution Control Plant Bufferlands, north of Highway 237.	Compliance monitoring and yearly reporting. Monitor presence/absence of burrowing owl in target areas.
	LAND-G7. Acquire, obtain easements, or retain management agreements on burrowing owl nesting habitat within 2 miles of the San Jose International Airport or other important northern San Jose breeding sites.	Compliance monitoring and yearly reporting. Monitor presence/absence of burrowing owl in target areas.

Table 5-1c. Continued

Biological Goals and Objectives	Conservation Actions	Monitoring Action
	LAND-G8. Acquire or obtain easements on 21,310 acres of suitable overwintering habitat in the Diablo Range that support ground squirrel populations or could support them with improved management. This acreage is in addition to of the targets identified in	Compliance monitoring and yearly reporting. Monitor presence/absence of burrowing owl in target areas.
	GRASS-5. Prohibit use of rodenticides within the Reserve System, except when needed to protect the integrity of structures, such as levees, stock ponds and dams.	Monitor population trend (i.e., number, density, range) of California ground squirrels in target areas.
	GRASS-6. Introduce livestock grazing where it is not currently used, and where conflicts with covered activities are minimized, to reduce vegetative cover and biomass that currently excludes ground squirrel and encourage ground squirrel colonization of new areas within the	Identify candidate grassland sites within the Reserve System to provide expansion areas for ground squirrel colonies.
	GRASS-8. Implement vegetation management (i.e., graze/mow) that reduces vegetation height and density to optimal conditions for burrowing owls.	Monitor status of burrowing owl population and correlate species response to vegetation management.
	GRASS-9. Create and maintain artificial burrows to encourage colonization of sites where ground squirrels establishment is not feasible or during the interim before ground squirrel colonies naturally establish.	Monitor artificial burrow for occupancy twice annually, during the breeding season.
Goal 14. Increase the ability of San Joaquin kit fox to move into and within the study area and provide habitat to increase the likelihood of breeding.		
Objective 14.1. Protect 4,100 acres of annual grassland and suitable oak woodland land cover types in a diversity of soils types and other environmental gradients to improve San Joaquin kit fox movement and potential breeding habitat as part of the Reserve System within the study area.[1]	LAND-G9. Acquire in fee title or obtain easements on 4,100 acres of annual grassland and suitable oak woodland types (e.g., oak savanna and oak woodland within 500 feet of annual grassland) north and south of Highway 152 in modeled San Joaquin kit fox habitat.	Compliance monitoring and yearly reporting. Monitor presence/absence of kit fox in target areas.
Objective 14.2. Increase the population size and density of the prey base for San Joaquin kit fox.[2]	GRASS-5. Prohibit use of rodenticides within the Reserve System, except when needed to protect the integrity of structures, such as levees, stock ponds and dams.	Monitor population trend (i.e., number, density, range) of California ground squirrels in target areas.
	GRASS-6. Introduce livestock grazing where it is not currently used, and where conflicts with covered activities are minimized, to reduce vegetative cover and biomass that currently excludes ground squirrel and encourage ground squirrel colonization of new areas within the Reserve System.	Identify candidate grassland sites within the Reserve System to provide expansion areas for ground squirrel colonies.

Table 5-1c. Continued

Biological Goals and Objectives	Conservation Actions	Monitoring Action
Objective 14.3. Educate the public about land management techniques that are compatible with kit fox movement within the southeastern portion of the study area.[2]	GRASS-10. Conduct at least one public education campaign in the southeastern portion of the study area within the first 10 years of implementation to provide landowners with information about management and land use techniques that are more compatible with movement and use by San Joaquin kit fox. Conduct additional meetings as needed.	Ensure that at least one educational meeting is conducted within the first two years of implementation and then as needed after that.
Objective 14.4. Increase the number of undercrossings, by a minimum of one, that are considered passable and safe for San Joaquin kit fox or increase the safety of at least two existing crossings across Highway 152 between the Highway 152/156 interchange and the Santa Clara/Merced County line. Identify target crossings by conducting a feasibility study by year 5 of Plan implementation (see Objective 2.1).[2, 3]	LM-1. Remove fences and private roads in areas where they are no longer needed and where their removal could increase the permeability of the study area for wildlife.	Compliance monitoring for infrastructure/structure removal, replacement, or installation. Monitor wildlife movement (or plant distribution if applicable) in target areas. Monitor movement of indicator species for connectivity.
	LM-2. When replacing small culverts ensure that the culvert has a natural bottom and is large enough for larger mammals such as deer and mountain lions to pass, if feasible. Culverts must provide direct movement from one side of the road to the other and ensure that the culvert is visible to the target species (i.e., do not obscure entrance with vegetation). Install fencing or other features that will direct wildlife towards the culvert or other safe crossing within the first 20 years of implementation.	Compliance monitoring for infrastructure/structure removal, replacement, or installation. Monitor wildlife movement (or plant distribution if applicable) in target areas. Monitor movement of indicator species for connectivity.
	LM-3. Where structurally possible, replace culverts with free span bridges to ensure free movement for wildlife under roadways.	Compliance monitoring for infrastructure/structure removal, replacement, or installation. Monitor wildlife movement (or plant distribution if applicable) in target areas. Monitor movement of indicator species for connectivity.
	LM-4. Ensure that median barrier removal and/or median perforations are considered as alternatives during project design.	Monitor wildlife movement in target areas. Monitor movement of indicator species for connectivity.
	LM-5. Remove median barriers or perforate sections of median barriers along roadways to improve successful wildlife crossings and install fencing or other features to direct wildlife to those open sections within first 20 years of implementation. Use feasibility study to determine location and length of barrier removal.	Compliance monitoring. Monitor wildlife movement in target areas. Monitor movement of indicator species for connectivity.

Table 5-1c. Continued

Biological Goals and Objectives	Conservation Actions	Monitoring Action
Goal 15. Provide for the expansion of a breeding population of least Bell's vireos into the study area and increase reproductive success of least Bell's vireo.		
Objective 15.1. Protect 462 acres of modeled Least Bell's vireo habitat (i.e., riparian woodland or forest with a dense understory (<3m tall) in the Uvas, Llagas, Pajaro, or Pacheco Watersheds in south Santa Clara County) as part of the Reserve System.[1] Target areas will contain occupied or potential least Bell's vireo habitat.	LAND-R1. Extend the Uvas Creek Park Preserve 1.6 miles upstream to Hecker Pass Highway and setback expected development adjacent to this stream segment by a minimum of 100 feet to protect the Uvas Creek Corridor consistent with Goals 5-5, 5-7, and 5-8 of the approved City of Gilroy Hecker Pass Specific Plan. Target acquisitions will to contribute to the protection of a total of 800 acres of riparian woodland and forest in the Uvas, Llagas, and Pacheco watersheds.	Compliance monitoring and yearly reporting. Assess habitat quality of acquired land and prioritize areas for management.
Objective 15.2. Restore a minimum of 50 acres of riparian woodland and forest and up to 339 acres in the Uvas, Llagas, or Pacheco Watersheds within the Reserve System.[2] Target areas that contain occupied or potential least Bell's vireo habitat.	LM-11. Graze, mow, hand-pull, to reduce non-native invasive plant species, both terrestrial and aquatic, to a level where native plants can reestablish and remain dominant within the Reserve System.	Monitor status of non-native invasive plants in target eradication areas and assess efficacy of various techniques. Monitor covered species response.
	STREAM-2. Plant and/or seed in native understory and overstory riparian vegetation within 15 feet of the edge of the low-flow channel to create structural diversity, provide overhead cover, and moderate water temperature at all riparian restoration sites.	Monitor survivorship of plantings/seedings as part of restoration and enhancement efforts and periodically survey for species response from least Bell's vireo, yellow-legged frog and other covered species.
	STREAM-3. Plant and/or seed in native riparian vegetation in gaps in existing riparian corridors, or re-establish severally degraded or historic riparian corridors, to promote continuity within conservation lands.	Monitor survivorship of plantings/seedings as part of restoration and enhancement efforts and periodically survey for species response from least Bell's vireo, yellow-legged frog and other covered species.
	STREAM-4. Replace concrete, earthen or other engineered channels as part of the 10.4 miles of stream restoration to restore floodplain connectivity. Location and length will be determine by site-specific conditions.	Compliance monitoring. Conduct pre- and post-treatment monitoring of riparian vegetation as part of a targeted study.
	STREAM-5. Replace confined channels to restore floodplain connectivity and commensurate functions as part of the 10.4 miles of stream restoration. Location and length will be determine by site-specific conditions.	Compliance monitoring. Conduct pre- and post-treatment monitoring of riparian vegetation as part of a targeted study.
Objective 15.3. Reduce the abundance of nest predators in target areas (i.e., occupied and potential habitat) in order to increase reproductive success of least Bell's vireo in riparian areas within the Reserve System.[2]	STREAM-7. Implement a brown-headed cowbird control program in coordination with species experts and regulatory agencies that will reduce the impact of brood parasitism on least Bell's vireo nest success, if least Bell's vireos become regular nesters in the study area (>3 nests over at least two consecutive years) and brown-headed cowbird eggs are discovered in vireo nests.	Compliance monitoring. Monitor for riparian song bird nesting within least Bell's vireo modeled habitat. Periodically, every 5 years, monitor for least Bell's vireo outside of modeled habitat to document range expansion. Quantify the number of occurrences of brood parasitism that are occurring and if/when brown-headed cowbird control program is initiated and efficacy of program.

Table 5-1c. Continued

Biological Goals and Objectives	Conservation Actions	Monitoring Action
Goal 16. Conserve existing populations of the foothill yellow-legged frog population where possible and increase the overall population of foothill yellow-legged frog in biologically appropriate locations in the study area.		
Objective 16.1. Protect 104 stream miles of modeled foothill yellow-legged frog habitat that currently have, or historically had, perennial flows as part of the Reserve System within the study area.[1] Target streams that contain occupied or potential foothill yellow-legged frog habitat.	LAND-R5. Acquire or obtain easements along 104 miles of perennial streams located above Uvas, Calero, Chesbro, Anderson, or in Uvas Creek below Uvas Reservoir, Upper Penitencia Creek, Alamitos Creek or Guadalupe Creek that have or could be restored to have cobblestone substrate and consistent, gentle flows from late March to late May.	Monitor status of non-native invasive plants in target eradication areas and assess efficacy of various techniques. Monitor covered species response.
Objective 16.2. Enhanced all acquired stream miles and restore 10.4 stream miles of perennial streams located above Uvas, Calero, Chesbro, Anderson, or Coyote Reservoirs or in Uvas Creek below Uvas Reservoir, Upper Penitencia Creek, Alamitos Creek or Guadalupe Creek.[2] Target streams that contain occupied or potential foothill yellow-legged frog habitat.	LM-14. Selectively apply herbicides or other treatments to invasive plants.	Monitor status of non-native invasive plants in target eradication areas and assess efficacy of various techniques. Monitor covered species response.
	STREAM-2. Plant and/or seed in native understory and overstory riparian vegetation within 15 feet of the edge of the low-flow channel to create structural diversity, provide overhead cover, and moderate water temperature at all riparian restoration sites.	Monitor survivorship of plantings/seedings as part of restoration and enhancement efforts and periodically survey for species response from least Bell's vireo, yellow-legged frog and other covered species.
	STREAM-4. Replace concrete, earthen or other engineered channels as part of the 10.4 miles of stream restoration to restore floodplain connectivity. Location and length will be determine by site-specific conditions.	Compliance monitoring. Conduct pre- and post-treatment monitoring of in-stream habitat as part of a targeted study.
	STREAM-5. Replace confined channels to restore floodplain connectivity and commensurate functions as part of the 10.4 miles of stream restoration. Location and length will be determine by site-specific conditions.	Compliance monitoring. Conduct pre- and post-treatment monitoring of floodplain function as part of a targeted study.
	STREAM-8. Increase the amount of cobblestone substrate suitable to support breeding foothill yellow-legged frogs to 2,000 ft. to areas close to known occurrence(s) of foothill yellow-legged frog or immediately upstream or downstream of known occurrences or other high quality foothill yellow-legged frog breeding habitat.	Assess yellow-legged frog response to increase in cobblestone substrate as part of a targeted study.
	STUDIES-6. Conduct a directed study to censuses egg masses in breeding habitat downstream of reservoirs before and after releases to determine whether eggs masses were lost.	Monitor effects of pulse flows on foothill yellow-legged frog.

Table 5-1c. Continued

Biological Goals and Objectives	Conservation Actions	Monitoring Action
Goal 17: Conserve existing populations of California red-legged frog, California tiger salamander, and western pond turtle populations where possible, and increase the number of individuals and expand the overall distribution of populations of these species in biologically appropriate locations within the study area to maintain viable populations and contribute to the regional recovery of these species.		
Objective 17.1. Protect California red-legged frog modeled primary (1,430 acres) and secondary (41,800) habitat, California tiger salamander modeled breeding (195 acres) and non-breeding (41,700 acres) habitat, and western pond turtle primary (9,800 acres) and secondary (29,100 acres) habitat as part of the Reserve System within the study area. Aquatic habitat will only be protected if adjacent upland habitat suitable for the terrestrial needs of these species are also protected.[1, 4]	LAND-WP4. Acquire habitat that is adjacent to permanently protected aquatic resources with a high potential to support CRLF and is in the East San Francisco Bay Recovery Unit for red-legged frog *(USFWS 2002)* (Coyote Creek, Pacheco, and Pescadero Watersheds).	Compliance monitoring and yearly reporting. Assess habitat quality of acquired land and prioritize areas for management.
	LAND-WP5. Acquire habitat that contains a matrix of aquatic and upland habitats and is also adjacent to Joseph D. Grant County Park, Palassou Ridge Open Space Preserve, southeast of Henry Coe State Park, Santa Cruz Mountain foothills, and Calero County Park in areas where dense forest is absent to reduce competition with other native amphibians (e.g., California newts).	Compliance monitoring and yearly reporting. Assess habitat quality of acquired land and prioritize areas for management.
	LAND-WP6a. Acquire stream segments or ponds that currently provide or could provide high quality basking, breeding, and nesting habitat (vegetated banks and at least 150 feet of adjacent upland habitat) for western pond turtle.	Compliance monitoring and yearly reporting. Assess habitat quality of acquired land and prioritize areas for management.
	LAND-WP6b. Acquire stream segments or ponds that currently provide or could provide high quality basking, breeding, and nesting habitat (vegetated banks and at least 0.5 miles of adjacent upland habitat) for California tiger salamander.	Monitor the removal of barriers within the reserve system to ensure that the highest priority barriers are removed first. Analyze and quantify any potential positive (native fish movement) and negative (spread of exotic species) effects of barrier removal during targeted study phase of implementation.
Objective 17.2. Protect corridors between existing protected areas to ensure genetic exchange within and movement between populations of covered amphibians and aquatic reptiles as part of the Reserve System within the study area.[1] Target corridors include Linkages 4, 5, 12, 13, 14, 15, and 16 (Table 5-6, Figure 5-6).	LAND-WP7. Acquire habitat near Santa Teresa Hills and Tulare Hill to provide connectivity between populations in the Diablo Range and the Santa Cruz foothills.	Compliance monitoring and yearly reporting. Assess habitat quality of acquired land and prioritize areas for management.
	LAND-G2. Acquire 13,300 acres of annual grassland by fee title or conservation easement as part of the Reserve System. Target areas on both sides of Santa Clara Valley with a high concentration of ponds occupied by covered species or native species and/or other ponds capable of being restored. Acquisition of native grassland will be given priority.	Compliance monitoring and yearly reporting. Assess use by covered amphibians and aquatic reptiles and experimentally manage to improve habitat for movement.

Table 5-1c. Continued

Biological Goals and Objectives	Conservation Actions	Monitoring Action
	LAND-OC1. Acquire in fee title or obtain conservation easements on 7,100 acres of mixed oak woodland and forest, including land in both the Santa Cruz Mountains and the Diablo Range. Target areas with a high concentration of ponds occupied by covered species or native species and/or other ponds capable of being restored.	Compliance monitoring and yearly reporting. Assess use by covered amphibians and aquatic reptiles and experimentally manage to improve habitat for movement.
	LAND-OC2. Acquire 2,900 acres of coast live oak woodland and forest by fee title or conservation easement, including land in both the Santa Cruz Mountains and the Diablo Range. Target areas with a high concentration of ponds occupied by covered species or native species and/or other ponds capable of being restored.	Compliance monitoring and yearly reporting. Assess use by covered amphibians and aquatic reptiles and experimentally manage to improve habitat for movement.
	LAND-OC3. Acquire 1,100 acres of blue oak woodland and 1,700 acres of valley oak woodland by fee title or conservation easement including land in both the Santa Cruz Mountains and the Diablo Range. Target areas with a high concentration of ponds occupied by covered species or native species and/or other ponds capable of being restored.	Compliance monitoring and yearly reporting. Assess use by covered amphibians and aquatic reptiles and experimentally manage to improve habitat for movement.
	LAND-OC4. Acquire 80 acres of foothill pine-oak woodland and forest by fee title or conservation easement, including land in both the Santa Cruz Mountains and Diablo Range. Target areas with a high concentration of ponds occupied by covered species or native species and/or other ponds capable of being restored.	Compliance monitoring and yearly reporting. Assess use by covered amphibians and aquatic reptiles and experimentally manage to improve habitat for movement.
	LAND-OC5. Acquire 20 acres of mixed evergreen forest by fee title or conservation easement including land in both the Santa Cruz Mountains and Diablo Range. Target areas with a high concentration of ponds occupied by covered species or native species and/or other ponds capable of being restored.	Compliance monitoring and yearly reporting. Assess use by covered amphibians and aquatic reptiles and experimentally manage to improve habitat for movement.
Objective 17.3. Enhance a minimum of 50 acres of ponds, 15 acres of wetlands, and 100 miles of streams in the Reserve System by eradicating or reducing exotic species and competitor species (such as nonnative pet-store turtles) that are detrimental to covered amphibians, aquatic reptiles, and native pond biodiversity. Enhance up to 104 acres of ponds and 80 acres of wetlands if all estimated impacts occur.[2]	LM-12. Eradicate or reduce nonnative pig disturbance within the Reserve System through trapping, hunting, or other control methods. Success criteria is achieved through ensuring disturbances by nonnative pigs do not impair the ability of the Reserve System from meeting the biological goals and objectives.	Conduct surveys every 5 years in areas of traditionally high feral pig populations to determine what the population levels are relative to baseline. Monitor response of California red-legged frog, California tiger salamander, and western pond turtle to control of exotic and competitor species as part of a targeted study.
	LM-13. Eradicate or reduce nonnative predators (bullfrogs, invasive fish, feral cats) within the Reserve System through habitat manipulation (e.g., periodic draining of ponds), trapping, hand capturing, electroshocking or other control methods to achieve targets identified in reserve unit management plans.	Monitor response of nonnative predators to habitat manipulation. Monitor response of California red-legged frog, California tiger salamander, and western pond turtle to control of exotic and competitor species

Table 5-1c. Continued

Biological Goals and Objectives	Conservation Actions	Monitoring Action
	STREAM-1. Exclude livestock access to target stream segments (e.g., Pacheco Creek, floodplain of Coyote Creek) using exclusion fencing, off-channel water sources, and other potential actions.	Conduct pre- and post-treatment monitoring to document vegetation and covered-species response to exclusion.
	STREAM-2. Plant and/or seed in native understory and overstory riparian vegetation within 15 feet of the edge of the low-flow channel to create structural diversity, provide overhead cover, and moderate water temperature at all riparian restoration sites.	Monitor the efficacy of seeding efforts with respect to structural diversity, overhead cover, and water temperature compared to designated reference locations. Indicator species will be selected and success criteria developed for large-scale restoration projects from the reference locations.
	STREAM-3. Plant and/or seed in native riparian vegetation in gaps in existing riparian corridors, or re-establish severally degraded or historic riparian corridors, to promote continuity within conservation lands.	STREAM-4. Plant and/or seed in native riparian vegetation in gaps in existing riparian corridors to promote continuity.
	POND-11. Offer financial and regulatory (Safe Harbor Agreement) incentives to private landowners to enhance pond and wetland habitat to suit breeding California red-legged frog, California tiger salamander, and western pond turtle.	Compliance monitoring.
	POND-12. Educate the public that the use of any salamander species as bait is illegal in the State of California.	Compliance monitoring.
Objective 17.4. Restore a minimum of 20 acres of perennial wetlands and 1 mile of streams for the California red-legged frog, California tiger salamander, and western pond turtle to maintain or increase breeding populations of covered amphibians and reptiles. Restore up to 45 acres of perennial wetlands, 30 acres of seasonal wetlands, and 10.4 miles of streams if all estimated impacts occur. [2]	POND-1. Install fencing that will reduce grazing pressure and exclude feral pigs on portions of ponds and wetlands and provide vegetated refuge sites for covered species. Fence installation will be carefully applied to avoid negative impacts on small mammal movement and upland habitat.	Conduct pre- and post-treatment monitoring to document vegetation and covered-species response to exclusion.
	POND-2. Install woody debris around perimeter and in submerged banks of ponds and wetlands to create basking habitat and cover for native juvenile amphibians and turtles. Materials imported from outside of the watershed shall be treated for chytrid and other potential pathogens prior to installation.	Analyze and quantify effectiveness of created basking site through routine monitoring in ponds with known western pond turtle occupancy.
	POND-3. Plant native emergent vegetation around the perimeter and in ponds and wetlands.	Monitor survivorship of planting, quantify vegetated perimeter of pond, describe habitat quality and periodically survey for species response from covered amphibians and reptiles. Evaluate success of wetland and pond enhancement using established success criteria.
	POND-4. Clear vegetation and/or remove sediment in a way that minimizes negative effects on covered species when vegetation and/or sediment restricts the ability of the aquatic environment from meeting the biological goals and objectives of the Plan.	Monitor status of non-native invasive plants in target eradication areas and assess efficacy of various techniques. Monitor covered species response.

Table 5-1c. Continued

Biological Goals and Objectives	Conservation Actions	Monitoring Action
	POND-13. Excavate sections of ponds to provide deeper pools that will be utilized by California red-legged frog adults and sub-adults and western pond turtles, while maintaining shallow areas to provide rearing habitat for California red-legged frog tadpoles, California tiger salamander larvae, and western pond turtle hatchlings.	Monitor use of excavated pond by red-legged frog and western pond turtles as part of a targeted study.
	STUDIES-7. In the case of ponds, wetlands, and/ or amphibian populations becoming infected with chytrid fungus or other diseases, use the best scientific information available to manage and stop spread of epidemic.	Monitor for the presence of disease. Monitor efficacy of disease control actions.
	STUDIES-8. Identify the distribution and risk to existing indigenous populations of covered amphibians and reptiles from hybridization (e.g., California tiger salamander hybridizing with Texas salamander) within the Reserve System. Appendix K, California Tiger Salamander Hybridization, will serve as the Management Plan for CTS hybridization issues and will be updated throughout the permit term for adaptive management purposes.	Monitor for the presence of non-natives and hybrids. Test and document efficacy of management plan.
	STUDIES-9. Annually identify and maintain upland breeding sites (even if sites are not "natural") for western pond turtle because of the high fidelity of use from year to year .	Monitor use of protected sites to determine factors influencing nest success in areas of known turtle use.
	GRASS-1. Continue or introduce livestock and native herbivore (e.g., elk) grazing in a variety of grazing regimes.	Monitor effects of various grazing regimes on increasing habitat for red-legged frog, western pond turtle and California tiger salamander
	GRASS-2. Conduct prescribed burns. Use targeted studies to inform methods, timing, location, and frequency.	Monitor effects of prescribed burning on increasing habitat for red-legged frog, western pond turtle and California tiger salamander
	LM-11. Graze, mow, hand-pull, to reduce non-native invasive plant species, both terrestrial and aquatic, to a level where native plants can reestablish and remain dominant within the Reserve System.	Monitor status of non-native invasive plants in target eradication areas and assess efficacy of various techniques. Monitor covered species response.
	LM-14. Selectively apply herbicides or other treatments to invasive plants.	Monitor effects of herbicide application on reducing nonnative species and ensure that herbicide use has no unwanted effects on native amphibian population.

Table 5-1c. Continued

Biological Goals and Objectives	Conservation Actions	Monitoring Action
Objective 17.5. Create a minimum of 20 acres of ponds to provide new breeding sites for California red-legged frog, California tiger salamander, and western pond turtle within the Reserve System. Create up to 72 acres of ponds if all estimated impacts occur.[2]	POND-1. Install fencing that will reduce grazing pressure and exclude feral pigs on portions of ponds and wetlands and provide vegetated refuge sites for covered species. Fence installation will be carefully applied to avoid negative impacts on small mammal movement and upland habitat.	Monitor pond creation and assess whether success criteria are being met. Monitor use of created ponds by covered amphibians and western pond turtle.
	POND-2. Install woody debris around perimeter and in submerged banks of ponds and wetlands to create basking habitat and cover for native juvenile amphibians and turtles. Materials imported from outside of the watershed shall be treated for chytrid and other potential pathogens prior to installation.	Analyze and quantify effectiveness of created basking site through routine monitoring in ponds with known western pond turtle occupancy.
	POND-3. Plant native emergent vegetation around the perimeter and in ponds and wetlands.	Monitor survivorship of planting, quantify vegetated perimeter of pond, describe habitat quality and periodically survey for species response from covered amphibians and reptiles. Evaluate success of wetland and pond enhancement using established success criteria.
	POND-4. Clear vegetation and/or remove sediment in a way that minimizes negative effects on covered species when vegetation and/or sediment restricts the ability of the aquatic environment from meeting the biological goals and objectives of the Plan.	Monitor status of non-native invasive plants in target eradication areas and assess efficacy of various techniques. Monitor covered species response.
	POND-9. Create at least 20 acres of ponds at 40 sites, at least 10 sites in the Santa Cruz Mountains and 20 sites in the Diablo Range.	Monitor pond creation and assess whether success criteria are being met. Monitor use of created ponds by covered amphibians and western pond turtle.
	POND-10. In addition to the creation of ponds described in POND-9, create up to 52 acres of ponds in-kind within the Reserve System to increase the amount available habitat and enhance connectivity among existing ponds and wetlands if all anticipated impacts occur.3	Monitor pond creation and assess whether success criteria are being met. Monitor use of created ponds by covered amphibians and western pond turtle.
	POND-11. Offer financial and regulatory (Safe Harbor Agreement) incentives to private landowners to enhance pond and wetland habitat to suit breeding California red-legged frog, California tiger salamander, and western pond turtle.	Compliance monitoring.
	POND-13. Excavate sections of ponds to provide deeper pools that will be utilized by California red-legged frog adults and sub-adults and western pond turtles, while maintaining shallow areas to provide rearing habitat for California red-legged frog tadpoles, California tiger salamander larvae, and western pond turtle hatchlings.	Monitor use of excavated pond by red-legged frog and western pond turtles as part of a targeted study.
	STUDIES-7. In the case of ponds, wetlands, and/ or amphibian populations becoming infected with chytrid fungus or other diseases, use the best scientific information available to manage and stop spread of epidemic.	Monitor for the presence of disease. Monitor efficacy of disease control actions.

Table 5-1c. Continued

Biological Goals and Objectives	Conservation Actions	Monitoring Action
	STUDIES-8. Identify the distribution and risk to existing indigenous populations of covered amphibians and reptiles from hybridization (e.g., California tiger salamander hybridizing with Texas salamander) within the Reserve System. Appendix K, California Tiger Salamander Hybridization, will serve as the Management Plan for CTS hybridization issues and will be updated throughout the permit term for adaptive management purposes.	Monitor for the presence of non-natives and hybrids. Test and document efficacy of management plan.
	STUDIES-9. Annually identify and maintain upland breeding sites (even if sites are not "natural") for western pond turtle because of the high fidelity of use from year to year .	Monitor use of protected sites to determine factors influencing nest success in areas of known turtle use.
	GRASS-1. Continue or introduce livestock and native herbivore (e.g., elk) grazing in a variety of grazing regimes.	Monitor effects of various grazing regimes on increasing habitat for red-legged frog, western pond turtle and California tiger salamander
	GRASS-2. Conduct prescribed burns. Use targeted studies to inform methods, timing, location, and frequency.	Monitor effects of prescribed burning on increasing habitat for red-legged frog, western pond turtle and California tiger salamander
	LM-11. Graze, mow, hand-pull, to reduce non-native invasive plant species, both terrestrial and aquatic, to a level where native plants can reestablish and remain dominant within the Reserve System.	Monitor status of non-native invasive plants in target eradication areas and assess efficacy of various techniques. Monitor covered species response.
	LM-14. Selectively apply herbicides or other treatments to invasive plants.	Monitor effects of herbicide application on reducing nonnative species and ensure that herbicide use has no unwanted effects on native amphibian population.
Goal 18. Increase the population size of tricolored blackbird to enhance the viability of the species in the study area.		
Objective 18.1. Protect and enhance at least 4 tricolored blackbird breeding sites that support, historically supported, or could support tricolored blackbird colonies as part of the Reserve System within the study area.[1] Each site must include at least 2-acres of breeding habitat and have foraging habitat within 2 miles.	LAND-WP8. Acquire in fee title or through a conservation easement at least 4 tricolored blackbird breeding sites that support, historically supported, or could support tricolored blackbird colonies each with at least 2-acres of breeding habitat and foraging habitat within 2 miles. Target at least 5 acres of suitable breeding habitat for tricolored blackbird within dry land farming or ranching complexes in the Santa Clara Valley and the Diablo Range	Compliance monitoring and yearly reporting. Assess habitat quality of acquired land and prioritize areas for management.
	POND-14. Offer financial or regulatory incentives (Safe Harbor Agreement, if listed) to private landowners to enhance pond and marsh habitat to suit breeding tricolored blackbirds, and to ensure that dry-land farming and ranching activities support breeding tricolored blackbirds.	Compliance Monitoring.

Table 5-1c. Continued

Biological Goals and Objectives	Conservation Actions	Monitoring Action
Objective 18.2. Protect and enhance 200 acres of suitable tricolored blackbird foraging habitat within 2 miles of protected and occupied breeding sites as part of the Reserve System within the study area.[1]	LAND-WP9. Acquire 200 acres of foraging habitat for tricolored blackbird in areas where there are protected breeding sites within 2 miles.	Compliance monitoring and yearly reporting. Monitor presence/absence of foraging habitat.
	POND-15 Offer financial incentives to private landowners to ensure that dry-land farming and ranching activities support foraging tricolored blackbirds.	Compliance Monitoring.
Objective 18.3. Enhance or restore 5 acres of suitable tricolor blackbird breeding habitat in historically/currently occupied areas within the Reserve System.[2]	POND-1. Install fencing that will reduce grazing pressure and exclude feral pigs on portions of ponds and wetlands and provide vegetated refuge sites for covered species. Fence installation will be carefully applied to avoid negative impacts on small mammal movement and upland habitat.	Conduct pre- and post-treatment monitoring to document vegetation and covered-species response to exclusion.
	POND-16. Restore freshwater marsh, seasonal wetlands, and/or ponds that will support dense reed-like vegetation (cattails) or other native vegetation that will attract nesting tricolored blackbirds.	Compliance monitoring. Monitor habitat restoration and assess whether success criteria are being met. Monitor use of restored habitat by tricolored blackbird.
	POND-17. In areas with non-native vegetation (e.g., Himalayan blackberry) that supports existing tricolored blackbird colonies, initiate a gradual (3-4 year) transition from non-native vegetation to native vegetation that is structurally similar.	Determine areas where tricolored blackbirds are using non-native vegetation and ensure that there is a management plan in place to control the spread of the non-native vegetation and transition the colony to native vegetation if necessary.
	POND-18. Restore up to 30 acres of seasonal wetlands within the Reserve System in the Santa Clara Valley.	Compliance monitoring. Monitor habitat restoration and assess whether success criteria are being met. Monitor use of restored habitat by tricolored blackbird.
	STREAM-4. Replace concrete, earthen or other engineered channels as part of the 10.4 miles of stream restoration to restore floodplain connectivity. Location and length will be determine by site-specific conditions.	Compliance monitoring. Conduct pre- and post-treatment monitoring of riparian vegetation as part of a targeted study.
Objective 18.4. Restore a minimum of 20 acres of freshwater wetland suitable for tricolored blackbird breeding habitat within 2 miles of suitable and foraging habitat to encourage colonization of new sites within the Reserve System. Restore up to 45 acres of freshwater wetlands if all estimated impacts occur.[2] The acreage targets in this objective are inclusive of targets identified in Objective 20.3.	POND-19. Restore a minimum of 20 acres and up to 45 acres of freshwater marsh within the Reserve System in the Santa Cruz Mountains, Santa Clara Valley, and Diablo Range.	Compliance monitoring. Monitor habitat restoration and assess whether success criteria are being met. Monitor use of restored habitat by tricolored blackbird.

Table 5-1c. Continued

Biological Goals and Objectives	Conservation Actions	Monitoring Action
Objective 18.5. Create a minimum of 20 acres of ponds to provide new nest colony sites for tricolored blackbird within the Reserve System. Create up to 72 acres of ponds if all estimated impacts occur.[2]	POND-9. Create at least 20 acres of ponds at 40 sites, at least 10 sites in the Santa Cruz Mountains and 20 sites in the Diablo Range.	Monitor pond creation and assess whether success criteria are being met. Monitor use of created ponds by covered amphibians, western pond turtle, and tricolored blackbird.
	POND-10. In addition to the creation of ponds described in POND-9, create up to 52 acres of ponds in-kind within the Reserve System to increase the amount available habitat and enhance connectivity among existing ponds and wetlands if all anticipated impacts occur.3	Monitor pond creation and assess whether success criteria are being met. Monitor use of created ponds by covered amphibians, western pond turtle, and tricolored blackbird.

Notes:

[1] Land acquisition must occur in rough step with impacts as required by the Stay-Ahead provision (see Chapter 8, Section 8.6.1). All land acquisition must be completed by Year 45. Section 5.4 of the Plan provides more detail on areas targeted for acquisition for each species. Reserve lands will be managed in accordance with reserve unit management plans, completed within 5 years of the acquisition of the 1st parcel within the reserve unit.

[2] Habitat enhancement, monitoring, and adaptive management program, will continue in perpetuity. Restoration and creation must occur in rough step with impacts as required by the Stay Ahead provision (see Chapter 8, Section 8.6.1). All habitat restoration will be completed by year 40 unless otherwise noted in this table. Reserve lands will be managed in accordance with reserve unit management plans, completed within 5 years of the acquisition of the 1st parcel within the reserve unit. All plans will be reviewed and approved by the Wildlife Agencies. The conservation strategy for aquatic land cover types includes preservation/enhancement, restoration, and/or creation. See Tables 5-14 and 5-15 for details.

[3] Design will be based on the best available science and be consistent with Condition 6 described in Chapter 6, Section 6.4.4, subheading *Condition 6 Design and Construction Requirements for Covered Transportation Projects*

[4] These occupied acreages are minimum requirements for each species that utilizes each referenced land cover type.

Table 5-1d. Biological Goals, Objectives and Conservation Actions: Plants

Biological Goals and Objectives	Conservation Actions	Monitoring Action
Goal 20. Maintain viability, protect, and increase the size and number of populations of covered serpentine plant species, including Coyote ceanothus, Santa Clara Valley dudleya, Metcalf Canyon jewelflower, most beautiful jewelflower, smooth lessingia, fragrant fritillary, Mt. Hamilton thistle, Loma Prieta hoita, and Tiburon Indian paintbrush, within the study area.[1]		
Objective 20.1. Protect and enhance the known extant occurrences of Coyote ceanothus as part of the Reserve System within the study area, including a buffer zone of 500 feet around each occurrence to reduce external influences and a minimum occurrence size of 5,000 individuals.[4,5,7]	LAND-P1. Acquire in fee title or conservation easement sites in the study area that support three unprotected occurrences of Coyote ceanothus and provide the necessary buffer between incompatible land uses.	Compliance monitoring and annual reports.
	STUDIES-5. Conduct targeted studies to determine factors limiting the expansion of the covered plant species, including but not limited to its management and micro-site needs, and implement measures to mitigate or eliminate these factors to promote occurrence expansion.	Monitor results of research and the effects of its application.
	STUDIES-11. Conduct experimental burning in protected occurrences of targeted covered plant species to determine the importance of fire for plant regeneration.	Monitor burning on known occurrences of Coyote ceanothus and species response.
	STUDIES-12. Ensure seeds from natural occurrences in the Study Area are stored and maintained at a minimum of one Center for Plant Conservation certified botanic garden.	Monitor viability of seed collection and refresh collection, as necessary.
	CHAP-1. Conduct prescribed burns in chaparral and northern coastal scrub to maintain canopy gaps and promote regeneration. Use targeted studies to inform locations and frequency.	Monitor burning on known occurrences of Coyote ceanothus and species response.
	CHAP-2. Mechanically thin chaparral and northern coastal scrub to promote structural diversity. Use targeted studies to inform location and frequency.	Monitor the impacts of grazing or other vegetation management techniques on known occurrences of Coyote ceanothus.
	LM-8. Negotiate with Cal Fire and other local fire-fighting agencies the use of management response measures for all fire events and fire-dependent ecosystems that minimize impacts to natural communities and covered species while protecting human life and property. All burns will be responded to, and prescribed burns will be conducted, with minimum impact suppression tactics. Burn response will take into consideration ignition location and method, seasonality, weather and availability of suppression forces.	Monitor all covered plants following a wildfire.

Table 5-1d. Continued

Biological Goals and Objectives	Conservation Actions	Monitoring Action
Objective 20.2. Establish two new occurrences of Coyote ceanothus in the Reserve System to reduce risk of extinction. Conduct targeted studies to determine feasibility of occurrence creation and identify locations and propagation/planting techniques.[6]	STUDIES-13. Identify suitable locations for and establish target number of new covered plant occurrences in the Reserve System.	Compliance monitoring and annual reports.
	STUDIES-14. Determine suitable propagation or planting techniques for targeted covered plant species and determine biologically appropriate seed sampling techniques from existing occurrences.	Monitor newly established and source occurrences.
	STUDIES-15. Design and implement field experiments (if the number of propagules will not be significantly impacted) to test alternative techniques for establishment of targeted covered plant occurrences. Field experiments will be continue until target number of occurrences are established.	Monitor the results of all experiments.
Objective 20.3. Protect at least 55 occurrences of Santa Clara Valley dudleya as part of the Reserve System within the study area, including a buffer zone of 500 feet around each occurrence to reduce external influences and promote expansion of occurrences.[2,4,5]	LAND-P2. Acquire in fee title or conservation easement sites in the study area that support 55 occurrences of Santa Clara Valley dudleya across a range of elevational gradients on both sides of Coyote Valley to ensure geographic diversity in protected occurrences.	Compliance monitoring and annual reports.
	STUDIES-12. Ensure seeds from natural occurrences in the Study Area are stored and maintained at a minimum of one Center for Plant Conservation certified botanic garden.	Monitor viability of seed collection and refresh collection, as necessary.
Objective 20.4. Increase the size of Santa Clara Valley dudleya occurrences to ensure each occurrence has at least 2,000 individuals within the Reserve System.[4,6,7]	STUDIES-5. Conduct targeted studies to determine factors limiting the expansion of the covered plant species, including but not limited to its management and micro-site needs, and implement measures to mitigate or eliminate these factors to promote occurrence expansion.	Monitor the results and application of research on Santa Clara Valley dudleya
	STUDIES-16. Monitor the effects of livestock grazing (or predation by other species, e.g., black-tailed jackrabbit) on targeted covered plant species by conducting exclusion experiments and monitoring effects on occurrences, including control sites in the monitoring plan.	Monitor the effects of grazing on management on covered plant species.

Table 5-1d. Continued

Biological Goals and Objectives	Conservation Actions	Monitoring Action
Objective 20.5. Protect at least three currently unprotected occurrences and adequate lands to create ten new occurrences of Metcalf Canyon jewelflower, including a buffer zone of 500 feet around each occurrence to reduce external influences and promote expansion of occurrences.[4,5]	LAND-P3. Acquire in fee title or conservation easement sites in the study area that support three occurrences of Metcalf Canyon jewelflower.	Compliance Monitoring; Yearly Reports
	STUDIES-12. Ensure seeds from natural occurrences in the Study Area are stored and maintained at a minimum of one Center for Plant Conservation certified botanic garden.	Monitor viability of seed collection and refresh collection, as necessary.
Objective 20.6. Create at least ten new occurrences and expand the size of all Metcalf Canyon jewelflower occurrences in the Reserve System to at least 2,000 individuals.[4,6,7]	LAND-P4. Acquire north side of Tulare Hill to promote reintroduction of Metcalf Canyon jewelflower on west side of Valley.	Compliance Monitoring; Yearly Reports
	STUDIES-5. Conduct targeted studies to determine factors limiting the expansion of the covered plant species, including but not limited to its management and micro-site needs, and implement measures to mitigate or eliminate these factors to promote occurrence expansion.	Monitor the results and application of research on Metcalf Canyon jewelflower
	STUDIES-14. Determine suitable propagation or planting techniques for targeted covered plant species and determine biologically appropriate seed sampling techniques from existing occurrences.	Monitor newly established and source occurrences.
	STUDIES-15. Design and implement field experiments (if the number of propagules will not be significantly impacted) to test alternative techniques for establishment of targeted covered plant occurrences. Field experiments will be continue until target number of occurrences are established.	Monitor the results of all experiments.
	STUDIES-17. Monitor Metcalf Canyon jewelflower and most beautiful jewelflower introgression and develop protocols to protect the genetic integrity of both species.	Monitor the results of research and success of developed protocols.
Objective 20.7. Protect at least 17 occurrences of most beautiful jewelflower, including a buffer zone of 500 feet around each occurrence to reduce external influences and promote expansion of occurrence.[4,5]	LAND-P5. Acquire sites in the study area that support 17 occurrences of most beautiful jewelflower.	Compliance monitoring and annual reports.
	STUDIES-12. Ensure seeds from natural occurrences in the Study Area are stored and maintained at a minimum of one Center for Plant Conservation certified botanic garden.	Monitor viability of seed collection and refresh collection, as necessary.

Table 5-1d. Continued

Biological Goals and Objectives	Conservation Actions	Monitoring Action
	STUDIES-17. Monitor Metcalf Canyon jewelflower and most beautiful jewelflower introgression and develop protocols to protect the genetic integrity of both species.	Monitor the results of research and success of developed protocols.
Objective 20.8. Increase the size of most beautiful jewelflower occurrences to ensure each occurrence has at least 2,000 individuals.[4,6,7]	STUDIES-5. Conduct targeted studies to determine factors limiting the expansion of the covered plant species, including but not limited to its management and micro-site needs, and implement measures to mitigate or eliminate these factors to promote occurrence expansion.	Monitor the results and application of research on most beautiful jewelflower
	STUDIES-14. Determine suitable propagation or planting techniques for targeted covered plant species and determine biologically appropriate seed sampling techniques from existing occurrences.	Monitor newly established and source occurrences.
Objective 20.9. Protect at least 22 occurrences of Mount Hamilton thistle as part of the Reserve System within the study area, including a buffer zone of 500 feet around each occurrence to reduce external influences and promote expansion of occurrence.[3,4,5]	LAND-P6. Acquire sites in the study area that support Mount Hamilton thistle in drainages or spring systems and stratify protection on both sides of Coyote Valley to ensure geographic diversity in protected occurrences.	Compliance monitoring and annual reports.
	STUDIES-12. Ensure seeds from natural occurrences in the Study Area are stored and maintained at a minimum of one Center for Plant Conservation certified botanic garden.	Monitor viability of seed collection and refresh collection, as necessary.
Objective 20.10. Increase the size of Mt. Hamilton thistle occurrences within the Reserve System to at least 2,000 individuals to ensure each occurrence has a viable number of individuals each year. Conduct targeted studies to determine feasibility of expanding occurrences.[4,6,7]	STUDIES-5. Conduct targeted studies to determine factors limiting the expansion of the covered plant species, including but not limited to its management and micro-site needs, and implement measures to mitigate or eliminate these factors to promote occurrence expansion.	Monitor the results and application of research on Mt. Hamilton thistle.
	STUDIES-16. Monitor the effects of livestock grazing (or predation by other species, e.g., black-tailed jackrabbit) on targeted covered plant species by conducting exclusion experiments and monitoring effects on occurrences, including control sites in the monitoring plan.	Monitor the effects of grazing on management on covered plant species.

Table 5-1d. Continued

Biological Goals and Objectives	Conservation Actions	Monitoring Action
Objective 20.11. Protect at least 12 occurrences of smooth lessingia as part of the Reserve System within the study area, including a buffer zone of 150-meter (500 foot) buffer around each occurrence to reduce external influences and promote expansion of occurrences.[4,5]	LAND-P7. Acquire sites in the Reserve System that support eight occurrences of smooth lessingia.	Compliance monitoring and annual reports.
	STUDIES-12. Ensure seeds from natural occurrences in the Study Area are stored and maintained at a minimum of one Center for Plant Conservation certified botanic garden.	Monitor viability of seed collection and refresh collection, as necessary.
Objective 20.12. Locate or create at least 12 new occurrences of smooth lessingia and increase the size of all occurrence to ensure each occurrence has at least 2,000 individuals within the Reserve System.[4,6,7]	STUDIES-5. Conduct targeted studies to determine factors limiting the expansion of the covered plant species, including but not limited to its management and micro-site needs, and implement measures to mitigate or eliminate these factors to promote occurrence expansion.	Monitor the results and application of research on smooth lessingia.
	STUDIES-14. Determine suitable propagation or planting techniques for targeted covered plant species and determine biologically appropriate seed sampling techniques from existing occurrences.	
	STUDIES-16. Monitor the effects of livestock grazing (or predation by other species, e.g., black-tailed jackrabbit) on targeted covered plant species by conducting exclusion experiments and monitoring effects on occurrences, including control sites in the monitoring plan.	Monitor the effects of grazing on management on covered plant species.
Objective 20.13. Protect at least four occurrences of fragrant fritillary as part of the Reserve System within the study area, including a buffer zone of 500 feet around each occurrence to reduce external influences and promote expansion of occurrences.[5]	LAND-P8. Acquire sites along Coyote Ridge that support the four remaining unprotected fragrant fritillary occurrences.	Compliance monitoring and annual reports.
	STUDIES-12. Ensure seeds from natural occurrences in the Study Area are stored and maintained at a minimum of one Center for Plant Conservation certified botanic garden.	Monitor viability of seed collection and refresh collection, as necessary.
Objective 20.14. Increase the size of fragrant fritillary occurrences within the Reserve System to ensure each occurrence has a viable number of individuals each year.[7]	STUDIES-5. Conduct targeted studies to determine factors limiting the expansion of the covered plant species, including but not limited to its management and micro-site needs, and implement measures to mitigate or eliminate these factors to promote occurrence expansion.	Monitor the results and application of research on fragrant fritillary.

Table 5-1d. Continued

Biological Goals and Objectives	Conservation Actions	Monitoring Action
	STUDIES-16. Monitor the effects of livestock grazing (or predation by other species, e.g., black-tailed jackrabbit) on targeted covered plant species by conducting exclusion experiments and monitoring effects on occurrences, including control sites in the monitoring plan.	Monitor the effects of grazing on management on covered plant species.
Objective 20.15. Protect the one known occurrence of Tiburon Indian Paintbrush within the permit area that is not currently permanently protected as part of the Reserve System, including a buffer zone of 500 feet around each occurrence to reduce external influences.[4]	LAND-P9. Acquire the Tiburon Indian paintbrush occurrence located at the Kirby Canyon landfill mitigation site prior to or at the time the temporary conservation easement expires.	
	STUDIES-12. Ensure seeds from natural occurrences in the Study Area are stored and maintained at a minimum of one Center for Plant Conservation certified botanic garden.	Monitor viability of seed collection and refresh collection, as necessary.
Objective 20.16. Increase the size of the protected Tiburon Indian paintbrush occurrence within the Reserve System to ensure occurrence has at least 2,000 individuals.[4,6,7]	STUDIES-5. Conduct targeted studies to determine factors limiting the expansion of the covered plant species, including but not limited to its management and micro-site needs, and implement measures to mitigate or eliminate these factors to promote occurrence expansion.	Monitor the results and application of research on Tiburon Indian paintbrush.
	STUDIES-16. Monitor the effects of livestock grazing (or predation by other species, e.g., black-tailed jackrabbit) on targeted covered plant species by conducting exclusion experiments and monitoring effects on occurrences, including control sites in the monitoring plan.	Monitor the effects of grazing on management on covered plant species.
Goal 21. Protect and increase the size and number of Loma Prieta hoita within the study area.		
Objective 21.1 (not used) **Objective 21.2** (not used) **Objective 21.3** (not used) **Objective 21.4** (not used) **Objective 21.5** (not used) **Objective 21.6** (not used)		
Objective 21.7. Protect four currently unprotected occurrences of Loma Prieta hoita in the study area as part of the Reserve System including a buffer zone of 500 feet around each occurrence to reduce external influences.[4,5]	LAND-P11. Acquire four sites in the study area that supports Loma Prieta hoita.	Compliance monitoring and annual reports.
	STUDIES-12. Ensure seeds from natural occurrences in the Study Area are stored and maintained at a minimum of one Center for Plant Conservation certified botanic garden.	Monitor viability of seed collection and refresh collection, as necessary.

Table 5-1d. Continued

Biological Goals and Objectives	Conservation Actions	Monitoring Action
Objective 21.8. Increase the size of protected Loma Prieta hoita occurrences within the Reserve System.[6,7]	STUDIES-5. Conduct targeted studies to determine factors limiting the expansion of the covered plant species, including but not limited to its management and micro-site needs, and implement measures to mitigate or eliminate these factors to promote occurrence expansion.	Monitor the results and application of research on Loma Prieta hoita.

Notes:

[1] For the purposes of this Plan, a plant occurrence is defined as a group of individuals that are separated by at least 0.25 mile from other groups of individuals of the same species or subspecies, consistent with how plants are tracked by the CNDDB. In some cases, an occurrence may be equivalent to a population; in other cases, multiple occurrences may form a single population. A biological population is defined differently for each of the covered plants and is often unknown due to a lack of population data. Therefore, an occurrence provides a single standard by which to measure impacts and conservation for all covered plants. During implementation, the Implementing Entity may conduct monitoring or management actions based on populations, which is a more biologically meaningful unit.

[2] Objectives that require protection of plant occurrence require that those occurrences be in currently unprotected land.

[3] For Mount Hamilton thistle population on the east side of Coyote Valley are defined as all occurrences in a discrete drainage; while population on the west side of Coyote Valley are defined as each occurrence point.

[4] Source for buffer width and minimum population size: USFWS Recovery Plan for Serpentine Soil Species of the San Francisco Bay Area (1998c)

[5] Land acquisition must occur in rough step with impacts as required by the Stay Ahead provision (see Chapter 8, Section 8.6.1). All land acquisition must be complete by Year 45 . Land acquisition requiring restoration or creation of habitat for Covered Species must be complete by Year 40. Reference Table 5-29 for interim land acquisition timelines.

[6] Habitat enhancement, monitoring, and adaptive management program, will continue in perpetuity. Restoration and creation must occur in rough step with impacts as required by the Stay-Ahead provision (see Chapter 8, Section 8.6.1). All habitat restoration will be completed by year 40.

[7] The target number of individuals per occurrence will be adjusted or established as necessary pending research carried out during Plan implementation to assure viable occurrences of each covered plant species.

Table 5-2a. Land Acquisition Actions

Acquisition Action	Target Species
Landscape (L)	
LAND-L1. Acquire in fee title or obtain easements on 100 stream miles within the study area.	All covered species
LAND-L2a. Acquire in fee title or obtain easements on at least 33,205 acres of land for the Reserve System.	All covered species
LAND-L2b. Incorporate 13,291 acres of existing open space into the Reserve System.	All covered species
LAND-L2c. Acquire in fee title or obtain easements on 33,205 acres of land for the Reserve System that includes the full range of topographic and geographic diversity in the study area.	All covered species
LAND-L2d. Incorporate 13,291 acres of existing open space into the Reserve System that includes the full range of topographic and geographic diversity in the study area.	All covered species
LAND-L3. Acquire in fee title or obtain easements on streams (100 miles), ponds (50 acres), freshwater wetlands (10 acres), and seasonal wetlands (5 acres) in all watersheds of the study area.	California red-legged frog, California tiger salamander, western pond turtle, least Bell's vireo,
LAND-L4. Acquire and enhance natural and semi-natural landscapes between the Santa Teresa Hills and Metcalf Canyon to the south that will contribute to providing connectivity between the Santa Cruz Mountains and the Diablo Range to promote the movement of covered and other native species at many spatial scales (Linkage 10 in Table 5-9 and Figure 5-6).	Bay checkerspot butterfly, covered serpentine plants
LAND-L5. Acquire in fee title or obtain easements on 2,900 acres of serpentine grassland along Coyote Ridge to link existing protected areas and to create a large core reserve for serpentine grassland species to move within (Linkage 6 in Table 5-9 and Figure 5-6). These acreages are inclusive of, not in addition to, acquisition targets set in LAND-G3.	Bay checkerspot butterfly, covered serpentine plants, western burrowing owl
LAND-L6. Acquire in fee title or obtain easements on at least 3,000 acres of grassland, chaparral & coastal scrub, and oak woodland natural communities south of Henry W. Coe State Park to link this core reserve with extensive wetlands surrounding San Felipe Lake in San Benito County (Linkage 14 in Table 5-9 and Figure 5-6).	San Joaquin kit fox, California tiger salamander, California red-legged frog

Table 5-2a. Continued

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Acquisition Action	Target Species
LAND- L7. Acquire in fee title or obtain easements on at least 2,300 acres of grassland, chaparral & coastal scrub, and oak woodland natural communities in the NE corner of the study area to link the core reserve that includes Joseph Grant County Park with SFPUC lands and other protected lands in Alameda County (Linkage 4 in Table 5-9 and Figure 5-6).	California tiger salamander, California red-legged frog
LAND-L8. Acquire in fee title or obtain easements on at least 500 acres of grassland, chaparral & coastal scrub, and oak woodland natural communities to connect Almaden Quicksilver County Park with protected open space to the east near Calero Lake (Linkage 9 in Table 5-9 and Figure 5-6).	California tiger salamander, California red-legged frog, western pond turtle
LAND-L9. Acquire in fee title or obtain easements on 2,000 acres of conifer woodland, riparian forest & scrub, oak woodland, and grassland natural communities, in the portion of the Pescadero Watershed that is in the study area and along the Pajaro River, to maintain wildlife connections between the Santa Cruz Mountains and the Gabilan Range outside the study area (Linkages 18, 19, and 20 in Table 5-9 and Figure 5-6).	California tiger salamander, California red-legged frog, western pond turtle, tricolored blackbird
LAND-L10. Acquire in fee title or obtain easements on serpentine grassland along Coyote Ridge to protect the connection between Silver Creek and Kirby Canyon (Linkage 6 in Table 5-9 and Figure 5-6) as part of the acquisition targets set in LAND-G3.	Bay checkerspot butterfly, covered serpentine plants
Grassland (G)	
LAND-G1. Acquire 4,130 acres of serpentine grassland by fee title or conservation easement with the full range of serpentine grassland associations and vegetation diversity found throughout the study area. This includes 4,000 acres of serpentine bunchgrass grassland, 120 of serpentine rock outcrops/barrens, and 10 acres of serpentine seeps.	Covered serpentine plants, Bay checkerspot butterfly
LAND-G2. Acquire 13,300 acres of annual grassland by fee title or conservation easement as part of the Reserve System. Target areas on both sides of Santa Clara Valley with a high concentration of ponds occupied by covered species or native species and/or other ponds capable of being restored. Acquisition of native grassland will be given priority.	California tiger salamander, western burrowing owl

Table 5-2a. Continued

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Acquisition Action	Target Species
LAND-G3. Acquire in fee title or obtain conservation easements on 4,000 acres of suitable serpentine grassland habitat along ridges for Bay checkerspot butterfly on Silver Creek Hills, Coyote Ridge, Pigeon Point, Tulare Hill, Santa Theresa Hills, areas west of Calero Reservoir, and the Kalanas, and Hale/Falcon Crest in fee title or conservation easement. Habitat acquisition on Coyote Ridge and Tulare Hill is top priority. For other sites totaling 554 acres, prioritize sites, threat, patch size, current occupancy and prevalence of cool microsites for Bay checkerspot butterflies.	Covered serpentine plants, Bay checkerspot butterfly
LAND-G4. (not used)	
LAND-G5. (not used)	
LAND-G6. Acquire, obtain easements, or retain management agreements on burrowing owl nesting habitat within 2 miles the San Jose Water Pollution Control Plant Bufferlands, north of Highway 237.	western burrowing owl, San Joaquin kit fox, California tiger salamander
LAND-G7. Acquire, obtain easements, or retain management agreements on burrowing owl nesting habitat within 2 miles of the San Jose International Airport or other important northern San Jose breeding sites.	western burrowing owl
LAND-G8. Acquire or obtain easements on 21,310 acres of suitable overwintering habitat in the Diablo Range that support ground squirrel populations or could support them with improved management. This acreage is in addition to of the targets identified in LAND-G6 and LAND-G7.	western burrowing owl, San Joaquin kit fox, California tiger salamander
LAND-G9. Acquire in fee title or obtain easements on 4,100 acres of annual grassland and suitable oak woodland types (e.g., oak savanna and oak woodland within 500 feet of annual grassland) north and south of Highway 152 in modeled San Joaquin kit fox habitat.	western burrowing owl, San Joaquin kit fox, California tiger salamander
Chaparral and Northern Coastal Scrub (C)	
LAND-C1. Acquire 400 acres of northern mixed chaparral/chamise chaparral by fee title or conservation easement.	California tiger salamander
LAND-C2. Acquire 700 acres of mixed serpentine chaparral by fee title or conservation easement.	California tiger salamander
LAND-C3. Acquire 1,400 acres of northern coastal scrub/Diablan sage scrub by fee title or conservation easement.	California tiger salamander

Table 5-2a. Continued

Acquisition Action	Target Species
Oak and Conifer Woodland (OC)	
LAND-OC1. Acquire in fee title or obtain conservation easements on 7,100 acres of mixed oak woodland and forest, including land in both the Santa Cruz Mountains and the Diablo Range. Target areas with a high concentration of ponds occupied by covered species or native species and/or other ponds capable of being restored.	western burrowing owl, San Joaquin kit fox, California tiger salamander, California red-legged frog
LAND-OC2. Acquire 2,900 acres of coast live oak woodland and forest by fee title or conservation easement, including land in both the Santa Cruz Mountains and the Diablo Range. Target areas with a high concentration of ponds occupied by covered species or native species and/or other ponds capable of being restored.	western burrowing owl, San Joaquin kit fox, California tiger salamander, California red-legged frog
LAND-OC3. Acquire 1,100 acres of blue oak woodland and 1,700 acres of valley oak woodland by fee title or conservation easement including land in both the Santa Cruz Mountains and the Diablo Range. Target areas with a high concentration of ponds occupied by covered species or native species and/or other ponds capable of being restored.	western burrowing owl, San Joaquin kit fox, California tiger salamander, California red-legged frog
LAND-OC4. Acquire 80 acres of foothill pine-oak woodland and forest by fee title or conservation easement, including land in both the Santa Cruz Mountains and Diablo Range. Target areas with a high concentration of ponds occupied by covered species or native species and/or other ponds capable of being restored.	western burrowing owl, San Joaquin kit fox, California tiger salamander, California red-legged frog
LAND-OC5. Acquire 20 acres of mixed evergreen forest by fee title or conservation easement including land in both the Santa Cruz Mountains and Diablo Range. Target areas with a high concentration of ponds occupied by covered species or native species and/or other ponds capable of being restored.	California tiger salamander, California red-legged frog, foothill yellow-legged frog
LAND-OC6. Acquire 10 acres of redwood forest by fee title or conservation easement.	California tiger salamander, California red-legged frog, foothill yellow-legged frog

Table 5-2a. Continued

Acquisition Action	Target Species
Riverine and Riparian Forest and Scrub (R)	
LAND-R1. Extend the Uvas Creek Park Preserve 1.6 miles upstream to Hecker Pass Highway and setback expected development adjacent to this stream segment by a minimum of 100 feet to protect the Uvas Creek Corridor consistent with Goals 5-5, 5-7, and 5-8 of the approved City of Gilroy Hecker Pass Specific Plan. Target acquisitions will to contribute to the protection of a total of 800 acres of riparian woodland and forest in the Uvas, Llagas, and Pacheco watersheds.	California red-legged frog, California tiger salamander, western pond turtle, foothill yellow-legged frog, least Bell's vireo
LAND-R2. Acquire in fee title or obtain conservation easements on lands that protect at least 250 acres and up to 578 acres of existing willow riparian forest and scrub or mixed riparian forest and woodland, including areas that provide key connectivity between existing riparian habitats in upper Coyote Creek, San Felipe Creek, Uvas Creek, Tar Creek, Little Arthur Creek, and Pacheco Creek.	California red-legged frog, California tiger salamander, western pond turtle, foothill yellow-legged frog, least Bell's vireo
LAND-R3. Acquire in fee title or obtain conservation easements on lands that protect at least 40 acres of existing Central California sycamore alluvial woodland to ensure that this very rare and threatened land cover type is preserved in the study area.	California red-legged frog, California tiger salamander, western pond turtle, foothill yellow-legged frog, least Bell's vireo
LANS-R4. (not used)	
LAND-R5. Acquire or obtain easements along 104 miles of perennial streams located above Uvas, Calero, Chesbro, Anderson, or in Uvas Creek below Uvas Reservoir, Upper Penitencia Creek, Alamitos Creek or Guadalupe Creek that have or could be restored to have cobblestone substrate and consistent, gentle flows from late March to late May.	California red-legged frog, California tiger salamander, western pond turtle, foothill yellow-legged frog, least Bell's vireo
Wetland and Pond (WP)	
LAND-WP1a. Acquire in fee title or conservation easement 10 acres of perennial freshwater wetlands suitable for covered or native species in the Santa Cruz Mountains, Santa Clara Valley, and the Diablo Range.	California tiger salamander, California red-legged frog, western pond turtle, tricolored blackbird
LAND-WP1b. Acquire in fee title or conservation easement up to 50 acres of perennial freshwater wetlands suitable for covered or native species in the Santa Cruz Mountains, Santa Clara Valley, and the Diablo Range.	California tiger salamander, California red-legged frog, western pond turtle, tricolored blackbird

Table 5-2a. Continued

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Acquisition Action	Target Species
LAND-WP2a. Acquire in fee title or conservation easement 5 acres of seasonal freshwater wetlands suitable for covered or native species and/or other seasonal wetlands capable of being enhanced or restored to support covered species in the Santa Cruz Mountains, Santa Clara Valley, and the Diablo Range.	California tiger salamander, California red-legged frog, western pond turtle, tricolored blackbird
LAND-WP2b. Acquire in fee title or conservation easement up to 30 acres of seasonal freshwater wetlands suitable for covered or native species and/or other seasonal wetlands capable of being enhanced or restored to support covered species in the Santa Cruz Mountains, Santa Clara Valley, and the Diablo Range.	California tiger salamander, California red-legged frog, western pond turtle, tricolored blackbird
LAND-WP3a. Acquire in fee title or conservation easement 50 acres of ponds suitable for covered or native species in the Santa Cruz Mountains, Santa Clara Valley, and the Diablo Range.	California tiger salamander, California red-legged frog, western pond turtle, tricolored blackbird
LAND-WP3b. Acquire in fee title or conservation easement up to 104 acres of ponds suitable for covered or native species in the Santa Cruz Mountains, Santa Clara Valley, and the Diablo Range.	California tiger salamander, California red-legged frog, western pond turtle, tricolored blackbird
LAND-G2. Acquire 13,300 acres of annual grassland by fee title or conservation easement as part of the Reserve System. Target areas on both sides of Santa Clara Valley with a high concentration of ponds occupied by covered species or native species and/or other ponds capable of being restored. Acquisition of native grassland will be given priority.	California tiger salamander, California red-legged frog, western pond turtle, tricolored blackbird
LAND-WP4. Acquire habitat that is adjacent to permanently protected aquatic resources with a high potential to support CRLF and is in the East San Francisco Bay Recovery Unit for red-legged frog (USFWS 2002) (Coyote Creek, Pacheco, and Pescadero Watersheds).	California tiger salamander, California red-legged frog, western pond turtle, tricolored blackbird
LAND-WP5. Acquire habitat that contains a matrix of aquatic and upland habitats and is also adjacent to Joseph D. Grant County Park, Palassou Ridge Open Space Preserve, southeast of Henry Coe State Park, Santa Cruz Mountain foothills, and Calero County Park in areas where dense forest is absent to reduce competition with other native amphibians (e.g., California newts).	California tiger salamander, California red-legged frog, western pond turtle, tricolored blackbird

Table 5-2a. Continued

Acquisition Action	Target Species
LAND-WP6a. Acquire stream segments or ponds that currently provide or could provide high quality basking, breeding, and nesting habitat (vegetated banks and at least 150 feet of adjacent upland habitat) for western pond turtle.	California tiger salamander, California red-legged frog, western pond turtle, tricolored blackbird
LAND-WP6b. Acquire stream segments or ponds that currently provide or could provide high quality basking, breeding, and nesting habitat (vegetated banks and at least 0.5 miles of adjacent upland habitat) for California tiger salamander.	California tiger salamander, California red-legged frog, western pond turtle, tricolored blackbird
LAND-WP7. Acquire habitat near Santa Teresa Hills and Tulare Hill to provide connectivity between populations in the Diablo Range and the Santa Cruz foothills.	California tiger salamander, California red-legged frog, western pond turtle, tricolored blackbird
LAND-WP8. Acquire in fee title or through a conservation easement at least 4 tricolored blackbird breeding sites that support, historically supported, or could support tricolored blackbird colonies each with at least 2-acres of breeding habitat and foraging habitat within 2 miles. Target at least 5 acres of suitable breeding habitat for tricolored blackbird within dry land farming or ranching complexes in the Santa Clara Valley and the Diablo Range	California tiger salamander, California red-legged frog, western pond turtle, tricolored blackbird
LAND-WP9. Acquire 200 acres of foraging habitat for tricolored blackbird in areas where there are protected breeding sites within 2 miles.	California tiger salamander, California red-legged frog, western pond turtle, tricolored blackbird
Specific Plant Occurrences (P)	
LAND-P1. Acquire in fee title or conservation easement sites in the study area that support three unprotected occurrences of Coyote ceanothus and provide the necessary buffer between incompatible land uses.	Coyote ceanothus
LAND-P2. Acquire in fee title or conservation easement sites in the study area that support 55 occurrences of Santa Clara Valley dudleya across a range of elevational gradients on both sides of Coyote Valley to ensure geographic diversity in protected occurrences.	Santa Clara Valley dudleya
LAND-P3. Acquire in fee title or conservation easement sites in the study area that support three occurrences of Metcalf Canyon jewelflower.	Metcalf canyon jewelflower
LAND-P4. Acquire north side of Tulare Hill to promote reintroduction of Metcalf Canyon jewelflower on west side of Valley.	Metcalf canyon jewelflower

Table 5-2a. Continued

Acquisition Action	Target Species
LAND-P5. Acquire sites in the study area that support 17 occurrences of most beautiful jewelflower.	Most beautiful jewel flower
LAND-P6. Acquire sites in the study area that support Mount Hamilton thistle in drainages or spring systems and stratify protection on both sides of Coyote Valley to ensure geographic diversity in protected occurrences.	Mount Hamilton thistle
LAND-P7. Acquire sites in the Reserve System that support eight occurrences of smooth lessingia.	Smooth lessingia
LAND-P8. Acquire sites along Coyote Ridge that support the four remaining unprotected fragrant fritillary occurrences.	Fragrant fritillary
LAND-P9. Acquire the Tiburon Indian paintbrush occurrence located at the Kirby Canyon landfill mitigation site prior to or at the time the temporary conservation easement expires.	Tiburon Indian paintbrush
LANS-P10. (not used)	
LAND-P11. Acquire four sites in the study area that supports Loma Prieta hoita.	Loma Prieta hoita

Table 5-2b. Land Management Actions

Management Action	Target Species	Monitoring Action
Landscape Management (LM)		
LM-1. Remove fences and private roads in areas where they are no longer needed and where their removal could increase the permeability of the study area for wildlife.	San Joaquin kit fox, American badger, Tule elk	Compliance monitoring for infrastructure/structure removal, replacement, or installation. Monitor wildlife movement (or plant distribution if applicable) in target areas. Monitor movement of indicator species for connectivity.
LM-2. When replacing small culverts ensure that the culvert has a natural bottom and is large enough for larger mammals such as deer and mountain lions to pass, if feasible. Culverts must provide direct movement from one side of the road to the other and ensure that the culvert is visible to the target species (i.e., do not obscure entrance with vegetation). Install fencing or other features that will direct wildlife towards the culvert or other safe crossing within the first 20 years of implementation.	San Joaquin kit fox, western pond turtle, foothill yellow-legged frog	Compliance monitoring for infrastructure/structure removal, replacement, or installation. Monitor wildlife movement (or plant distribution if applicable) in target areas. Monitor movement of indicator species for connectivity.
LM-3. Where structurally possible, replace culverts with free span bridges to ensure free movement for wildlife under roadways.	San Joaquin kit fox, western pond turtle, foothill yellow-legged frog	Compliance monitoring for infrastructure/structure removal, replacement, or installation. Monitor wildlife movement (or plant distribution if applicable) in target areas. Monitor movement of indicator species for connectivity.
LM-4. Ensure that median barrier removal and/or median perforations are considered as alternatives during project design.	San Joaquin kit fox, American badger, bobcat	Compliance monitoring for infrastructure/structure removal, replacement, or installation.
LM-5. Remove median barriers or perforate sections of median barriers along roadways to improve successful wildlife crossings and install fencing or other features to direct wildlife to those open sections within first 20 years of implementation. Use feasibility study to determine location and length of barrier removal.	San Joaquin kit fox, mule deer, Tule elk	Compliance monitoring for infrastructure/structure removal, replacement, or installation. Monitor wildlife movement (or plant distribution if applicable) in target areas. Monitor movement of indicator species for connectivity.
LM-6. Enhance or restore an estimated 17,440 acres of grassland, 2,500 acres of chaparral and northern coastal scrub, 12,900 acres of oak woodland, 290 acres of riparian forest and scrub, and 10 acres of conifer woodland within the Reserve System.	California tiger salamander, western burrowing owl, San Joaquin kit fox, covered plant species	Compliance monitoring for infrastructure/structure removal, replacement, or installation. Monitor wildlife movement (or plant distribution if applicable) in target areas. Monitor movement of indicator species for connectivity.

Table 5-2b. Continued

Management Action	Target Species	Monitoring Action
LM-7a. Restore a minimum of 1.0 miles of stream, 50 acres of riparian forest and scrub, and 20 acres of freshwater marsh, and create 20 acres of ponds to contribute to species recovery.	Least Bell's vireo, foothill yellow-legged frog, California red-legged frog, western pond turtle	Compliance monitoring for infrastructure/structure removal, replacement, or installation. Monitor wildlife movement (or plant distribution if applicable) in target areas. Monitor movement of indicator species for connectivity.
LM-7b. If all predicted impacts occur, restore 10.4 miles of streams, 339 acres of riparian forest and scrub, 45 acres of freshwater marsh, and 30 acres of seasonal wetlands, and create 72 acres of ponds within all watersheds of the study area to maintain and when necessary improve stream hydrologic functions.	Least Bell's vireo, tricolored blackbird, foothill yellow-legged frog, California red-legged frog, western pond turtle	Compliance monitoring for infrastructure/structure removal, replacement, or installation. Monitor wildlife movement (or plant distribution if applicable) in target areas. Monitor movement of indicator species for connectivity.
LM-8. Negotiate with Cal Fire and other local fire-fighting agencies the use of management response measures for all fire events and fire-dependent ecosystems that minimize impacts to natural communities and covered species while protecting human life and property. All burns will be responded to, and prescribed burns will be conducted, with minimum impact suppression tactics. Burn response will take into consideration ignition location and method, seasonality, weather and availability of suppression forces.	Covered plants, California tiger salamander, western burrowing owl	Compliance monitoring for infrastructure/structure removal, replacement, or installation. Monitor wildlife movement (or plant distribution if applicable) in target areas. Monitor movement of indicator species for connectivity.
LM-9. In identified “no burn” areas implement the biologically appropriate management actions that mimic the natural effects of fire (e.g., mowing, grazing, hand pulling) to subsequently improve habitat for native vegetation.	Covered plants, California tiger salamander, western burrowing owl	Analyze and quantify effectiveness of burning vs. other management actions in increasing diversity and quantity of native vegetation. Monitor target covered species response, if applicable.
LM-10. Integrate adopted policies for natural flood protection (i.e., Ordinance O6-1, Clean, Safe Creeks and Natural Flood Protection Plan, Coyote Watershed Stream Stewardship Plan) into flood protection projects to protect habitat for covered fish, amphibians, and reptiles.	Least Bell's vireo, foothill yellow-legged frog, California red-legged frog, western pond turtle	Compliance monitoring
LM-11. Graze, mow, hand-pull, to reduce non-native invasive plant species, both terrestrial and aquatic, to a level where native plants can reestablish and remain dominant within the Reserve System.	Covered plant species, California tiger salamander, western burrowing owl	Monitor status of non-native invasive plants in target eradication areas and assess efficacy of various techniques. Monitor covered species response.

Table 5-2b. Continued

Management Action	Target Species	Monitoring Action
LM-12. Eradicate or reduce nonnative pig disturbance within the Reserve System through trapping, hunting, or other control methods. Success criteria is achieved through ensuring disturbances by nonnative pigs do not impair the ability of the Reserve System from meeting the biological goals and objectives.	Covered plant California tiger salamander, California red-legged frog, western pond turtle, oak woodlands	Analyze and quantify numbers of pigs eradicated and evidence of remaining population (e.g., pig observations or signs of damage).
LM-13. Eradicate or reduce nonnative predators (bullfrogs, invasive fish, feral cats) within the Reserve System through habitat manipulation (e.g., periodic draining of ponds), trapping, hand capturing, electroshocking or other control methods to achieve targets identified in reserve unit management plans.	California tiger salamander, California red-legged frog, western pond turtle, foothill yellow-legged frog	Monitor response of nonnative predators to habitat manipulation. Evaluate effect of predator abatement on native pond and wetland biodiversity. Determine presence of covered species.
LM-14. Selectively apply herbicides or other treatments to invasive plants.	Covered plants	Monitor status of non-native invasive plants in target eradication areas and assess efficacy of various techniques. Monitor covered species response.
Grassland Management (GRASS)		
GRASS-1. Continue or introduce livestock and native herbivore (e.g., elk) grazing in a variety of grazing regimes.	California tiger salamander, western burrowing owl, San Joaquin kit fox, covered plant species	Monitor effects of various grazing regimes on reducing nonnative plants and increasing diversity and biomass of native plants. In oak woodlands, monitor effects of various grazing regimes on oak woodland regeneration and recruitment. Monitor target covered species responses.
GRASS-2. Conduct prescribed burns. Use targeted studies to inform methods, timing, location, and frequency.	California tiger salamander, western burrowing owl, San Joaquin kit fox, covered plant species	Monitor effects of burning on reducing nonnative plants and increasing diversity and biomass of native plants. Monitor target covered species responses.
GRASS-3. Conduct mowing in selected areas to mimic grazing where use of livestock is impractical.	California tiger salamander, western burrowing owl, San Joaquin kit fox, covered plant species	Monitor effects of mowing on reducing nonnative plants and increasing diversity and biomass of native plants. Monitor target covered species response.
GRASS-4. Conduct selected seeding of native forbs and grasses in the Reserve System.	California tiger salamander, western burrowing owl, San Joaquin kit fox, covered plant species	Monitor success of seeding efforts in promoting native forbs and grasses. Monitor target covered species responses.

Table 5-2b. Continued

Management Action	Target Species	Monitoring Action
GRASS-5. Prohibit use of rodenticides within the Reserve System, except when needed to protect the integrity of structures, such as levees, stock ponds and dams.	California tiger salamander, western burrowing owl, San Joaquin kit fox	Monitor population trend of California ground squirrels. Track changes in burrowing mammal colony size over time.
GRASS-6. Introduce livestock grazing where it is not currently used, and where conflicts with covered activities are minimized, to reduce vegetative cover and biomass that currently excludes ground squirrel and encourage ground squirrel colonization of new areas within the Reserve System.	western burrowing owl, San Joaquin kit fox, California tiger salamander, California red-legged frog	Monitor population trend of California ground squirrels. Analyze and quantify changes in burrowing mammal colony size over time.
GRASS-7. Implementing Entity will initiate translocation efforts if natural colonization fails after five seasons in which core populations are at above-average population sizes. Through coordination with species experts and regulatory agencies translocate Bay checkerspot butterflies (eggs, larvae, or adults) from core populations into suitable but unoccupied sites if natural dispersal fails to reestablish population.	Bay checkerspot butterfly	Monitor at periodic intervals the success of translocation efforts in establishing new populations of Bay checkerspot butterfly.
GRASS-8. Implement vegetation management (i.e., graze/mow) that reduces vegetation height and density to optimal conditions for burrowing owls.	California tiger salamander, covered grassland plants, western burrowing owl	Monitor status of burrowing owl population and correlate species response to vegetation management.
GRASS-9. Create and maintain artificial burrows to encourage colonization of sites where ground squirrels establishment is not feasible or during the interim before ground squirrel colonies naturally establish.	Western burrowing owl	Monitor artificial burrow for occupancy twice annually, during the breeding season.
GRASS-10. Conduct at least one public education campaign in the southeastern portion of the study area within the first 10 years of implementation to provide landowners with information about management and land use techniques that are more compatible with movement and use by San Joaquin kit fox. Conduct additional meetings as needed.	San Joaquin kit fox	Ensure that at least one educational meeting is conducted within the first two years of implementation and then as needed after that.
Chaparral and Northern Coastal Scrub Management (CHAP)		
CHAP-1. Conduct prescribed burns in chaparral and northern coastal scrub to maintain canopy gaps and promote regeneration. Use targeted studies to inform locations and frequency.	California tiger salamander, California red-legged frog, western pond turtle, western burrowing owl, Coyote ceanothus	Monitor effects of burning on promoting canopy gaps, regeneration, and succession in chaparral and northern coastal scrub.

Table 5-2b. Continued

Management Action	Target Species	Monitoring Action
CHAP-2. Mechanically thin chaparral and northern coastal scrub to promote structural diversity. Use targeted studies to inform location and frequency.	California tiger salamander, California red-legged frog, western pond turtle, western burrowing owl, Coyote ceanothus	Monitor effects of mechanical thinning on promoting canopy gaps, regeneration, and succession in chaparral and northern coastal scrub.
CHAP-3. Identify areas in the Santa Cruz Mountains and eastern mountains where adjacent natural communities (e.g. grassland, oak woodland, conifer forests) are encroaching on chaparral and scrub land cover and, if appropriate, work to reduce the spread through manual reduction.		Analyze and quantify spread of adjacent natural communities into chaparral and scrub land cover types. Study spread rate after manual reduction.
Oak and Conifer Woodland Management (OAK)		
OAK-1. Conduct prescribed burns in low-density oak woodlands to enhance the community and to reduce non-native, invasive grass cover beneath oaks and encourage growth of a native understory and oak seedlings.	California tiger salamander, California red-legged frog, western pond turtle	Monitor effects of burning on promoting regeneration and recruitment of oak woodlands and understory land cover. Monitor covered species response.
OAK-2. Conduct prescribed burns in redwood forest to maintain or enhance native species diversity in the mid-canopy and understory.	California tiger salamander, California red-legged frog, western pond turtle, San Joaquin kit fox	Monitor effects of burning on promoting native species diversity.
OAK-3. Mechanically thin the understory of redwood forest in target areas to promote a healthy understory/canopy.	California tiger salamander, California red-legged frog	Monitor effects of mechanical thinning on regeneration and succession in the understory and canopy of conifer woodlands. Monitor target covered species response, if applicable.
Riverine and Riparian Forest and Scrub Management (STREAM)		
STREAM-1. Exclude livestock access to target stream segments (e.g., Pacheco Creek, floodplain of Coyote Creek) using exclusion fencing, off-channel water sources, and other potential actions.	California red-legged frog, foothill yellow-legged frog, western pond turtle, least Bell's vireo	Conduct pre- and post-treatment monitoring to document vegetation and covered-species response to exclusion.
STREAM-2. Plant and/or seed in native understory and overstory riparian vegetation within 15 feet of the edge of the low-flow channel to create structural diversity, provide overhead cover, and moderate water temperature at all riparian restoration sites.	California red-legged frog, foothill yellow-legged frog, western pond turtle, least Bell's vireo	Monitor the efficacy of seeding efforts with respect to structural diversity, overhead cover, and water temperature compared to designated reference locations. Indicator species will be selected and success criteria developed for large-scale restoration projects from the reference locations.

Table 5-2b. Continued

Management Action	Target Species	Monitoring Action
STREAM-3. Plant and/or seed in native riparian vegetation in gaps in existing riparian corridors, or re-establish severally degraded or historic riparian corridors, to promote continuity within conservation lands.	California red-legged frog, foothill yellow-legged frog, western pond turtle, least Bell's vireo	STREAM-4. Plant and/or seed in native riparian vegetation in gaps in existing riparian corridors to promote continuity.
STREAM-4. Replace concrete, earthen or other engineered channels as part of the 10.4 miles of stream restoration to restore floodplain connectivity. Location and length will be determine by site-specific conditions.	California red-legged frog, foothill yellow-legged frog, western pond turtle, least Bell's vireo	Compliance monitoring and annual reporting. Assess habitat quality of acquired land and prioritize areas for management.
STREAM-5. Replace confined channels to restore floodplain connectivity and commensurate functions as part of the 10.4 miles of stream restoration. Location and length will be determine by site-specific conditions.	California red-legged frog, foothill yellow-legged frog, western pond turtle	Conduct pre- and post-treatment monitoring of community function (performance of ecological processes); habitat composition, structure and pattern; and connectivity as part of a targeted study.
STREAM-6. Manage watershed-wide fine sediment inputs by conditioning controls on runoff from all development projects (see Condition 3) to improve riverine habitat functions and geomorphic processes.	California red-legged frog, foothill yellow-legged frog, western pond turtle, least Bell's vireo	Conduct annual spot checks on new developments to determine whether sediment run-off provisions are consistent with the Conditions outlined in this Plan.
STREAM-7. Implement a brown-headed cowbird control program in coordination with species experts and regulatory agencies that will reduce the impact of brood parasitism on least Bell's vireo nest success, if least Bell's vireos become regular nesters in the study area (>3 nests over at least two consecutive years) and brown-headed cowbird eggs are discovered in vireo nests.	Least Bell's vireo	Compliance monitoring. Monitor for riparian song bird nesting within least Bell's vireo modeled habitat. Periodically, every 5 years, monitor for least Bell's vireo outside of modeled habitat to document range expansion. Quantify the number of occurrences of brood parasitism that are occurring and if/when brown-headed cowbird control program is initiated and efficacy of program.
STREAM-8. Increase the amount of cobblestone substrate suitable to support breeding foothill yellow-legged frogs to 2,000 ft. to areas close to known occurrence(s) of foothill yellow-legged frog or immediately upstream or downstream of known occurrences or other high quality foothill yellow-legged frog breeding habitat.	Foothill yellow-legged frog	Assess yellow-legged frog response to increase in cobblestone substrate as part of a targeted study.

Table 5-2b. Continued

Management Action	Target Species	Monitoring Action
Wetland and Pond Management (POND)		
POND-1. Install fencing that will reduce grazing pressure and exclude feral pigs on portions of ponds and wetlands and provide vegetated refuge sites for covered species. Fence installation will be carefully applied to avoid negative impacts on small mammal movement and upland habitat.	California tiger salamander, California red-legged frog, western pond turtle	Monitor effectiveness of fencing to exclude livestock and feral pigs and compare vegetation inside of fencing to vegetation outside of fencing. Evaluate success of wetland and pond enhancement using established success criteria.
POND-2. Install woody debris around perimeter and in submerged banks of ponds and wetlands to create basking habitat and cover for native juvenile amphibians and turtles. Materials imported from outside of the watershed shall be treated for chytrid and other potential pathogens prior to installation.	California tiger salamander, California red-legged frog, western pond turtle	Analyze and quantify effectiveness of created basking site through routine monitoring in ponds with known western pond turtle occupancy.
POND-3. Plant native emergent vegetation around the perimeter and in ponds and wetlands.	California tiger salamander, California red-legged frog, western pond turtle	Monitor survivorship of planting, quantify vegetated perimeter of pond, describe habitat quality and periodically survey for species response from covered amphibians and reptiles. Evaluate success of wetland and pond enhancement using established success criteria.
POND-4. Clear vegetation and/or remove sediment in a way that minimizes negative effects on covered species when vegetation and/or sediment restricts the ability of the aquatic environment from meeting the biological goals and objectives of the Plan.	California tiger salamander, California red-legged frog, western pond turtle	Evaluate success of wetland and pond enhancement using established success criteria.
POND-5. If biologically appropriate, graze or mechanically thin around pond perimeter to mimic grazing and promote native species.	California tiger salamander, California red-legged frog, western pond turtle	Evaluate success of wetland and pond enhancement using established success criteria.
POND-6. Restore 20 acres of perennial freshwater marsh within the Reserve System in suitable sites and those likely to support covered species.	California tiger salamander, California red-legged frog, western pond turtle	Compliance monitoring. Monitor freshwater marsh and wetland restoration and assess whether success criteria are being met. Assess connectivity of restored complexes.
POND-7. In addition to the perennial freshwater marsh restoration described in POND-6, restore up to 25 acres of perennial freshwater marsh within the Reserve System in the Santa Cruz Mountains, Santa Clara Valley, and Diablo Range.	California tiger salamander, California red-legged frog, western pond turtle, tricolored blackbird	Compliance monitoring. Monitor freshwater marsh and wetland restoration and assess whether success criteria are being met. Assess connectivity of restored complexes.

Table 5-2b. Continued

Management Action	Target Species	Monitoring Action
POND-8. Restore up to 30 acres of seasonal wetlands within the Reserve System in the Santa Cruz Mountains, Santa Clara Valley, and Diablo Range.	California tiger salamander, California red-legged frog, western pond turtle, tricolored blackbird	Compliance monitoring. Monitor habitat restoration and assess whether success criteria are being met. Monitor use of restored habitat by tricolored blackbird.
POND-9. Create at least 20 acres of ponds at 40 sites, at least 10 sites in the Santa Cruz Mountains and 20 sites in the Diablo Range.	California tiger salamander, California red-legged frog, western pond turtle, tricolored blackbird	Compliance monitoring. Monitor pond construction and assess whether success criteria are being met.
POND-10. In addition to the creation of ponds described in POND-9, create up to 52 acres of ponds in-kind within the Reserve System to increase the amount available habitat and enhance connectivity among existing ponds and wetlands if all anticipated impacts occur.3	California tiger salamander, California red-legged frog, western pond turtle	Compliance monitoring. Monitor pond construction and assess whether success criteria are being met.
POND-11. Offer financial and regulatory (Safe Harbor Agreement) incentives to private landowners to enhance pond and wetland habitat to suit breeding California red-legged frog, California tiger salamander, and western pond turtle.	California tiger salamander, California red-legged frog, western pond turtle	Compliance monitoring.
POND-12. Educate the public that the use of any salamander species as bait is illegal in the State of California.	California tiger salamander	Compliance monitoring.
POND-13. Excavate sections of ponds to provide deeper pools that will be utilized by California red-legged frog adults and sub-adults and western pond turtles, while maintaining shallow areas to provide rearing habitat for California red-legged frog tadpoles, California tiger salamander larvae, and western pond turtle hatchlings.	California tiger salamander, California red-legged frog, western pond turtle	Monitor use of excavated pond by red-legged frog and western pond turtles as part of a targeted study.
POND-14. Offer financial or regulatory incentives (Safe Harbor Agreement, if listed) to private landowners to enhance pond and marsh habitat to suit breeding tricolored blackbirds, and to ensure that dry-land farming and ranching activities support breeding tricolored blackbirds.	Tricolored blackbird	Compliance Monitoring.
POND-15 Offer financial incentives to private landowners to ensure that dry-land farming and ranching activities support foraging tricolored blackbirds.	Tricolored blackbird	Compliance Monitoring.
POND-16. Restore freshwater marsh, seasonal wetlands, and/or ponds that will support dense reed-like vegetation (cattails) or other native vegetation that will attract nesting tricolored blackbirds.	Tricolored blackbird	Compliance monitoring. Monitor habitat restoration and assess whether success criteria are being met. Monitor use of restored habitat by tricolored blackbird.

Table 5-2b. Continued

Management Action	Target Species	Monitoring Action
POND-17. In areas with non-native vegetation (e.g., Himalayan blackberry) that supports existing tricolored blackbird colonies, initiate a gradual (3-4 year) transition from non-native vegetation to native vegetation that is structurally similar.	Tricolored blackbird	Determine areas where tricolored blackbirds are using non-native vegetation and ensure that there is a management plan in place to control the spread of the non-native vegetation and transition the colony to native vegetation if necessary.
POND-18. (not used)		
POND-19. Restore a minimum of 20 acres and up to 45 acres of freshwater marsh within the Reserve System in the Santa Cruz Mountains, Santa Clara Valley, and Diablo Range.	Tricolored blackbird	Compliance monitoring. Monitor habitat restoration and assess whether success criteria are being met. Monitor use of restored habitat by tricolored blackbird.
Directed Studies		
STUDIES-1. Conduct feasibility study to determine wildlife movement across Coyote Creek downstream of Anderson Reservoir, Pacheco Creek (SR 152), and the Pajaro River.	Covered wildlife species	Analyze and quantify movement of indicator species to determine whether linkages are functioning as intended.
STUDIES-2. Determine factors relevant to the health and regeneration of native chaparral/scrub species. Targeted studies will be imitated within first 10 years of plan implementation. Use results of targeted studies to revise and improve management actions.	California tiger salamander, California red-legged frog, western pond turtle, western burrowing owl	Conduct targeted research that identifies key factors affecting regeneration and succession of chaparral/scrub.
STUDIES-3. Experimentally manage oak woodlands to reduce seedling mortality, increase seedling and sapling survival and determine factors relevant to regeneration, including browsing by mammals, birds, and insects.	California tiger salamander, California red-legged frog, western pond turtle, San Joaquin kit fox	Conduct targeted research that identifies key factors affecting seedling mortality, seedling and sapling survival and factors relevant to oak woodland regeneration.
STUDIES-4. Experimentally manage redwood forest to determine factors relevant to regeneration and maintenance; possibly including prescribed burning, selective thinning, and other management actions to meet this objective.	California red-legged frog, foothill yellow-legged frog, western pond turtle	Conduct targeted research in redwood forest, ponderosa pine woodland, and knobcone pine woodland to guide management actions and other factors relevant to regeneration and maintenance.
STUDIES-5. Conduct targeted studies to determine factors limiting the expansion of the covered plant species, including but not limited to its management and micro-site needs, and implement measures to mitigate or eliminate these factors to promote occurrence expansion.	Coyote ceanothus, Santa Clara Valley dudleya, Metcalf Canyon jewelflower, most beautiful jewelflower, Mount Hamilton thistle, smooth lessingia, fragrant fritillary, Tiburon Indian paintbrush, Loma Prieta hoita	Monitor results of research and the effects of its application.

Table 5-2b. Continued

Management Action	Target Species	Monitoring Action
STUDIES-6. Conduct a directed study to censuses egg masses in breeding habitat downstream of reservoirs before and after releases to determine whether eggs masses were lost.	Foothill yellow-legged frog	Monitor effects of pulse flows on foothill yellow-legged frog.
STUDIES-7. In the case of ponds, wetlands, and/ or amphibian populations becoming infected with chytrid fungus or other diseases, use the best scientific information available to manage and stop spread of epidemic.	California tiger salamander, California red-legged frog, western pond turtle, foothill yellow-legged frog	Monitor for the presence of disease. Monitor efficacy of disease control actions.
STUDIES-8. Identify the distribution and risk to existing indigenous populations of covered amphibians and reptiles from hybridization (e.g., California tiger salamander hybridizing with Texas salamander) within the Reserve System. Appendix K, California Tiger Salamander Hybridization, will serve as the Management Plan for CTS hybridization issues and will be updated throughout the permit term for adaptive management	California tiger salamander	Monitor for the presence of non-natives and hybrids. Test and document efficacy of management plan.
STUDIES-9. Annually identify and maintain upland breeding sites (even if sites are not “natural”) for western pond turtle because of the high fidelity of use from year to year .	Western pond turtle	Monitor use of protected sites to determine factors influencing nest success in areas of known turtle use.
STUDIES-10. (not used)		
STUDIES-11. Conduct experimental burning in protected occurrences of targeted covered plant species to determine the importance of fire for plant regeneration.	California tiger salamander, western burrowing owl, San Joaquin kit fox, Coyote ceanothus	Monitor effects of burns on covered species
STUDIES-12. Ensure seeds from natural occurrences in the Study Area are stored and maintained at a minimum of one Center for Plant Conservation certified botanic garden.	Coyote ceanothus, Santa Clara Valley dudleya, Metcalf Canyon jewelflower, most beautiful jewelflower, Mount Hamilton thistle, smooth lessingia,	Monitor viability of seed collection and refresh collection, as necessary.

Table 5-2b. Continued

Management Action	Target Species	Monitoring Action
STUDIES-13. Identify suitable locations for and establish target number of new covered plant occurrences in the Reserve System.	Coyote ceanothus, Metcalf Canyon jewelflower	Compliance monitoring and annual reports.
STUDIES-14. Determine suitable propagation or planting techniques for targeted covered plant species and determine biologically appropriate seed sampling techniques from existing occurrences.	Coyote ceanothus, Metcalf Canyon jewelflower	Monitor newly established and source occurrences.
STUDIES-13. Identify suitable locations for and establish target number of new covered plant occurrences in the Reserve System.	Coyote ceanothus, Metcalf Canyon jewelflower	Monitor the results of all experiments.
STUDIES-14. Determine suitable propagation or planting techniques for targeted covered plant species and determine biologically appropriate seed sampling techniques from existing occurrences.	Coyote ceanothus, Metcalf Canyon jewelflower	Monitor newly established and source occurrences.
STUDIES-15. Design and implement field experiments (if the number of propagules will not be significantly impacted) to test alternative techniques for establishment of targeted covered plant occurrences. Field experiments will be continue until target number of occurrences are established.	Coyote ceanothus, Metcalf Canyon jewelflower	Monitor the results of all experiments.
STUDIES-16. Monitor the effects of livestock grazing (or predation by other species, e.g., black-tailed jackrabbit) on targeted covered plant species by conducting exclusion experiments and monitoring effects on occurrences, including control sites in the monitoring plan.	Santa Clara Valley dudleya, Mount Hamilton Thistle, smooth lessingia, Tiburon Indian paintbrush, fragrant fritillary	Monitor the effects of grazing on management on covered plant species.
STUDIES-17. Monitor Metcalf Canyon jewelflower and most beautiful jewelflower introgression and develop protocols to protect the genetic integrity of both species.	Metcalf Canyon jewelflower, most beautiful jewelflower,	Monitor the results of research and success of developed protocols.

Table 5-3. Guidelines Used to Set Quantitative Objectives for Species Habitat Protection in the Absence of Species-Specific Data

Proportion of Species' Current Range in the Study Area	General Range of Conservation Obligation of Plan[1, 2]	Example Covered Species
96–100%	80–100%	Bay checkerspot butterfly, Coyote ceanothus, Santa Clara Valley dudleya, smooth lessingia, Metcalf Canyon jewelflower, most beautiful jewelflower
66–95%	65–90%	Mount Hamilton thistle
36–65%	40–75%	Loma Prieta hoita
11–35%	20–50%	California tiger salamander
1–10%	10–35%	California red-legged frog, foothill yellow-legged frog, least Bell's vireo
<1%	5–20%	San Joaquin kit fox, tricolored blackbird, Western burrowing owl, Western pond turtle

Notes:

1: Values expressed as a percentage of the available habitat in the study area and used as guidelines only in the absence of species-specific data. Actual conservation obligations were determined based on a variety of biological, economic, land use, and regulatory factors; see text for more explanation. Quantitative objectives were set using land cover types rather than species habitat.

2: Quantitative biological objectives were developed at the lower or higher end of these ranges based on a series of additional factors, or "modifiers."

A conservation obligation was set at the higher end of the guideline (or beyond it) if one or more of the following factors applied:
-species' historic range was much greater than current range (i.e., a substantial range contraction has occurred);
-species is highly sensitive to management or human disturbance, or management needs are uncertain;
-species population sizes are relatively low or unknown;
-threats to species are severe or widespread;
-impacts from covered activities affect a relatively high proportion of species occurrences or potential habitat.

A conservation obligation was set near the low end of the scale if one or more of the following factors applied:
-species' habitat is abundant in the study area;
-there are a relatively large number of extant occurrences in the study area;
-the proportion of the species' range in the study is at the low end of the scale.

Table 5-4. Gap Analysis for Land Cover Types (acres)

		Open Space Classification (acres, unless otherwise noted)						% of Total in StudyArea	
Land Cover Type	Total in Study Area	Type 1	Type 2	Type 3	Type 4	Total Type 1, 2, 3	Total Open Space	Type 1	Type 1, 2, 3
California Annual Grassland	81,795	8,538	2,290	9,988	568	20,816	21,383	10%	25%
Serpentine Bunchgrass Grassland	10,308	1,262	183	2,160	407	3,605	4,012	12%	35%
Serpentine Rock Outcrop / Barrens	260	6	2	48	2	56	58	2%	22%
Serpentine Seep	34	1	0	12	4	13	16	2%	37%
Rock Outcrop	87	10	0	2	8	12	20	12%	14%
Northern Mixed Chaparral / Chamise Chaparral	23,763	3,766	1,525	475	37	5,766	5,804	16%	24%
Mixed Serpentine Chaparral	3,712	221	356	791	67	1,369	1,436	6%	37%
Northern Coastal Scrub / Diablan Sage Scrub	10,306	574	1,083	1,260	102	2,918	3,019	6%	28%
Coyote Brush Scrub	180	10	0	47	6	56	63	5%	31%
Valley Oak Woodland	12,895	3,460	249	1,320	19	5,029	5,048	27%	39%
Mixed Oak Woodland and Forest	84,488	16,522	5,463	11,934	485	33,920	34,405	20%	40%
Blue Oak Woodland	11,160	4,263	124	946	33	5,333	5,366	38%	48%
Coast Live Oak Forest and Woodland	31,652	3,155	1,454	3,826	265	8,434	8,700	10%	27%
Foothill Pine - Oak Woodland	10,960	3,053	578	505	2	4,136	4,138	28%	38%
Mixed Evergreen Forest	5,775	14	767	1,025	0	1,806	1,806	0%	31%
Willow Riparian Forest and Scrub	2,544	23	204	805	311	1,032	1,343	1%	41%
Central California Sycamore Alluvial Woodland	373	0	111	56	0	167	168	0%	45%
Mixed Riparian Forest and Woodland	3,766	183	61	591	263	834	1,097	5%	22%
Redwood Forest	9,693	4	138	3,006	0	3,148	3,148	0%	32%
Ponderosa Pine Woodland	419	411	1	1	0	414	414	98%	99%
Knobcone Pine Forest	711	0	50	87	0	137	137	0%	19%
Coastal and Valley Freshwater Marsh	381	24	42	140	11	206	217	6%	54%
Seasonal Wetland	201	37	3	55	5	95	100	18%	47%
Pond	1,110	65	28	316	169	410	579	6%	37%
Reservoir	2,767	0	78	2,337	49	2,415	2,465	0%	87%
Streams (miles; not included in totals)	2,392	376	134	293	51	803	854.3	16%	34%

Table 5-4. Continued

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Land Cover Type	Total in Study Area	Open Space Classification (acres, unless otherwise noted) Type 1	Type 2	Type 3	Type 4	Total Type 1, 2, 3	Total Open Space	% of Total in StudyArea Type 1	Type 1, 2, 3
Subtotal All Natural or Water Land Cover Types	**309,338**	**45,604**	**14,790**	**41,732**	**2,816**	**102,126**	**104,942**		
Orchard	2,697	3	0	91	99	94	193	0%	3%
Vineyard	1,393	1	8	0	95	9	104	0%	1%
Grain, Row-crop, Hay & Pasture, Disked/short-te	33,648	873	381	923	2,371	2,177	4,548	3%	6%
Agriculture developed / Covered Ag	1,935	11	0	2	10	13	24	1%	1%
Subtotal All Agricultural Land Cover Types	**39,673**	**887**	**389**	**1,016**	**2,576**	**2,293**	**4,869**		
Urban - Suburban	89,438	67	243	742	1,271	1,052	2,323		
Rural - Residential	12,414	9	16	231	157	256	414		
Golf Courses / Urban Parks	8,673	10	13	1,322	3,763	1,345	5,108		
Ornamental Woodland	95	0	0	0	11	0	11		
Landfill	364	0	0	0	0	0	0		
Barren	211	0	0	19	0	19	19		
Subtotal All Development Land Cover Types	**111,194**	**85**	**272**	**2,315**	**5,203**	**2,672**	**7,875**		
Grand Total	**460,205**	**46,577**	**15,451**	**45,063**	**10,595**	**107,091**	**117,686**		

Table 5-5. Existing Open Space and Interim Conservation Lands Proposed for the Reserve System and Specific Conservation Actions within Each Site

Ownership	Area in Study Area (acres)	Proposed for Reserve System[1] (acres)	Existing Resources that Contribute Substantially to Biological Goals and Objectives of Habitat Plan	Conservation Actions Proposed
Existing Open Space				
County Parks				
Almaden Quicksilver County Park	4,138	653	• Extensive stands of mixed oak woodland (2,100 acres) and over 200 acres of blue oak woodland • Over 300 acres of mixed evergreen forest • Provides habitat connectivity within the Santa Cruz Mountains and to extensive protected open space outside of study area • Important populations of covered plants including most beautiful jewelflower, Santa Clara Valley dudleya, and Loma Prieta hoita. • Suitable habitat present for fragrant fritillary and smooth lessingia.	• Enhance serpentine grassland and chaparral • Improved management of covered plant populations
Anderson Lake County Park	3,144	486	• Small stands of serpentine grassland (33 acres) and serpentine chaparral (37 acres) as well as coast live oak and mixed oak woodland and forest • Provides watershed protection for Anderson Reservoir and subsequently Coyote Creek • Provides important wildlife linkage between Coyote Creek, Coyote Ridge and Henry W. Coe State Park • Two of four populations of Coyote ceanothus (all of one, a portion of another) • Populations of Mt. Hamilton thistle, Santa Clara dudleya, and smooth lessingia	• Protect and enhance two populations of Coyote ceanothus, including a portion of the largest known population • Protect and enhance smooth lessingia populations • Enhance serpentine chaparral • Protect and enhance of Mt. Hamilton population • Protect and enhance Santa Clara dudleya population

Table 5-5. Continued Page 2 of 5

Ownership	Area in Study Area (acres)	Proposed for Reserve System[1] (acres)	Existing Resources that Contribute Substantially to Biological Goals and Objectives of Habitat Plan	Conservation Actions Proposed
Calero County Park	4,455	1,690	• Extensive stands of mixed oak woodland (1,562 acres) and over 620 acres of California annual grassland • 268 acres of serpentine grassland, much of which may be suitable for Bay checkerspot butterfly • Provides important habitat connectivity within the Santa Cruz Mountains • California tiger salamander and Bay checkerspot butterfly critical habitat • Populations of most beautiful jewelflower, Santa Clara Valley dudleya, Loma Prieta hoita, smooth lessingia and fragrant fritillary	• Enhance breeding habitat for California tiger salamander and Western pond turtle in 3 ponds • Stream enhancement in upper Llagas Creek and tributaries to benefit known population of foothill yellow-legged frog • Enhancement of potential Bay checkerspot butterfly habitat • Enhance covered serpentine plant populations: Santa Clara Valley dudleya, most beautiful jewelflower, Loma Prieta hoita, and fragrant fritillary • Protect key landscape linkage between Diablo Range and Santa Cruz Mountains
Coyote Lake-Harvey Bear Ranch County Park	4,595	825	• Over 2,400 acres of California annual grassland and extensive stands of oak woodland and willow riparian forest and scrub (154 acres) • Provides watershed protection for Coyote Reservoir and subsequently Coyote Creek • California tiger salamander critical habitat • Bay checkerspot butterfly habitat occupied in recent past • Extensive ponds and aquatic habitat for covered amphibians and reptiles	• Enhance serpentine grassland to create potential satellite population of Bay checkerspot butterfly • Improve breeding habitat for California tiger salamander
Joseph D. Grant County Park	9,560	7,760	• Over 5,000 acres of mixed oak woodland, 920 acres of valley oak woodland, and 350 acres of blue oak woodland • Extensive annual grassland (2,800 acres) • Core protected area between Henry W. Coe State Park to the south and protected lands both inside and outside of the study area to the north • California tiger salamander and California red-legged frog critical habitat and likely provides important regional connectivity for both species • Many ponds and other aquatic habitat for red-legged frog, tiger salamander, pond turtle • Stream habitat for foothill yellow-legged frog • Important stands of riparian woodland • 20% of seasonal wetland in study area (40 acres)	• Restoration and enhancement of valley oak woodland • Increase breeding and upland habitat quality for both California red-legged frog and California tiger salamander • Riparian restoration and enhancement along San Felipe Creek and tributaries that will improve habitat for foothill yellow-legged frog • Freshwater marsh restoration, possibly to support tricolored blackbird

Table 5-5. Continued — Page 3 of 5

Ownership	Area in Study Area (acres)	Proposed for Reserve System[1] (acres)	Existing Resources that Contribute Substantially to Biological Goals and Objectives of Habitat Plan	Conservation Actions Proposed
Santa Teresa County Park	1,646	877	• Over 670 acres of serpentine bunchgrass grassland, 164 acres of mixed oak woodland, and 179 acres of coast live oak woodland • Extensive potential habitat Bay checkerspot butterfly; core site on west side of Valley • Large populations of most beautiful jewelflower, Santa Clara Valley dudleya, Loma Prieta hoita, smooth lessingia, and Mount Hamilton thistle • Provides habitat connectivity on the west side of the narrowest point in the valley and likely is important for wildlife movement	• Enhance serpentine bunchgrass grassland through livestock grazing • Best opportunity to create large amount of Bay checkerspot butterfly habitat • Enhance serpentine covered plant populations
Open Space Authority[2]				
Palasou Ridge	782	TBD	• 310 acres of mixed oak woodland and forest, 114 acres of coast live oak forest and woodland, 89 acres of mixed evergreen forest, 61 acres of sycamore alluvial woodland, 26 acres of foothill pine-oak woodland, 23 mixed serpentine chaparral, foothill pine-oak woodland, and willow riparian forest and scrub • 782 acres of California red-legged frog critical habitat (STC-1B) • One occurrence of smooth lessingia • Includes modeled habitat for foothill yellow-legged frog, western pond turtle, California red-legged frog, California tiger salamander, western pond turtle, and golden eagle • 1.5 stream miles of upper Coyote Creek (above Coyote Reservoir)	• Habitat enhancement along upper Coyote Creek for least Bell's vireo • Maintain and enhance sycamore alluvial woodland • Enhance pond habitat for California tiger salamander and California red-legged frogs; control bullfrog populations

Table 5-5. Continued Page 4 of 5

Ownership	Area in Study Area (acres)	Proposed for Reserve System[1] (acres)	Existing Resources that Contribute Substantially to Biological Goals and Objectives of Habitat Plan	Conservation Actions Proposed
Sierra Vista	984	TBD	• 388 acres of mixed oak woodland and forest, 109 acres coast live oak forest, 95 acres northern coastal scrub/Diablan sage scrub, 38 acres northern mixed chaparral/chamise chaparral, 2.4 acres of ponds, and 0.8 acres of willow riparian and scrub • 984 acres of California red-legged frog critical habitat (STC-1A) • Bordered completely on the east by proposed Reserve System lands • Includes modeled habitat for California red-legged frog, foothill yellow-legged frog, California tiger salamander, western pond turtle, and golden eagle. • 2.2 stream miles of upper Penitencia Creek and tributaries	• Enhance pond habitat for California tiger salamander and California red-legged frogs; control bullfrog populations • Enhance willow riparian habitat for least Bell's vireo and tri-colored blackbird • If needed, enhance stream habitat for foothill yellow-legged frog
Rancho Cañada del Oro	626	TBD	• 401 acres of mixed evergreen forest, 99 acres of northern mixed chaparral/chamise chaparral, 70 acres of mixed oak woodland and forest, 53 acres of redwood forest, and 1.6 acres of knobcone pine woodland • Includes modeled habitat for foothill yellow-legged frog, California red-legged frog, western pond turtle, and golden eagle • Proposed Reserve System lands abut property to the west and to the south • 1.3 stream miles of upper Uvas-Carnadero Creek (above Calero Reservoir) that has suitable habitat for foothill yellow-legged frog	• Fire management for knobcone pine • If needed, enhance stream habitat for foothill yellow-legged frog
County Parks subtotal	27,538	12,291		
Open Space Authority subtotal	2,392	1,000		
Total Existing Open Space	29,930	13,291[3]		

Table 5-5. Continued

Ownership	Area in Study Area (acres)	Proposed for Reserve System[1] (acres)	Existing Resources that Contribute Substantially to Biological Goals and Objectives of Habitat Plan	Conservation Actions Proposed
Interim Conservation Lands[4]				
County Parks				
Tulare Hill (October 2009)	141	134	• Habitat for Bay checkerspot butterfly, known locations of smooth lessingia and Santa Clara Valley dudleya, reintroduction site for Metcalf Canyon jewelflower, critical corridor connecting Diablo Range with Santa Cruz Mountains (Linkage 8).	• Conservation Analysis Zone Guadalupe-3
Rancho San Vicente (October 2009)	966	966	• Extensive serpentine grassland, serpentine chaparral, blue oak woodland, valley oak woodland, and riparian woodland; supports known populations of at least four covered species: Santa Clara Valley dudleya, most beautiful jewelflower, smooth lessingia, and Mt. Hamilton thistle; supports habitat for at least five covered species: Bay checkerspot butterfly, California red-legged frog (upland), California tiger salamander (upland), and Western burrowing owl (foraging); completes landscape linkage between Almaden Quicksilver County Park and complex of open space surrounding Calero Lake (Linkage 9).	• Conservation Analysis Zone Guadalupe-1
Total Interim Lands	1,107	1,100		

Notes:

[1] Estimated amount to be added to the Reserve System based on air photo and land cover map analysis. Final acreage may differ (but will not exceed 13,291 acres). See Section 5.2.3, subheading *Existing Open Space in the Reserve System* and Section 9.4.2, subheading *Santa Clara County Open Space Authority* for a detailed discussion regarding incorporation of existing open space into the Reserve System.

[2] As described in Section 9.4.2 subheading *Santa Clara County Open Space Authority*, the Open Space Authority intends to enroll up to 1,000 acres of its existing lands into the Reserve System. These 1,000 acres may come from any of the Open Space Authority land identified.

[3] This is the maximum acreage of existing open space that would be credited toward the Reserve System size under the Plan. Additional acres of existing open space could be incorporated into the Reserve System; however, they would not receive credit toward the Reserve System size. Alternatively, the Implementing Entity may acquire new lands for the Reserve System in place of adding this acreage from existing open space, as long as the total Reserve System size requirements are met.

[4] Following the issuance of permits, lands acquired during Plan preparation may count toward permit obligations once the partner agency completes its recreation plans and the Wildlife Agencies approve of their incorporation into the Reserve System. Rancho San Vicente and Tulare Hill (acquired October 2009 using County Park Charter Fund) are considered interim conservation and could be incorporated into the Reserve System after recreation plans have been completed for those lands.

Table 5-6. Gap Analysis for Covered Species with Habitat Distribution Models (acres)

Species and Habitat Type	Total Modeled Habitat in Study Area	Open Space Classification (acres, unless otherwise noted) Type 1	Type 2	Type 3	Type 4	Total Type 1, 2, 3	Total Open Space	% of Total Modeled Habitat in Study Area Type 1	Type 1, 2, 3
Bay Checkerspot Butterfly									
Primary Habitat	8,621	1,336	34	1,550	384	2,921	3,304	15%	34%
California Tiger Salamander									
Breeding Habitat	1,027	100	32	271	29	403	432	10%	39%
Non-breeding Habitat	323,721	45,667	13,770	37,583	4,567	97,020	101,587	14%	30%
Total	324,748	45,767	13,802	37,853	4,596	97,423	102,019	14%	30%
California Red-Legged Frog									
Primary Habitat	10,101	730	576	1,924	633	3,230	3,863	7%	32%
Secondary Habitat	331,672	45,523	14,479	37,932	4,203	97,934	102,137		
Total	341,773	46,253	15,055	39,856	4,836	101,164	106,000	14%	30%
Foothill Yellow-Legged Frog (length in miles)									
Primary Habitat	244	37	9	24	7	70	77	15%	29%
Secondary Habitat	447	82	18	52	6	152	158	18%	34%
Total	690	119	28	76	13	222	235	17%	32%
Western Pond Turtle									
Primary Habitat	82,895	13,900	4,566	10,102	1,233	28,568	29,802	17%	34%
Secondary Habitat	232,021	31,067	10,346	28,078	3,048	69,491	72,539	13%	30%
Total	314,916	44,967	14,912	38,180	4,281	98,060	102,341	14%	31%
Western Burrowing Owl[1]									
Overwintering Habitat	132,770	12,584	2,710	13,224	3,507	28,517	32,024	9%	21%
Occupied Nesting Habitat	1,348	0	179	26	287	204	491	0%	15%
Potential Nesting Habitat	63,751	1,003	904	7,174	6,353	9,080	15,433	2%	14%
Total	197,869	13,586	3,792	20,423	10,146	37,802	47,948	7%	19%
Tricolored Blackbird									
Primary Habitat	7,933	295	440	1,811	676	2,546	3,222	4%	32%
Secondary Habitat	132,358	10,742	2,867	13,280	3,570	26,888	30,459	8%	20%
Total	140,291	11,037	3,307	15,091	4,246	29,435	33,681	8%	21%

Table 5-6. Continued

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Species and Habitat Type	Total Modeled Habitat in Study Area	Open Space Classification (acres, unless otherwise noted) Type 1	Type 2	Type 3	Type 4	Total Type 1, 2, 3	Total Open Space	% of Total Modeled Habitat in Study Area Type 1	Type 1, 2, 3
Least Bell's Vireo									
Primary Habitat	3,097	65	62	203	179	330	509	2%	11%
San Joaquin Kit Fox									
Secondary Habitat	38,543	5,067	293	652	1	6,012	6,013	13%	16%
Secondary Habitat (Low Use)	2,349	0	303	0	11	303	314	0%	13%
Total	40,892	5,067	596	652	11	6,315	6,326	12%	15%
Mt. Hamilton Thistle									
Primary Habitat	487	55	6	144	10	204	214	11%	42%
Fragrant Fritllary									
Primary Habitat	8,820	1,025	122	1,927	305	3,074	3,379	12%	35%
Secondary Habitat	156,635	15,346	6,931	16,967	957	39,243	40,201	10%	25%
Total	165,455	16,371	7,053	18,894	1,263	42,317	43,580	10%	26%
Loma Prieta Hoita									
Primary Habitat	104,126	15,133	6,405	12,888	734	34,426	35,160	15%	33%
Secondary Habitat	17,745	2,143	924	1,174	104	4,241	4,345	12%	24%
Total	121,871	17,276	7,328	14,063	839	38,667	39,506	14%	32%
Smooth Lessingia									
Primary Habitat	10,491	1,268	185	2,207	410	3,659	4,069	12%	35%
Metcalf Canyon Jewelflower									
Primary Habitat	8,105	984	48	1,811	306	2,843	3,149	12%	35%
Most Beautiful Jewelflower									
Primary Habitat	14,277	1,490	541	2,999	477	5,030	5,506	10%	35%
Secondary Habitat	85	10	0	2	8	12	20	12%	14%
Total	14,362	1,500	541	3,000	485	5,042	5,527	10%	35%

[1] Western burrowing owl modeled habitat includes occupied and potential nesting habitat only in the study area.

Table 5-7. Gap Analysis of Bay Checkerspot Butterfly Populations (acres)

						Open Space (OS) (acres)						% of Total Habitat unit in		
Bay Checkerspot Butterfly Habitat Units[1]	Habitat unit Status[2]	Core or Satellite Habitat Unit[3]	Consevation Target for Habitat Plan[4]	Site Name in USFWS Recovery Plan (1998)	Total Habitat unit (acres)	Type 1	Type 2	Type 3	Type 4	Total Type 1, 2,3	Total in OS (acres)	Type 1	Type 1, 2, 3	Total Outside OS (acres)
UTC	Occupied	Core	Yes	Kirby	1,607	96		16	134	112	246	6%	7%	1,361
Kirby/East Hills	Occupied	Core	Yes	Kirby	1,334	588	8	43	2	640	641	44%	48%	693
Pigeon Point	Occupied	Core	Yes	Kirby	117			11		11	11	0%	10%	106
Silver Creek Hills Central	Occupied	Core	Yes	Silver Creek	208					0	0	0%	0%	208
Metcalf North Ridge	Occupied	Core	Yes	San Felipe	518			0		0	0	0%	0%	518
Metcalf	Occupied	Core	Yes	Metcalf	629	3			0	3	3	0%	0%	626
Hale/Falcon Crest	Occupied	Satellite	Yes	W Hills of Santa Clara Valley	371	4				4	4	1%	1%	366
Caňada Garcia	Occupied	Satellite	Yes	W Hills of Santa Clara Valley	180	23	19			42	42	13%	23%	137
Kalana Avenues (1-4)	Occupied	Satellite	Yes	W Hills of Santa Clara Valley	110			2		2	2	0%	2%	109
Tulare Hill	Occupied	Satellite	Yes	Tulare Hill	336	144		125	0	269	269	43%	80%	67
Santa Teresa Main	Occupied	Satellite	Yes	Santa Teresa Hills	936			464	169	464	633	0%	50%	303
Santa Teresa North	Potential (no records)	Satellite	Yes	Santa Teresa Hills	190			186	0	186	186	0%	98%	4
Coyote-Bear Ranch County Park	Occupied	Satellite	Yes	None	60			60		60	60	0%	100%	0
Calero	Occupied	Satellite	Yes	Calero	359			352		352	352	0%	98%	7
Subtotal: Target Areas					6,955	858	28	1,260	305	2,146	2,450	12%	31%	4,505
Silver Creek Hills North #1	Occupied	Core	No	Silver Creek	382	345			5	345	350	90%	90%	32
Silver Creek Hills North #2	Potential (no records)	Core	No	Silver Creek	406	103		27	27	130	156	25%	32%	249
Pound Site	Occupied	Core	No[5]	Metcalf	216			216		216	216	0%	100%	0
Communications Hill 1	Historic/Unoccupied	Satellite	No	Communications Hill	230				2	0	2	0%	0%	229
Communications Hill 2	Historic/Unoccupied	Satellite	No	Communications Hill	25				4	0	4	0%	0%	21
San Martin/Hayes Valley	Occupancy Unknown[6]	Satellite	No	W Hills of Santa Clara Valley?	201	29			0	29	29	14%	14%	172
Southwest Anderson Reservoir	Occupancy Unknown	Satellite	No[7]	North of Llagas Ave.	189		7	48	36	55	90	0%	29%	99
Valley Christian High School	Historic/Unoccupied	Satellite	No	None	15				6	0	6	0%	0%	9
Subtotal: Non-Target Areas					1,665	477	7	291	79	775	854	29%	47%	811
Grand Total					**8,621**	**1,336**	**34**	**1,551**	**384**	**2,921**	**3,304**	**15%**	**34%**	**5,316**

Notes:

1 See species account in Appendix D for key to habitat units and map of their locations. Habitat Unit names are derived from the long-term monitoring conducted by Stanford University.

2 Occupied = known to be occupied at least in some years; Occupancy Unknown = site has not been surveyed thoroughly or surveyed in last 10 years;
Historic/Unoccupied = individuals present historically but now unoccupied and site likely no longer suitable; Potential (no records) = Site contains habitat that could be made suitable with proper management (currently unoccupied).

3 Core habitat units are defined as moderate to large areas of suitable habitat that support persistent populations of the species. Satellite habitat units are defined as smaller areas of lower-quality habitat that are not consistently occupied and rely on recolonization from core habitat units to be sustained (U.S. Fish and Wildlife Service 1998).

4 Habitat units targeted for conservation were determined through consultations with experts through the biological goals and objectives workshop and were based on factors such as population size, distance from Coyote Ridge, land ownership patterns, and overall long-term population viability.

5 The majority of this habitat unit is not suitable habitat and is not targeted for conservation. However, portions of this site that support suitable habitat may be targeted for conservation to support connectivity to the Tulare Hill habitat unit.

6 Population documented in late 1980s but no recent surveys.

7 A small portion (less than 1 acre) of this habitat unit is expected to be added to the Reserve System from existing open space for Coyote ceanothus conservation. It is not considered a conservation target for Bay checkerspot butterfly.

Table 5-8. Gaps in Conservation Identified by San Francisco Bay Area Gap Analysis Project for Land Cover Types in the Habitat Plan Study Area[1]

Vegetation Community (Holland 1986)	Equivalent Land Cover Type in Habitat Plan (see Table 3-2)	Protection Estimated in Bay Area (Wild 2002)	Protection Estimated in California (Wild 2002)
Non-native grassland	Annual grassland	18%	5%
Northern mixed chaparral	Northern mixed chaparral / chamise chaparral	1%	8%
Mixed serpentine chaparral	Mixed serpentine chaparral	0%	1%
Diablan sage scrub	Northern coastal scrub/ Diablan sage scrub	12%	2%
Valley oak woodland	Valley oak woodland	18%	1%
Blue oak woodland	Blue oak woodland	19%	4%
Coast live oak woodland[2]	Coast live oak forest and woodland	20%	4%
Coast live oak forest[2]	Coast live oak forest and woodland	12%	5%
Foothill pine-oak woodland	Foothill pine-oak woodland	18%	3%
Great Valley cottonwood riparian forest	Mixed riparian forest and woodland	0%[3]	19%
North coast riparian scrub	Willow riparian woodland and scrub	0%	4%
Coast range ponderosa pine forest	Ponderosa pine forest	13%	23%
Coastal and valley freshwater marsh	Coastal and valley freshwater marsh	21%	38%

Notes:

[1] Vegetation communities are those in Wild (2002) with less than 20% protection for most types or less than 100% protection for those communities with a range-wide historic decline of more than 80%.

[2] These vegetation communities were also identified as having >25% of the state's extent within the San Francisco Bay Area (i.e., high endemism).

[3] Due to large minimum mapping unit, actual protection is likely higher.

Table 5-9. Landscape Linkages in and Near the Study Area Considered for the Reserve Design

Ref. # (Fig. 5-6)	Linkage (Listed Generally from North to South)	Approx. Length[1] (miles)	General Linkage Purpose	Covered and Other Native Species Likely to Use Linkage[2]	Sources
1	Guadalupe River and Guadalupe Creek	33	Connection between San Francisco Bay/Pacific Ocean and spawning habitat for native resident and anadromous fish. Provides regional linkage for riparian birds into the study area. Upper watershed provides local linkages for many wildlife species.	Steelhead trout, Chinook salmon, Pacific lamprey, and Sacramento sucker.	Leidy et al. 2005; FAHCE 2000
2	Coyote Creek from San Francisco Bay to Anderson Dam	32	Connection between San Francisco Bay/Pacific Ocean and spawning habitat for native resident and anadromous fish. Provides regional linkage for riparian birds into the study area. Also provides linkages for native amphibians and aquatic reptiles between off-stream breedings sites in Diablo Range and Santa Cruz Mountains.	Steelhead trout, Chinook salmon, Pacific lamprey, Sacramento sucker, California red-legged frog, Western pond turtle, foothill yellow-legged frog (?)	Leidy et al. 2005; FAHCE 2000; County of Santa Clara Parks & Recreation Department 2007; EDAW 2001; California Wilderness Coalition 2002
3	Upper Penitencia Creek	11.5	Connection between San Francisco Bay/Pacific Ocean and spawning habitat for native resident and anadromous fish.	Steelhead trout, Pacific lamprey, Sacramento sucker.	Leidy et al. 2005; Stillwater Sciences 2006; Biotic Resource Group 2001
4	Joseph D. Grant County Park to SFPUC Alameda Watershed (outside study area)	3	Provide linkage between protected lands in northeast corner of study area and protected lands in Alameda County (land owned by SFPUC and East Bay Regional Park District). Primary route may be along upper Calaveras Creek or Arroyo Hondo.	California red-legged frog, California tiger salamander, American badger, mountain lion, bobcat	L. Serpa pers. comm.; Jones & Stokes 2006; Thorne et al. 2002
5	Joseph Grant Co. Park to Henry W. Coe State Park	11.5	Provide connection between two large blocks of protected lands across a variety of land-cover types, possibly along San Felipe Creek.	California red-legged frog, California tiger salamander, American badger, Tule elk, mountain lion, bobcat, pronghorn,	State of California 1985; H. Coletto pers. comm.; Thorne et al. 2002
6	Coyote Ridge from Silver Creek Hills to Anderson Dam	9.5	Provide connectivity for serpentine species within core habitat along Coyote Ridge. Link patches of protected lands along the ridge.	Bay checkerspot butterfly, Mt. Hamilton thistle, Metcalf Canyon jewelflower, most beautiful jewelflower, smooth lessingia, Santa Clara Valley dudleya, fragrant fritillary, Tiburon paintbrush, Opler's longhorn moth, Hom's and Jung's microblind harvestman	USFWS 1998c; J. Hillman pers. comm.; Weiss and Wright 2005; T. Marker pers. comm.; Also see species accounts in Appendix D

Table 5-9. Continued

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Ref. # (Fig. 5-6)	Linkage (Listed Generally from North to South)	Approx. Length[1] (miles)	General Linkage Purpose	Covered and Other Native Species Likely to Use Linkage[2]	Sources
7	Coyote Ridge to Anderson Lake County Park and Henry W. Coe State Park	7.5	Provide connectivity along an elevation gradient and between protected open space along Coyote Ridge and large blocks of protected open space centered on Henry W. Coe State Park. Provide connectivity among stands of valley oak woodland at different elevations.	Tule elk, American badger, bobcat, Mt. Hamilton thistle, Santa Clara Valley dudleya	H. Coletto pers. comm.; Diamond 2006; T. Diamond pers. comm.; Also see species accounts in Appendix D
8	Santa Teresa Hills to Metcalf Canyon	3	Most northerly and narrowest connection between Diablo Range and the Santa Cruz Mountains. Provides important linkages for variety of mammals and invertebrates.	Bay checkerspot butterfly, Mt. Hamilton thistle, American badger, bobcat	Spencer et al. 2006; Diamond 2006; T. Diamond, pers. comm.; Coastal Training Program 2006; The Nature Conservancy 2006a
9	Calero Co. Park to Almaden Quicksilver County Park	1.5	Provides short linkage between two large County parks (and Open Space Authority lands) and provides linkage outside the study area to extensive protected lands in the Santa Cruz Mountains owned by Midpeninsula Regional Open Space District and the Peninsula Open Space Trust. May be the only viable grassland connection between extensive grassland in the two County parks.	American badger (?), bobcat, mountain lion, Mt. Hamilton thistle, most beautiful jewelflower, smooth lessingia, Loma Prieta hoita, Santa Clara Valley dudleya	See plant species accounts in Appendix D
10	Calero County Park to Coyote Lake-Harvey Bear Ranch County Park, across Tulare Hill/Santa Teresa Hills	18	Provides linkage from Coyote Ridge and Diablo Range to Santa Cruz Mountains via Tulare Hill or Fisher Creek.	Bay checkerspot butterfly, American badger, bobcat, mule deer	City of San Jose 2007; Coastal Training Program 2006; California Wilderness Coalition 2002
11	Llagas Creek from headwaters to confluence with Pajaro River	32	Provides access in wet years from Pajaro River to current and historic spawning and rearing habitat for resident and anadromous fish. Provides regional linkage for riparian birds into the study area from the south and the west. Also may provide local linkages for native amphibians and aquatic reptiles.	Steelhead trout, Pacific lamprey, Monterey roach, Sacramento sucker, Sacramento pikeminnow, western pond turtle, foothill yellow-legged frog, least Bell's vireo, bobcat, California red-legged frog (?)	Smith 2007; Also see species accounts in Appendix D

Table 5-9. Continued | Page 3 of 4

Ref. # (Fig. 5-6)	Linkage (Listed Generally from North to South)	Approx. Length[1] (miles)	General Linkage Purpose	Covered and Other Native Species Likely to Use Linkage[2]	Sources
12	Uvas Creek from headwaters to confluence with Pajaro River	25.5	Provides access from Pajaro River to spawning habitat for resident and anadromous fish. Provides regional linkage for riparian birds into the study area from the south and the west. Also provides local linkages for native amphibians and aquatic reptiles. Provides linkage to outside the study area in Santa Cruz County and to the large and diverse Forest of Nisene Marks State Park.	Steelhead trout, Pacific lamprey, Monterey roach, Sacramento sucker, Sacramento pikeminnow, western pond turtle, least Bell's vireo, bobcat, California red-legged frog, foothill yellow-legged frog	Smith 2007; Also see species accounts in Appendix D
13	Uvas Canyon County Park to Pajaro River through Santa Cruz Mountains	15.5	Provides long-distance connection along spine of Santa Cruz Mountains within the study area (similar linkages identified nearby outside the study area). Provides important connectivity for redwood forest and associated plants. Links Mount Madonna County Park with Uvas Canyon County Park.	Bobcat, mountain lion, California red-legged frog, California tiger salamander, coast redwood	The Nature Conservancy 2006a; Thorne et al. 2002
14	Henry W. Coe State Park to San Felipe Lake	5	Provides closest link between upland habitat and San Felipe Lake, an important large wetland complex in San Benito County. Also provides linkage with high density of ponds between high-elevation habitats in Henry W. Coe State Park and low elevation uplands at edge of study area (i.e., strong environmental gradient).	California tiger salamander, California red-legged frog, western pond turtle, American badger (?), tricolored blackbird (?)	See species accounts in Appendix D
15	Henry W. Coe State Park southeast to San Benito County line	9	Provides linkage across Pacheco Creek and Highway 152 within the Diablo Range. Highway 152 is permeable to wildlife only in certain places (see text for details).	San Joaquin kit fox, mountain lion, bobcat, Tule elk (?), California tiger salamander, California red-legged frog, western pond turtle	Thorne et al. 2002; Also see species accounts in Appendix D
16	Romero Ranch to Henry W. Coe State Park	3.5	Provides connectivity between two large blocks of protected open space.	Mountain lion, bobcat, California tiger salamander, California red-legged frog, western pond turtle	See species accounts in Appendix D

Table 5-9. Continued

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Ref. # (Fig. 5-6)	Linkage (Listed Generally from North to South)	Approx. Length[1] (miles)	General Linkage Purpose	Covered and Other Native Species Likely to Use Linkage[2]	Sources
17	Main stem of Pacheco Creek	12	Provides passage for resident and anadromous fish between Monterey Bay, the Pajaro River, and potential spawning and rearing habitat on south fork of Pacheco Creek and Cedar Creek. Passage through main stem of Pacheco Creek is restricted in dry years.	Steelhead trout, Pacific lamprey, California red-legged frog, Sacramento sucker, western pond turtle, mountain lion, bobcat, least Bell's vireo	Smith 2007; Also see species accounts in Appendix D
18	Santa Cruz Mountains to Diablo Range along Pajaro River	9.5	Provides movement habitat for anadromous fish between Monterey Bay and spawing habitat in the Pacheco Creek watershed. Also provides important linkage for upland and riparian wildlife between Diablo Range and Santa Cruz Mountains.	Steelhead trout, Pacific lamprey, California red-legged frog, western pond turtle, mountain lion, bobcat, least Bell's vireo, tricolored blackbird (?)	The Nature Conservancy 2006a; also see species accounts in Appendix D
19	Santa Cruz Mountains to Gabilan Range	4	Provides linkage from the Santa Cruz Mountains to the Gabilan Range in San Benito County. The only connection south from the Santa Cruz Mountains to the Santa Lucia Ranges to the south.	Mountain lion, bobcat, California red-legged frog	Coastal Training Program 2006; The Nature Conservancy 2006a; Thorne et al. 2002
20	Santa Cruz Mountains to Lomerias Muertas Range	4.5	Provides linkage from the Santa Cruz Mountains to the Lomerias Muertas Range in San Benito County.	Mountain lion, bobcat	The Nature Conservancy 2006a; Thorne et al. 2002

Notes:

[1] Approximate length within the study area.

[2] Other native species identified in this column include species that depend on linkages for long-distance movement or to maintain large home ranges and for which data are available indicating the species may use the particular linkage. Common native species such as raccoon, opossum, coyote, and skunk would likely use all of the linkages and are less sensitive to land use changes within the linkages than the other native species identified.

Table 5-10. Conservation Analysis Zones and Land Cover Types (acres)

	Conservation Analysis Zone								
Land Cover Type	Alameda	Coyote	Guadalupe	Llagas	Pacheco	Pescadero	San Tomas	Uvas	Grand Total
California Annual Grassland	514	20,980	1,283	6,515	23,641	2,779	-	5,537	61,249
Serpentine Bunchgrass Grassland	-	4,535	991	930	123	7	-	419	7,005
Serpentine Rock Outcrop / Barrens	-	132	4	20	19	-	-	31	207
Serpentine Seep	-	4	3	7	7	-	-	-	21
Rock Outcrop	-	6	25	1	39	2	-	0	74
Northern Mixed Chaparral / Chamise Chaparral	-	8,728	101	1,216	4,901	193	-	2,551	17,691
Mixed Serpentine Chaparral	-	376	159	472	555	-	-	843	2,406
Northern Coastal Scrub / Diablan Sage Scrub	18	2,226	370	807	702	753	-	2,765	7,641
Coyote Brush Scrub	-	71	6	10	-	-	-	36	123
Valley Oak Woodland	256	2,955	104	285	3,887	17	-	454	7,958
Mixed Oak Woodland and Forest	299	13,337	1,395	3,193	22,605	1,337	-	8,397	50,563
Blue Oak Woodland	62	1,362	194	1,014	2,326	2	-	1,068	6,029
Coast Live Oak Forest and Woodland	179	8,571	731	3,746	4,148	998	-	5,050	23,421
Foothill Pine - Oak Woodland	-	3,688	-	10	1,942	-	-	797	6,437
Mixed Evergreen Forest	-	1	158	1,538	-	-	-	2,378	4,075
Willow Riparian Forest and Scrub	8	421	202	317	73	98	37	345	1,499
Central California Sycamore Alluvial Woodland	-	3	-	-	195	-	-	9	207
Mixed Riparian Forest and Woodland	-	548	226	453	586	56	-	1,053	2,921
Redwood Forest	-	-	-	108	-	927	-	5,576	6,611
Ponderosa Pine Woodland	-	4	-	0	-	-	-	-	5
Knobcone Pine Woodland	-	-	-	1	-	-	-	591	592
Coastal and Valley Freshwater Marsh	-	38	42	56	8	0	-	31	176
Seasonal Wetland	1	88	7	15	13	1	-	7	131
Pond	1	153	157	122	163	7	-	101	704
Reservoir	-	166	-	-	140	-	-	45	352

Table 5-10. Continued

	Conservation Analysis Zone								
Land Cover Type	Alameda	Coyote	Guadalupe	Llagas	Pacheco	Pescadero	San Tomas	Uvas	Grand Total
Orchard	-	659	114	1,252	172	-	-	406	2,603
Vineyard	2	1	-	846	307	-	-	228	1,385
Grain, Row-crop, Hay & Pasture, Disked/short-term	25	6,827	1,627	16,642	1,155	40	-	5,629	31,945
Agriculture developed / Covered Ag	-	450	-	1,149	23	-	-	300	1,922
Urban - Suburban	12	31,549	37,588	11,599	317	8	5,890	1,404	88,369
Rural - Residential	25	2,633	754	7,049	160	-	-	1,539	12,161
Golf Courses / Urban Parks	-	3,702	2,194	915	-	-	189	309	7,309
Landfill	-	208	73	-	82	-	-	-	364
Ornamental Woodland	-	6	-	14	20	-	-	55	95
Barren	-	152	-	-	-	-	-	40	191
Grand Total	**1,402**	**114,580**	**48,510**	**60,300**	**68,311**	**7,225**	**6,116**	**47,999**	**354,443**

Table 5-11. Land Acquisition and Enhancement Requirements within the Study Area for Selected Terrestrial Land-Cover Types (acres)

							Minimum Open Space Protected[4]			
							Habitat Plan Protection Requirements & Type 1		Habitat Plan Protection Requirements & Type 1, 2, 3	
Land Cover Type[1]	Total in Study Area	Outside Type 1, 2, 3, 4 Open Space	Estimated and Allowable Impact[2]	Estimated Impact (% of Total)	Remain Outside Type 1, 2, 3, 4 Open Space	Protection Requirements for Compensation & Contribution to Recovery[3]	Area (acres)	% of Study Area	Area (acres)	% of Study Area
California Annual Grassland	81,795	60,411	2,006	2.5%	58,405	13,300	21,838	27%	34,116	42%
Serpentine Bunchgrass Grassland	10,308	6,296	550	5.3%	5,746	4,000	5,262	51%	7,605	74%
Serpentine Rock Outcrop/ Barrens	260	202	22	8.5%	180	120	126	49%	176	68%
Serpentine Seep	34	18	0.5	1.5%	17	10	11	32%	23	67%
Rock Outcrop	87	67	0.5	0.6%	66	10	20	23%	22	25%
Northern Mixed Chaparral/ Chamise Chaparral	23,763	17,959	86	0.4%	17,873	400	4,166	18%	6,166	26%
Mixed Serpentine Chaparral	3,712	2,276	131	3.5%	2,145	700	921	25%	2,069	56%
Northern Coastal Scrub/ Diablan Sage Scrub	10,306	7,286	178	1.7%	7,108	1,400	1,974	19%	4,318	42%
Valley Oak Woodland	12,895	7,847	201	1.6%	7,646	1,700	5,160	40%	6,729	52%
Mixed Oak Woodland and Forest	84,488	50,083	1,441	1.7%	48,642	7,100	23,622	28%	41,020	49%
Blue Oak Woodland	11,160	5,793	131	1.2%	5,662	1,100	5,363	48%	6,433	58%
Coast Live Oak Forest and Woodland	31,652	22,953	840	2.7%	22,113	2,900	6,055	19%	11,334	36%
Foothill Pine—Oak Woodland	10,960	6,822	46	0.4%	6,776	80	3,133	29%	4,216	38%
Mixed Evergreen Forest	5,775	3,970	50	0.9%	3,920	20	34	1%	1,826	32%
Redwood Forest	9,693	6,546	109	1.1%	6,437	10	14	0%	3,158	33%
Ponderosa Pine Woodland	419	5	0	0.0%	5	0	411	98%	414	99%
Knobcone Pine Woodland	711	573	8	1.1%	565	0	0	0%	137	19%
Total	**298,016**	**199,105**	**5,800**	**1.9%**	**193,305**	**32,850**	**78,112**	**26%**	**129,760**	**44%**

Notes:

[1] All terrestrial natural land cover types with permanent impacts have land acquisition requirements except for coyote brush scrub and knobcone pine woodland. Coyote brush scrub is not important for any covered species and it is an early-successional community. It will be acquired anyway in the course of meeting other requirements. Knobcone pine woodlands do not provide important habitat for the covered species; as such they are not targeted for acquisition. For ponderosa pine, no permanent impacts are anticipated to occur and nearly all of this terrestrial natural land cover type is protected as Type 1 open space. As such, it is not targeted for acquisition.

[2] Permanent impact only. Source = Table 4-2.

[3] These acreage requirements are the minimum necessary to compensate for impacts of covered activities and contribute to the recovery of covered species. Actual acquisitions of these land cover types is likely to be greater than these minimum requirements because the Plan also includes requirements for connectivity, protection of plant occurrences, and others that will result in additional acquisitions and because parcels purchased to meet a specific requirement will include additional acres of non-target land cover types.

[4] Minimum Open Space = Habitat Plan requirement + existing open space.

Table 5-12. Required Preservation, Enhancement, Restoration and Creation Mitigation Ratios and Estimated Acquisition, Enhancement, Restoration, and Creation Requirements for Aquatic Land Cover Types

Land Cover Type	Maximum Allowable Permanent Impacts[1] (acres)	Preservation and Enhancement Requirements		Restoration or Creation Requirements		
		Required Preservation Ratio	Preservation Requirement to Offset Impacts[1] (acres)	Required Mitigation Ratio (in addition to preservation)		Estimated Total Restoration or Creation (acres)
				Restoration	Creation	
Riparian forest and scrub						
Willow riparian forest and scrub or mixed riparian forest and woodland[3]	289	2:1	578[2]	1:1	–	289
Central California sycamore alluvial woodland	7	2:1	14	2:1	–	14
Wetland						
Coastal and valley freshwater marsh (perennial wetland)	25	2:1	50	1:1	–	25
Seasonal wetland[3]	15	2:1	30[3]	2:1	–	30
Open Water						
Pond[4]	52	2:1	104	–	1:1	52
Total Aquatic Land Cover Types (acres)	388		776			410
Stream (miles)	9.4	3:1	28.2	1:1	–	9.4

Notes:

1 Impact limits are based on Table 4-2 for permanent impacts only. Actual acquisition requirements will be based on field-delineated resources at impact sites and application of the required preservation ratios in this table. Restoration, creation, and enhancement of aquatic land cover is required in addition to preservation of aquatic land cover as mitigation for impacts. See Chapter 5 for details.

2 Because these land cover types are dynamic and represent different points on a continuum of vegetation succession, acquisition requirements for willow riparian woodland and scrub and mixed riparian woodland and forest are considered together and can be counted against either type of impact.

3 Seasonal wetland acreage was quantified as the minimum polygon encompassing clusters of seasonal pools or drainages (i.e., wetland complexes). Impacts and land acquisition requirements will be tracked by the wetland delineation submitted in the Application Package described in Chapter 6, Section 6.8 and verified by the local jurisdiction, so estimates in this table overstate the expected impacts to and preservation of these land cover types. .

4 Pond creation to mitigate for impacts will be accomplished by creating ponds of approximately the same size as those lost. Pond creation to contribute to recovery will be accomplished by creating ponds with an approximate average size of a 0.5 acre.

Table 5-13. Acquisition, Restoration, and Creation Requirements for all Land-Cover Types (acres)

Land Cover Type	Total in Study Area	Estimated and Allowable Permanent Impact[1]	Estimated Impact (% of Total)	Min. Protection Requirements for Contribution to Recovery[2]	Min. Habitat Restoration or Creation Requirements to Contribute to Recovery[3]	Min. Protection, Restoration, and Creation Requirements	Required Protection if All Impacts Occur[4]	Required Restoration or Creation if All Impacts Occur[3]	Total Protection, Restoration, and Creation if All Impacts Occur
Land Cover Types with Acquisition, Restoration, or Creation Requirements									
California annual grassland	81,795	2,006	2.5%	13,300	-	13,300	13,300	-	13,300
Serpentine bunchgrass grassland	10,308	550	5.3%	4,000	-	4,000	4,000	-	4,000
Serpentine Rock Outcrop/ Barrens	260	22	8.5%	120	-	120	120	-	120
Serpentine Seep	34	0.5	1.5%	10	-	10	10	-	10
Rock Outcrop	87	0.5	0.6%	10	-	10	10	-	10
Northern Mixed Chaparral / Chamise Chaparral	23,763	86	0.4%	400	-	400	400	-	400
Mixed Serpentine Chaparral	3,712	131	3.5%	700	-	700	700	-	700
Northern Coastal Scrub / Diablan Sage Scrub	10,306	178	1.7%	1,400	-	1,400	1,400	-	1,400
Valley Oak Woodland	12,895	201	1.6%	1,700	-	1,700	1,700	-	1,700
Mixed Oak Woodland and Forest	84,488	1,441	1.7%	7,100	-	7,100	7,100	-	7,100
Blue Oak Woodland	11,160	131	1.2%	1,100	-	1,100	1,100	-	1,100
Coast Live Oak Forest and Woodland	31,652	840	2.7%	2,900	-	2,900	2,900	-	2,900
Foothill Pine - Oak Woodland	10,960	46	0.4%	80	-	80	80	-	80
Mixed Evergreen Forest	5,775	50	0.9%	20	-	20	20	-	20
Willow Riparian Forest and Scrub and Mixed Riparian Forest and Woodland	6,310	289	4.6%	250	50	300	578	339	917
Central California Sycamore Alluvial Woodland	373	7	1.9%	40	-	40	40	14	54
Redwood Forest	9,693	109	1.1%	10	-	10	10	-	10
Coastal and Valley Freshwater Marsh (Perennial Wetland)	381	25	6.6%	10	20	30	50	45	95
Seasonal Wetland	201	15	7.4%	5	-	5	30	30	60
Pond	1,110	52	4.7%	50	20	70	104	72	177
Subtotal	305,262	6,180	2.0%	33,205	90	33,295	33,652	501	34,153
Streams (miles)	2,392	9.4	0.4%	100.0	1.0	101.0	100.0	10.4	110.4

Table 5-13. Continued

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Land Cover Types without Acquisition, Restoration, or Creation Requirements									
Coyote brush scrub	180	10	5.5%	-	-	-	-	-	-
Ponderosa Pine Woodland	419	0	0.0%	-	-	-	-	-	-
Knobcone Pine Woodland	711	8	1.1%	-	-	-	-	-	-
Reservoir	2,767	0	0.0%	-	-	-	-	-	-
Orchard	2,697	625	23.2%	-	-	-	-	-	-
Vineyard	1,393	37	2.6%	-	-	-	-	-	-
Agriculture developed / covered	1,935	0	0.0%	-	-	-	-	-	-
Grain, row-crop, hay and pasture,	33,648	7,356	21.9%	-	-	-	-	-	-
Urban-suburban	89,438	0	0.0%	-	-	-	-	-	-
Rural - residential	12,414	1,603	12.9%	-	-	-	-	-	-
Barren	211	32	15.2%	-	-	-	-	-	-
Landfill	364	0	0.0%	-	-	-	-	-	-
Golf courses / urban parks	8,673	2,095	24.2%	-	-	-	-	-	-
Ornamental woodland	95	30	31.3%	-	-	-	-	-	-
Subtotal	154,944	11,795	7.6%	-	-	-	-	-	-
TOTAL	**460,205**	**17,975**	**3.9%**	**33,205**	**90**	**33,295**	**33,652**	**501**	**34,153**

Notes:

[1] Source: Table 4-2.

[2] These acreage requirements are the minimum necessary to compensate for impacts of covered activities and contribute to the recovery of covered species, regardless of the actual level of impact. Sources: Tables 5-11 and 5-12. Actual acquisitions of these land cover types is likely to be greater than these minimum requirements because the Plan also includes requirements for connectivity, protection of plant occurrences, and others that will result in additional acquisitions and because parcels purchased to meet a specific requirement will include additional acres of non-target land cover types. Requirements for acquisition of Willow Riparian Forest and Scrub and Mixed Riparian Forest and Woodland are 250 acres of either type; for the purposes of this table the requirement is split in half (see Table 5-12).

[3] Habitat restoration and creation requirements apply only to riparian, wetlands, pond, and stream land cover types. See Table 5-12 for details.

[4] Compensatory protection applies only to riparian, pond, and wetland land cover types (see Table 5-12). Values are the maximum compensation estimated if all impacts of covered activities occur to these land cover types. The estimate for Willow Riparian Forest and Scrub and Mixed Riparian Forest and Woodland is a joint requirement and is split for this table. These values are inclusive of the acres in the proceeding Minimum Protection Requirements for Contribution to Recovery (see Section 5.3.1, subtitle *Acquisition and Restoration Requirements for Aquatic Land Cover Types* for rationale).

Table 5-14. Commitments by Time Period for Restoration and Creation Requirements that Contribute to Species Recovery

Land Cover Types	Restoration/ Creation Requirements to Contribute to Recovery[1]	Restoration/ Creation Commitments by Time Period (acres, except where noted) Year 15	Year 30	Year 40[2]
Willow Riparian Forest and Scrub and Mixed Riparian Forest and Woodland	50	18.8	37.5	50
Coastal and Valley Freshwater Marsh	20	7.5	15.0	20
Pond	20	7.5	15.0	20
Total	**90**	**33.8**	**67.5**	**90**
Streams (miles)	1.0	0.3	0.7	1.0

Notes:

[1] Source: Table 5-13. For wetland and riparian land cover types, timing targets in this table apply to contributions to recovery; preservation and restoration required due to impacts is tied to the Stay-Ahead provision.

[2] All land acquisition must be completed by Year 45. All habitat restoration must be completed by Year 40.

Table 5-15. Minimum Distance from Urban Development[1] Required for Aquatic Land Cover Types to Count Toward Land Acquisition or Restoration/Creation Requirements

Land Cover Type	Minimum Distance from Dense Urban Development Required for Credit	Rationale and Sources
Coastal and valley freshwater marsh	750 feet	Perennial wetlands may support a variety of covered species including tricolored blackbird, California red-legged frog, western pond turtle, and California tiger salamander. Tricolored blackbirds may be sensitive to disturbance and predation from urban pets and aquatic amphibians rely on adjacent upland habitats for nesting and non-breeding season refugia, so a relatively large buffer is required. Though amphibians have been documented traveling great distances from aquatic breeding sites (Reese 1996 [Western pond turtle]; Trenham and Shafer 2005 [California tiger salamander] there is a gradual reduction of upland occurrence as distance from the aquatic feature increases. Trenham and Shafer (2005) captured 50% of California tiger salamander adults within 150 m (492 ft) and 90% within 490 m (1608 ft) from aquatic breeding habitat. A 750-foot buffer between aquatic habitat and urbanization could reasonably support more than 50% of individuals breeding in the wetland/pond if suitable upland habitat was available.
Seasonal wetland	100 feet if wetland is up-gradient from development; 250 feet if wetland is down-gradient of development	Habitat function may decline if seasonal wetlands are located within 100 feet of dense urban development. Hydrologic effects of development can be more severe if seasonal wetland is located down-gradient. Seasonal wetlands, as defined by the Plan, are unlikely to support covered species because their hydroperiod is often shorter than the breeding time required by covered aquatic species. As a result, buffer requirements are based more on ecosystem function rather than species needs.
Pond	750 feet from pond edge	This is the approximate distance below which available upland habitat for pond-breeding covered species begins to diminish substantially (Reese 1996 [Western pond turtle]; Trenham 2001[California tiger salamander]; Semlitsch and Bodie 2003 [amphibians]).
Stream[2]	150 feet from top of bank	This setback is recommended by many authors to maintain stream physical properties (e.g., sediment and nutrient reduction, moderation of stream temperature, channel complexity), salmonid habitat, plant diversity, and other functions.
Riparian woodland/scrub (any land cover type)	50 feet from vegetation dripline	The minimum setback required in Condition 11 (Chapter 6) from the riparian dripline is 50 feet. The land acquisition credit limit accounts for the loss of riparian habitat function within this buffer and the estimated loss of some value for riparian birds and amphibians beyond it.

Notes:

[1] Urban development is defined as the planning limit of urban growth. Development within County jurisdiction outside the planning limit of urban growth triggers these restrictions if that development is as dense as that found within the planning limit of urban growth.

[2] Applies to land acquisition requirement only. Stream restoration can be accomplished within urban areas at any distance from dense urban development for stream restoration credit under the Habitat Plan.

Table 5-16. Species Occurrences, Impacts, and Conservation Requirements for Covered Plants

	Current Known Occurrences[1,2]			Occurrences in Study Area During Plan Implementation[3]		Plant Occurrence Impacts and Conservation					Total Occurrences Protected in Reserve System	
Covered Species	Extant in California	Study Area	Type 1 Open Space[4]	Additional Occurrences Found (relative to baseline)	Total in Study Area	Total Maximum Impacted[5]	Mitigation Ratio[6]	Protected per Mitigation Ratio	Protected to Contribute to Recovery[7]	Total Protected in Reserve System[8]	Acquired[9]	Allowable Creation in lieu of New Occurrence Acquisition[10]
Tiburon Indian paintbrush	9	2	0	–	2	0	N/A	–	1	1	1	–
Coyote ceanothus	3	3	0	–	3	0[11]	N/A	–	5	5	3	2
Mt. Hamilton thistle	48	40	2	0	40	6	3:1	18	4	22	22	–
				6	46	7		21		25	25	–
				12	52	8		24		28	28	–
Santa Clara Valley dudleya	209	207	2	0	207	11	4:1	44	11	55	55	–
				6	213	12		48		59	59	–
				12	219	13		52		63	63	–
				18	225	14		56		67	67	–
Fragrant fritillary	59	8	0	0	8	1	3:1	3	1	4	4	–
				5	13	2		6		7	7	–
				10	18	3		9		10	10	–
Loma Prieta hoita	26	14	1	0	14	0	2:1	0	4	4	4	–
				3	17	1		2		6	6	–
				6	20	2		4		8	8	–
Smooth lessingia	39	39	3	0	39	6	2:1	12	12	24	12	12
				7	46	7		14		26	14	
				10	49	8		16		28	16	
				13	52	9		18		30	18	
Metcalf Canyon jewelflower	11	10	1	–	10	2	N/A	–	10	13	3	10
Most beautiful jewel-flower	86	39	3	0	39	6	2:1	12	5	17	17	–
				4	43	7		14		19	19	–
				8	47	8		16		21	21	–

Table 5-16. Continued Page 2 of 2

	Current Known Occurrences[1,2]			Occurrences in Study Area During Plan Implementation[3]		Plant Occurrence Impacts and Conservation					Total Occurrences Protected in Reserve System	
Covered Species	Extant in California	Study Area	Type 1 Open Space[4]	Additional Occurrences Found (relative to baseline)	Total in Study Area	Total Maximum Impacted[5]	Mitigation Ratio[6]	Protected per Mitigation Ratio	Protected to Contribute to Recovery[7]	Total Protected in Reserve System[8]	Acquired[9]	Allowable Creation in lieu of New Occurrence Acquisition[10]

Notes:

1 See Chapter 3 for data sources.

2 For the purposes of this Plan and the analyses, occurrences are equivalent to populations for all species except for Santa Clara Valley dudleya.

3 More occurrences may be found during Plan implementation than were known during Plan preparation (baseline). These columns represent the minimum number of known occurrences that must be known in the study area before impacts described in the subsequent column can occur. The first line for each species accounts for occurrences known at the time of permit issuance. "Additional Occurrences Found" refers to the number of additional occurrence found during the permit term. "Total in Study Area" is the number of additional occurrence found during the permit term plus the number of occurrence known during Plan preparation.

4 Occurrences that are only partially in open space are not included in totals.

5 Occurrences are considered impacted if the occurrence is removed or a qualified biologist determines that occurrence viability will be reduced as a result of covered activities, as further described in Chapter 6, Condition 20. Impacts solely associated with implementation of the conservation strategy are not reflected in this column as those impacts will be minor and temporary in nature and will have a net benefit to the species. No new occurrence acquisition will allow additional impacts beyond what is listed in this table. Refer to Chapter 4 for full explanation of impacts by species.

6 Mitigation ratios were only developed for species for which additional impacts could occur in the event that additional occurrences are found during the permit term. Ratios were calculated as the number of occurrences acquired if no additional occurrences were discovered during the permit term by the total maximum occurrences that could be impacted if no additional occurrences were discovered during the permit term. The mitigation ratio represents the number of occurrences that must be acquired prior to each impact, including the first impact. Species-specific requirements regarding timing of mitigation/conservation relative to impact are provided in Section 5.4 for the Tiburon Indian paintbrush, Coyote ceanothus, and Metcalf Canyon jewelflower.

7 Recovery actions will occur regardless of impacts; however, acquisition activities performed for mitigation purposes can count toward recovery once the total mitigation obligation is achieved.

8 With the exception of the Coyote ceanothus (see Section 5.4.11), all occurrences acquired or created in this Plan will be permanently protected within the Reserve System with a conservation easement and/or will be owned in fee by the Implementing Entity. The first row for each species in this column represents the minimum requirement of acquisition and creation regardless of the number of occurrences impacted (e.g., if no additional occurrences of Mt. Hamilton thistle are found during Plan implementation, the Implementing Entity will acquire 22 occurrences for the Reserve System even if less than six occurrences are impacted during the permit term).

9 Acquisition of naturally-occurring occurrences could occur through fee title and/or conservation easement. Occurrences could be on land newly acquired under the Habitat Plan or on existing open space that is incorporated into the Reserve System. Occurrences must be acquired prior to impacts, with the exception of the Coyote ceanothus (see Section 5.4.11).

10 For occurrence preservation, priority will always be given to acquisition, however, if acquisition is infeasible, creation is allowed as stipulated in Section 5.4. The decision to focus conservation effort on occurrence creation will be made jointly with the Wildlife Agencies. Creation will be completed by Year 40, acquisition will be completed by Year 45.

11 Impacts are allowed to no more than 3,650 individuals or 5% of the population adjacent to Anderson Dam, whichever is smaller. This standard will be applied to the population as it existed during the 2009 surveys. It will not be applied to any new recruits that are a result of natural or artificial disturbance event such as fire.

Table 5-17. Commitments to Acquire and Enhance Modeled Habitat in the Reserve System for Covered Species with Models (acres)

Species and Habitat Type	Habitat in Study Area (acres)[1]	Modeled Habitat in Type 1 Open Space: Area (acres)	Modeled Habitat in Type 1 Open Space: Proportion (%)	Modeled Habitat in Type 1,2, and 3 Open Space: Area (acres)	Modeled Habitat in Type 1,2, and 3 Open Space: Proportion (%)	Commitment to Acquire Modeled Habitat for Reserve System (acres)	Maximum Modeled Habitat added to the Reserve System from Existing Open Space (acres)[2]	Total Protected in Reserve System and Type 1 Open Space: Amount (acres)	Total Protected in Reserve System and Type 1 Open Space: Proportion (%)	Total in Reserve System and Type 1, 2, and 3 Open Space: Amount (acres)	Total in Reserve System and Type 1, 2, and 3 Open Space: Proportion (%)
Bay Checkerspot Butterfly											
Primary Habitat	8,621	1,336	15%	2,921	34%	3,800	754	5,890	68%	6,721	78%
California Tiger Salamander											
Breeding Habitat	1,027	100	10%	403	39%	150	45	295	29%	553	54%
Non-breeding Habitat	323,721	45,667	14%	97,020	30%	30,000	11,700	87,367	27%	127,020	39%
Total	324,748	45,767	14%	97,423	30%	30,150	11,745	87,662	27%	127,573	39%
California Red-Legged Frog											
Primary Habitat	10,101	730	7%	3,230	32%	1,300	130	2,160	21%	4,530	45%
Secondary Habitat	331,672	45,523	14%	97,934	30%	30,000	11,800	87,323	26%	127,934	39%
Total	341,773	46,253	14%	101,164	30%	31,300	11,930	89,483	26%	132,464	39%
Foothill Yellow-Legged Frog (length in miles)											
Primary Habitat	244	37	15%	70	29%	30	7	74	30%	100	41%
Secondary Habitat	447	82	18%	152	34%	50	17	149	33%	202	45%
Total	690	119	17%	222	32%	80	24	222	32%	302	44%
Western Pond Turtle											
Primary Habitat	82,895	13,900	17%	28,568	34%	7,000	2,800	23,700	29%	35,568	43%
Secondary Habitat	232,021	31,067	13%	69,491	30%	20,000	9,100	60,167	26%	89,491	39%
Total	314,916	44,967	14%	98,060	31%	27,000	11,900	83,867	27%	125,060	40%
Western Burrowing Owl											
Overwintering Habitat	132,770	12,584	9%	28,517	21%	17,000	4,310	33,894	26%	45,517	34%
Occupied and Potential Nesting Habitat[3]	65,099	1,003	2%	9,284	14%	5,300	0	6,303	10%	14,584	22%
Total	197,869	13,586	7%	37,802	19%	22,300	4,310	40,196	20%	60,102	30%
Tricolored Blackbird											
Primary Habitat	7,933	295	4%	2,546	32%	1,000	40	1,335	17%	3,546	45%
Secondary Habitat	132,358	10,742	8%	26,888	20%	18,000	3,800	32,542	25%	44,888	34%
Total	140,291	11,037	8%	29,435	21%	19,000	3,840	33,877	24%	48,435	35%
Least Bell's Vireo											
Primary Habitat	3,097	65	2%	330	11%	460	2	527	17%	790	26%
San Joaquin Kit Fox											

Table 5-17. Continued

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Species and Habitat Type	Habitat in Study Area (acres)[1]	Modeled Habitat in Type 1 Open Space: Area (acres)	Modeled Habitat in Type 1 Open Space: Proportion (%)	Modeled Habitat in Type 1,2, and 3 Open Space: Area (acres)	Modeled Habitat in Type 1,2, and 3 Open Space: Proportion (%)	Commitment to Acquire Modeled Habitat for Reserve System (acres)	Maximum Modeled Habitat added to the Reserve System from Existing Open Space (acres)[2]	Total Protected in Reserve System and Type 1 Open Space: Amount (acres)	Total Protected in Reserve System and Type 1 Open Space: Proportion (%)	Total in Reserve System and Type 1, 2, and 3 Open Space: Amount (acres)	Total in Reserve System and Type 1, 2, and 3 Open Space: Proportion (%)
Secondary Habitat	38,543	5,067	13%	6,012	16%	4,000	0	9,067	24%	10,012	26%
Secondary Habitat (Low Use)	2,349		0%	303	13%	100	0	100	4%	403	17%
Total	40,892	5,067	12%	6,315	15%	4,100	0	9,167	22%	10,415	25%
Mt. Hamilton Thistle											
Primary Habitat	487	55	11%	204	42%	150	60	265	54%	354	73%
Fragrant Fritillary											
Primary Habitat	8,820	1,025	12%	3,074	35%	3,000	1,000	5,025	57%	6,074	69%
Secondary Habitat	156,635	15,346	10%	39,243	25%	20,000	3,000	38,346	24%	59,243	38%
Total	165,455	16,371	10%	42,317	26%	23,000	4,000	43,371	26%	65,317	39%
Loma Prieta Hoita											
Primary Habitat	104,126	15,133	15%	34,426	33%	9,000	3,500	27,633	27%	43,426	42%
Secondary Habitat	17,745	2,143	12%	4,241	24%	1,000	600	3,743	21%	5,241	30%
Total	121,871	17,276	14%	38,667	32%	10,000	4,100	31,376	26%	48,667	40%
Smooth Lessingia											
Primary Habitat	10,491	1,268	12%	3,659	35%	4,000	1,100	6,368	61%	7,659	73%
Metcalf Canyon Jewelflower											
Primary Habitat	8,105	984	12%	2,843	35%	3,200	1,000	5,184	64%	6,043	75%
Most Beautiful Jewelflower											
Primary Habitat	14,277	1,490	10%	5,030	35%	4,000	1,700	7,190	50%	9,030	63%
Secondary Habitat	85	10	12%	12	14%	0	0	11	13%	12	14%
Total	14,362	1,500	10%	5,042	35%	4,000	1,700	7,201	50%	9,042	63%

[1] All area measurements are in acres unless otherwise noted.

[2] County Park lands added to Reserve System and converted from Type 2 or 3 Open Space to Type 1 (see Table 5-5) within the Reserve System would be enhanced, where appropriate. A maximum of 13,291 acres of existing open space could be credited toward the Reserve System size under the Plan. Additional acres of existing open space could be incorporated into the Reserve System; however, they would not receive credit toward the Reserve System size. Alternatively, the Implementing Entity may acquire new lands for the Reserve System in place of adding this acreage from existing open space, as long as the total Reserve System size requirements are met.

[3] Western burrowing owl modeled occupied nesting and potential nesting modeled habitat is quantified inside the study area only. The Implementing Entity will manage a minimum of 5,300 acres of western burrowing owl nesting (occupied and potential) habitat throughout the permit area by the end of the permit term. Of this acreage, a minimum of 600 acres of occupied nesting habitat must be protected in fee title or conservation easement as part of the Reserve System. For the remaining 4,700 acres, land acquisition (fee title or easement) or management agreements may be used and the land may not be part of the Reserve System . However, lands not acquired will be under permanent management agreements by year 45. Additional detail is provided in Chapter 5 and Appendix M.

Table 5-18. Land Acquisition and Enhancement Requirements for Selected Conservation Analysis Zones (acres)

Conservation Analysis Zone[1]	Natural Land Cover Types in Zone(s) (acres)	Natural Land Cover Acquisition Requirement in Zone(s) (acres)	Proportion (%)
Alameda 1	1,338	--	--
Coyote 7	4,567	--	--
Subtotal[2]	5,905	2,300	39%
Coyote 4	9,146	4,200	46%
Subtotal	9,146	4,200	46%
Uvas 1	10,891	1,000	9%
Uvas 2	8,573	800	9%
Uvas 3	4,761	--	--
Uvas 4	4,357	--	--
Uvas 5	8,630	4,600	53%
Uvas 6	831	200	24%
Subtotal	38,043	6,600	17%
Pacheco 1	9,093	--	--
Pacheco 2	7,535	--	--
Pacheco 3	5,849	--	--
Pacheco 4	5,477	--	--
Pacheco 5	12,959	--	--
Pacheco 6	8,278	--	--
Subtotal[2]	49,190	2,400	5%
Coyote 2	4,954	900	18%
Pacheco 7	5,037	800	16%
Pacheco 8	11,706	3,800	32%
Subtotal	21,697	5,500	25%
Total[3]	**123,981**	**21,000**	**17%**

Notes:

[1] Conservation Analysis Zones with separate land acquisition requirements were selected based on the need to be more geographically specific to achieve conservation goals and objectives.

[2] Land acquisition can be achieved in any applicable conservation analysis zone to meet the requirements in the subtotal.

[3] Total land acquisition requirement for these conservation analysis zones overlap with land acquisition requirements for land cover types in Tables 5-11 and Table 5-13. Land acquisition requirements by conservation analysis zone include both terrestrial and wetland land cover types.

Table 5-19. Land Acquisition and Enhancement Requirements for Serpentine Grassland in the Study Area

Conservation Analysis Zone[1]	Serpentine Grassland in Zone(s) (acres)	Serpentine Grassland Acquisition Requirement in Zone(s) (acres)	Proportion (%)
Guadalupe 1 and 3	980	500	51%
Guadalupe 2	11	-	0%
Coyote 3	21	-	0%
Coyote 4	131	100	76%
Coyote 5	2,655	1,900	72%
Coyote 6	1,735	900	52%
Coyote 7	22	-	0%
Coyote 9	66	-	0%
Coyote 10	153	-	0%
Llagas 2	299	200	67%
Llagas 3	583	100	17%
Llagas 4	32	-	0%
Llagas 5	16	-	0%
Uvas 1	147	-	0%
Uvas 2	42	-	0%
Uvas 3	38	-	0%
Uvas 4	10	-	0%
Uvas 5	175	-	0%
Uvas 6	8	-	0%
Pescadero 1	7	-	0%
Pacheco 5	50	-	0%
Pacheco 6	73	-	0%
Any Conservation Analysis Zone		300	
Total	**7,254**	**4,000**	**55%**

Notes:
[1] Only those conservation analysis zones with serpentine grassland are shown.

Table 5-20. Management Consideration for Significant Invasive Plants in the Plan Area

Species	Management Considerations
Non-native Annual Grasses (multiple species)	The grasslands of the region are overwhelmingly dominated by very aggressive weedy grasses and forbs that evolved under extreme grazing pressure in the Mediterranean region of Southern Europe, North Africa, and the Middle East before invading and replacing the native California grasslands. The annual-dominated grasslands that we have today are quite different in significant ways from the native grasslands of the past—different species, different animal herbivory and traffic, and different management by people. Without management (mostly with livestock grazing), these aggressive plants grow tall and dense (even in serpentine), choking out the habitat structure that allowed the currently endangered plants and animals to survive through the last 250 or more years. Grazing still controls the growth of these plants in their native grasslands around the Mediterranean Sea, and in California has facilitated the persistence of a host of endangered species in our grasslands. **Grazing Management.** The existing science of grasslands and their management tells us that some kind of grazing is far better than none, for multiple conservation purposes, including maintenance of habitat for grassland-dependent special-status species. Grazing termination or exclusion has lead to local extirpations of endangered species, particularly during years of above-normal precipitation (e.g., Bay checkerspot butterfly). Research and experience has shown that grazing can be prescribed more precisely to create and maintain the desired habitat structure for special-status species, fire fuel patterns, and reduction of pest plants, while minimizing impacts. Livestock's role in grassland conservation and grazing management, as well as the fire, mechanical, and herbicide treatment options are described in text.
Barbed goatgrass (*Aegilops triuncialis*)	**Grazing Management (risks of spread/timing/intensity).** Small infestations can be spread quickly by attachment of the barbed seeds to livestock and wildlife, and by distribution of livestock replacement hay. Heavy grazing during the growing period, followed by late-spring rest has increased the density of this pest. Heavy grazing during the early growing season can be effective in limiting seed production. **Fire.** Thorough late-spring burning of infested patches, where there is abundant herbaceous fuels and before seedheads have emerged, has been effective. Multiple burns are required because of persistence of a viable seedbank. **Mechanical.** Mowing has been less effective than grazing because prostrate plants escape injury. Mowing during the early growing season can be effective in limiting seed production. **Herbicides.** Glyphosate can be effective if the infestations are small and found early. This herbicide can be effective if used in the winter or spring, but repeated applications are likely to be necessary to deplete the seedbank.
Black mustard (*Brassica nigra*)	**Grazing Management (Timing/Intensity).** Disturbance, including excessive grazing, promotes the dominance and spread of black mustard. The fast growing, fibrous stems and branches of black mustard are generally not preferable to livestock. Black mustard favors nutrient-rich soils that are especially prevalent in areas used by cattle. Once dominance by black mustard is established, allelopathic chemicals leaching from dead stalks and tissues further prevents the establishment of other plants. **Fire.** Dense black mustard stands may increase the fire frequency as plants are extremely flammable upon desiccation. There is no evidence in the available literature that prescribed burning is an effective technique to control black mustard infestations. The increased nitrification of soil and lack of viable competitors may increase the level of infestation. **Mechanical.** Mowing and hand pulling is very effective for controlling relatively small populations of black mustard. Mowing should be timed for early spring, prior to the production of viable seeds. **Herbicides.** 2-4-D and glyphosphate are both effective herbicides for control of black mustard. These are best applied to rosettes immediately after mowing.

Table 5-20. Continued

Species	Management Considerations
Italian thistle (*Carduus pycnocephalus*)	**Grazing Management (Timing/Intensity).** Although cattle grazing has demonstrated limited success in controlling Italian thistle, properly timed grazing will minimize the spread of seed and slow the rate of infestation. Light to moderate intensity early to mid-spring grazing prior to the production of flowering heads is preferable and will minimize soil disturbance and nitrification of soil, which favors Italian thistle establishment and spread. **Fire.** Very little data supports the use of fire as an effective mechanism for Italian thistle control. Many ecologists have observed dramatic increases in the size of Italian thistle infestations following fire. This is likely due to the increased nutrients released into the soils and lack of competition from other annual plants. However, similar to YST, burning over 2 or more consecutive years is likely to reduce the viable seedbank and decrease the size and density of Italian thistle colonies. This strategy is best used as part of an integrated pest management program. **Mechanical.** For relatively small infestations of Italian thistle, mowing is the preferred method for control. This technique requires mowing before seed production over several consecutive years (or even within years). Slashing is even more effective because more of the above ground plant material is removed. Italian thistle has been shown to readily flower in plants that are cut at or above 8 cm above the ground. Further, if plants are cut too close to flowering, they can still produce viable seed after they have been mowed. Hand hoeing is the most effective technique for small patches, especially if roots are severed 10 cm below the ground surface because plants will not resprout in the same growing season. **Herbicides.** Herbicides are most effective in combination with other weed management techniques. 2-4-D has shown some success and is best applied directly to the roots when thistles are less than 0.25m.
Yellow star thistle (*Centaurea solstitialis*)	**Grazing Management. (Timing/Intensity).** Cattle grazing must occur prior to blooming period of spiny flower heads. High intensity early spring grazing followed by mowing/herbicide application is an effective method for control although full eradication is highly improbable. Note: Goats are preferable to cattle because they will browse on spiny flower heads later in the year. Yellow star thistle is highly toxic and may be fatal to horses. **Fire.** Prescribed burning has proven effective only after repeated burns over 2 or more consecutive years. Otherwise, fire is counterproductive and will increase germination and spread of YST due to increased light penetration and soil warming resulting from the removal of thatch and other competing plant species. Prescribed burning in a single year may be effective as part of an integrated pest management strategy including mowing and herbicides. **Mechanical.** Although labor intensive and time consuming, mowing is an effective strategy for controlling yellow star thistle after plants have bolted but prior to the production of viable seeds. This technique is most effective for small, isolated populations. **Herbicides.** Clopyralid is the most effective herbicide for full season control of YST registered for use in California. Unlike most post-emergence herbicides, it provides both foliar and soil activity. The best timing for application is when YST is in the early rosette stage. Glyphosphate (Roundup) is useful for control after plants have bolted. Herbicides are best utilized as part of an integrated pest management program.
Bull thistle (*Cirsium vulgare*)	**Grazing Management (Timing/Intensity).** Cattle will not consume bull thistle due to long, stiff spines at the end of the leaves and subtending the flowers. However, bull thistle tends to colonize in disturbed overgrazed areas including wallows near water troughs. **Fire.** Biennial forbs, including most thistles, require burning over 2 or more consecutive years for effective control. A single fire will likely increase the level of bull thistle infestation. **Mechanical.** Repeated mowing will control infestations of bull thistle, but mowing must be timed before the production of flowers

Table 5-20. Continued

Species	Management Considerations
	and viable seeds. **Chemical.** 2-4-D, clopyralid, picloram, and dicamba are effective herbicides for controlling bull thistle. Herbicide application is most effective when applied to rosettes prior to the production of flowers and viable seeds.
Common teasel (*Dipsacus fullonum*)	**Grazing Management (Exclusion).** In general, spiny flower-heads are natural deterrent to cattle grazing. Dense infestations are generally impenetrable to livestock. There is evidence that cattle will not consume teasel prior to flower production due to the bitter taste and spiny leaves. However, because teasel is spread by seed, cattle may incidentally translocate seeds and spread teasel to other sites. Disturbance and denuded vegetation from heavy grazing is also likely to facilitate teasel establishment due to increased nutrients (nitrification) and lack of competition from other plants. **Fire.** Late spring prescribed burns may be somewhat effective for teasel control. However, because fire will not carry well through dense stands of mature plants, fire alone will not eradicate teasel. Prescribed burning may make it easier to locate rosettes for mechanical or chemical control. **Mechanical.** Mowing prior to the production of mature flowers is effective for control of teasel, but will not eradicate common teasel. Hand pulling or mattocking is preferable due to full removal of perennial root systems. **Chemical.** 2-4-D applied in the spring to rosettes prior to mature flower production is effective for teasel eradication. This strategy is best used in combination with mowing as part of an integrated pest management program.
Blue gum eucalyptus (*Eucalyptus globulus*)	**Grazing Management. (None).** Eucalyptus displaces native plant communities/wildlife habitat due to rapid establishment and growth. Allelopathic properties in the leaves and stems prevent recruitment of all but the hardiest understory vegetation. Eucalyptus will rapidly invade grasslands, reducing the available forage for cattle. Furthermore, aromatic and woody seedlings/saplings are unlikely to be ingested by cattle. **Fire.** No data exists to support the use of prescribed fire to control eucalyptus. However, there is some speculation that prescribed burning prior to cutting trees may assist with herbicide application. In general, eucalyptus infestations are expected to increase the wildfire frequency due to fast growing and highly flammable properties of this species. **Mechanical.** Cutting trees and leaving stumps flat and low to the ground is the common method for control followed by stump grinding or direct herbicide application. Hand pulling of seedlings and saplings up to one inch is diameter is also an effective means of control. **Chemical.** Various herbicides are typically applied to cut stumps. The most commonly used herbicide is 25–50% dilute glyphosphate applied directly to the stump within several minutes of cutting. Because eucalyptus will re-sprout from cut stumps, new growth should be monitored and controlled for up to three years. It has been postulated the best time to remove regrowth is when shoots are 6-8 feet high and are still a major net energy investment for the tree.
Fennel (*Foeniculum vulgare*)	**Grazing Management (None).** Grazing management will not control existing fennel infestations in SCTP. Mature fennel is not palatable to livestock and most infestations are located outside of selected grazing management units. However, fennel is not typically found in grazed pastures. Moderate intensity grazing should prevent the establishment of new fennel infestations. **Fire.** Prescribed burning is not a feasible strategy for fennel control in STCP due to proximity to roads and private residences. **Mechanical.** While mowing prior to seed production may prevent further spread of fennel, eradication requires cultivation of plants including full removal of the roots. Although labor intensive, mattocking or hand digging are the preferred strategies for eradication. **Chemical.** Application of 2-4-D while plants are growing but prior to flower production has proven effective. Plants must be wetted

Table 5-20. Continued

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Species	Management Considerations
	prior to application, particularly the crowns. However, because fennel is often located on embankments adjacent to waterways or impermeable road surfaces, herbicide application may not be feasible.
Milk thistle (*Silybum marianum*)	**Grazing Management (Intensity).** Accumulated nitrates in milk thistle leaves are toxic to cattle. Thorny spines on the leaf margins and flower heads will cause selective avoidance by cattle as well. Residual dry matter (litter) in the late summer and fall is a highly important inhibitive factor in the germination of milk thistle seed. Thus, the level of grazing in areas supporting this plant should be carefully managed for appropriate levels of RDM. **Fire.** No data exists to support the use of prescribed fire to control milk thistle infestations. Some observers have noticed a decrease in milk thistle following accidental burns, but this has not been corroborated experimentally. It is generally believed that nutrient loading from fire and lack of competitors will increase milk thistle germination. Prescribed burning may be useful if repeated over 2+ consecutive years. **Mechanical.** Mowing alone is not an effective method of control for milk thistle. Plants are often able to re-sprout and grow back in the same year, or produce viable flower heads below the level of the mower. Tilling or digging prior to flower productions is far more effective in that it removes the entire plant. Plants removed in this manner should be bagged and disposed of offsite because any flowers will still go to seed even after they have been uprooted. Tilled areas should be re-vegetated using a non-invasive, preferably native seed mix to avoid further establishment of milk thistle and other invasive species. **Herbicides.** Spot spray application of 2-4-D, dicamba or piclroam during the seedling to rosette phases of milk thistle development has demonstrated effective control. A recent experiment using the herbicides picloram and methabenzthiazuron in combination with phenoxyacetic acid compound was 100% effective in eradicating milk thistle.

Sources:
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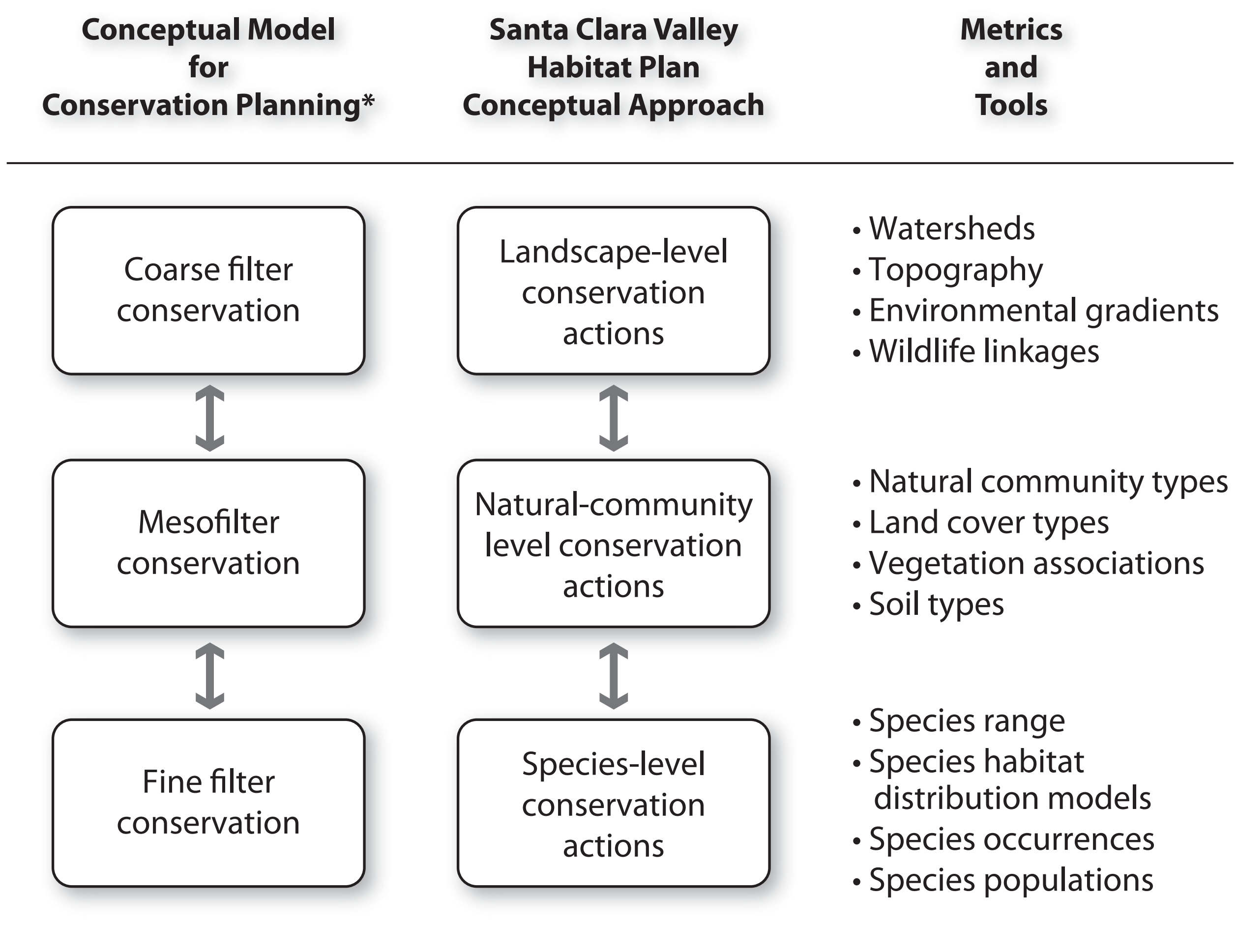
DiTomaso, J.M. and E.A. Healy. 2007. Weeds of California and Other Western States. Vols. 1 and 2. University of California Agriculture and Natural Resources, Oakland, CA.
Lawrence D. Ford Rangeland Management and Conservation Science and EcoSystems West Consulting Group. 2011. Grazing Management Plan, Santa Teresa County Park, San Jose, California. Prepared for Santa Clara County Department of Parks and Recreation.

Table 5-21. Protected Critical Habitat Units

Critical Habitat Unit[1]	Total Critical Habitat in Study Area	Critical Habitat in Open Space Type 1	Percent in Open Space Type 1	Critical Habitat in Open Space Types 2–4	Percent in Open Space Types 2–4	Estimated Critical Habitat in Reserve System[2]	Percent in Reserve System
Bay Checkerspot Butterfly							
5-Metcalf	4,503	780	17%	41	1%	2,580	57%
6-Tulare Hill	348	158	45%	0	0%	169	49%
7-Santa Teresa Hills	3,278		0%	1,699	52%	2,135	65%
8-Calero Reservoir	1,543	2	0%	913	59%	1,336	87%
9a-Kalana	170		0%	0	0%	103	61%
9b-Kalana	56		0%	0	0%	–	0%
10-Hale	507	28	5%	–	0%	434	86%
11-Bear Ranch	283		0%	283	100%	274	97%
12-San Martin	467	241	52%	16	3%	–	0%
13-Kirby	5,446	834	15%	1,244	23%	2,596	48%
Total	**16,601**	**2,042**	**12%**	**4,197**	**25%**	**9,627**	**58%**
California Tiger Salamander							
East Bay-5	1,393	674	48%	169	12%	549	39%
East Bay-6	3,916		0%	3,757	96%	2,519	64%
East Bay-7	8,595	5,767	67%	–	0%	1,757	20%
East Bay-8	2,536	2	0%	2,357	93%	1,701	67%
East Bay-9	2,935		0%	1,930	66%	190	6%
East Bay-10A	194	0	0%	–	0%	–	0%
East Bay-10B	698	0	0%	–	0%	570	82%
East Bay-11	2,223		0%	1,837	83%	0	0%
East Bay-12	5,607		0%	–	0%	1,436	26%
Total	**28,096**	**6,443**	**23%**	**10,049**	**33%**	**8,722**	**31%**
California Red-Legged Frog							
ALA-2	1,465		0%	73	5%	819	56%
STC-1	52,283	23,805	46%	12,716	24%	13,573	26%
STC-2	97,214	12,897	13%	9,000	9%	7,344	8%
Total	**150,962**	**36,703**	**24%**	**21,789**	**14%**	**21,736**	**14%**

[1] Covered species critical habitat within the study area is depicted in **Figure 4-4** (Bay checkerspot butterfly), **Figure 4-5** (California tiger salamander), and **Figure 4-6** (California red-legged frog).

[2] Assumes all land within critical habitat supports primary constituent elements. Includes existing parklands that will be integrated into the Reserve System.



* Source: Hunter (2005)

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Figure 5-1
Conceptual Model and Conceptual Approach to the Conservation Strategy for the Santa Clara Valley Habitat Plan

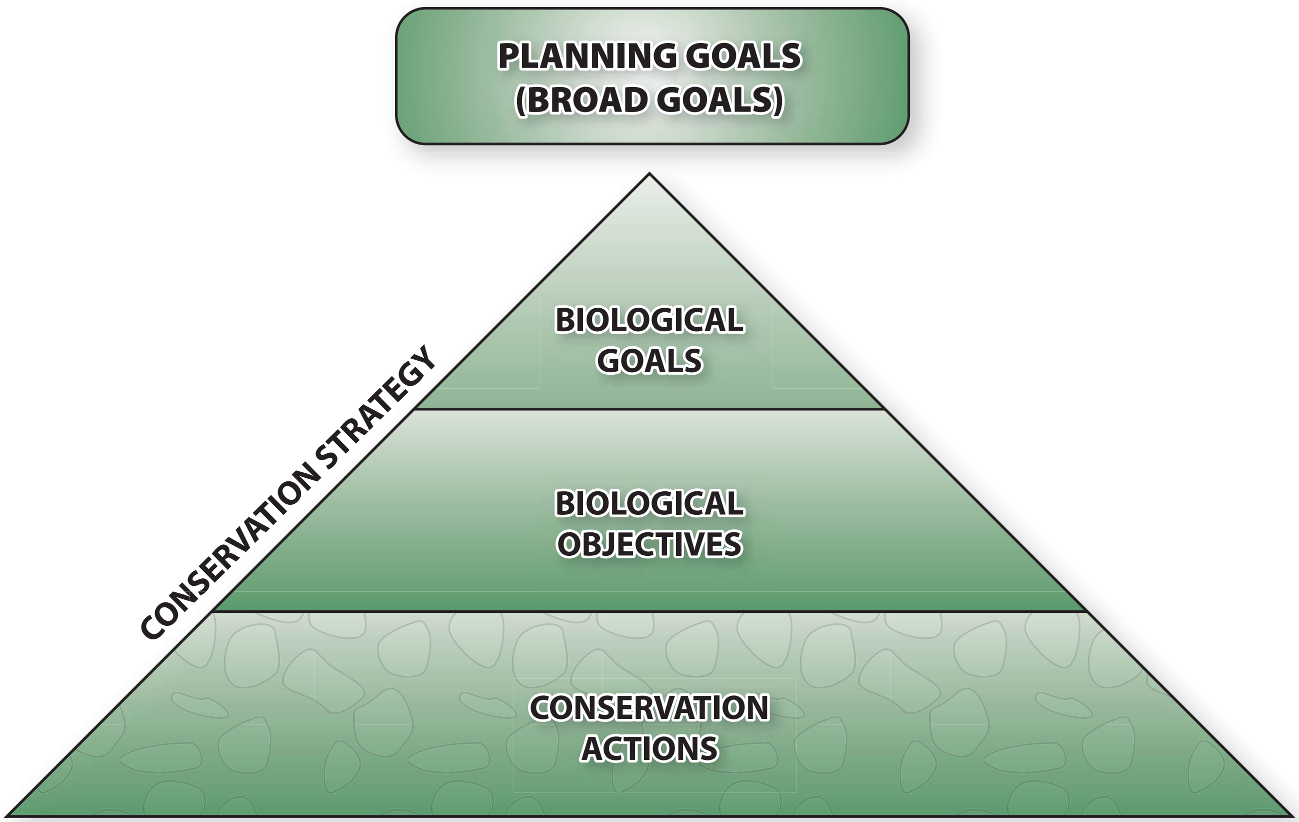

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Figure 5-2
Structure of the Biological Goals and Objectives

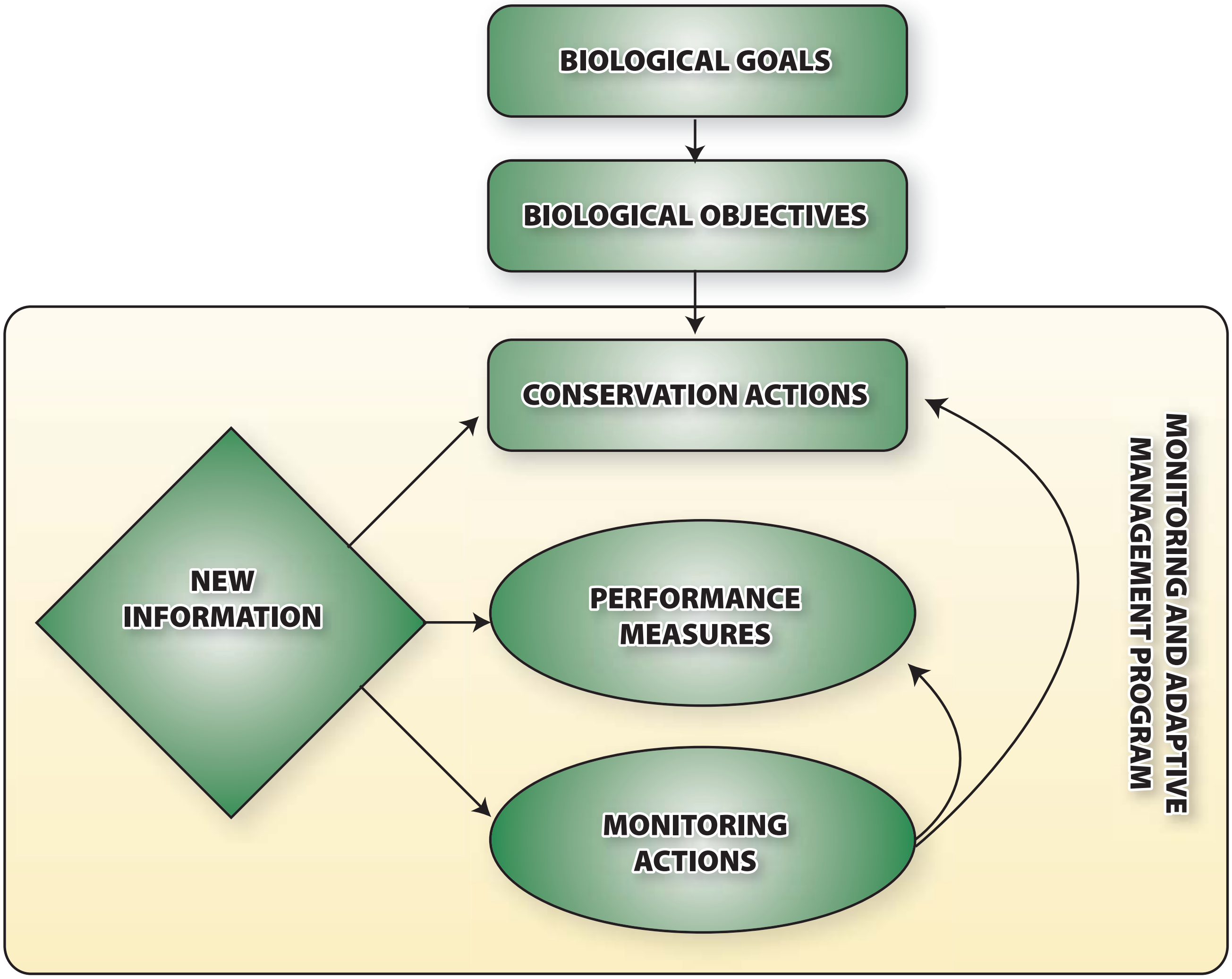

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Figure 5-3
Relationship of Biological Goals and Objectives to Adaptive Management and Monitoring

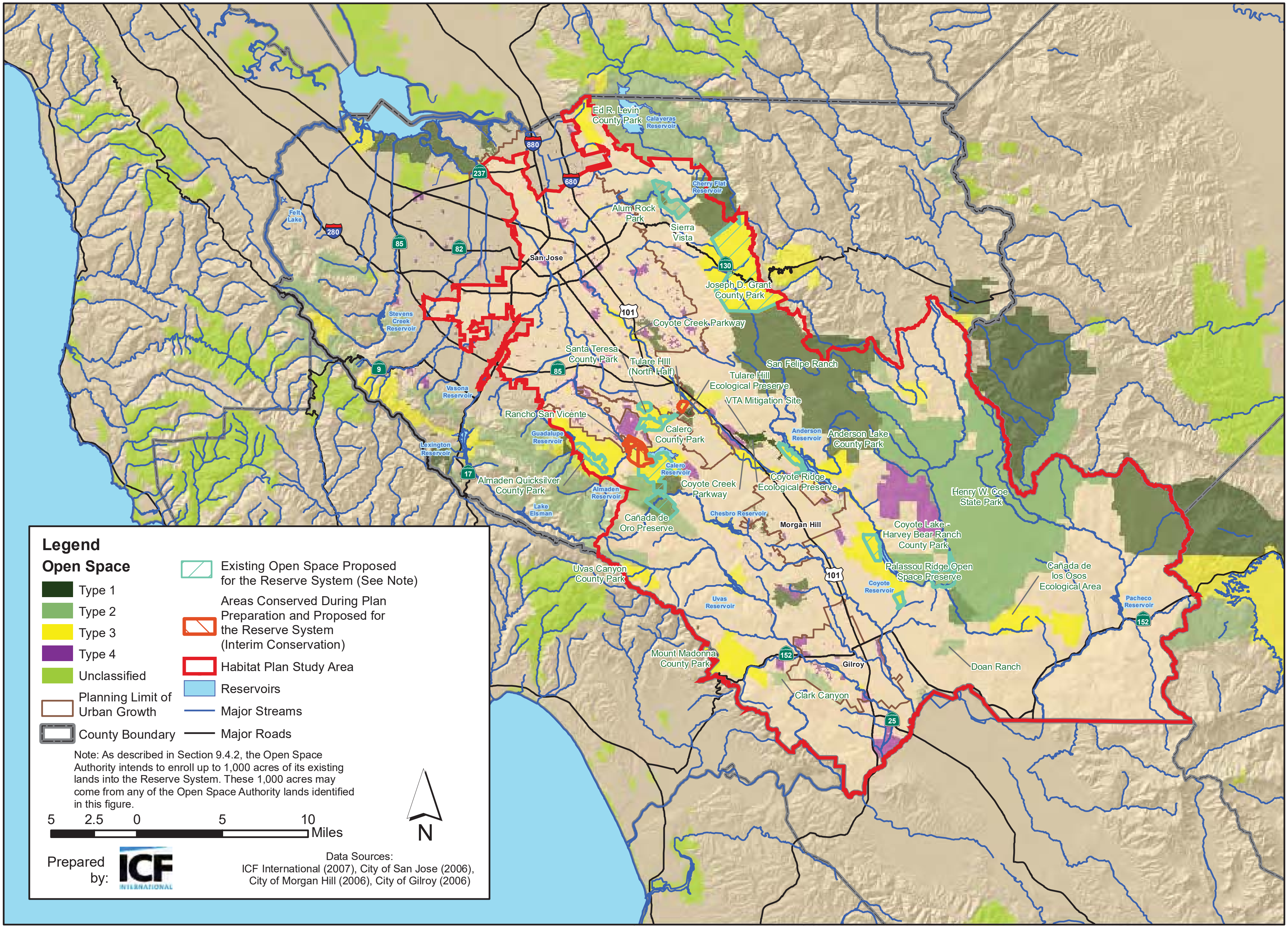

Figure 5-4
Existing Open Space and Interim Conservation Proposed for the Reserve System

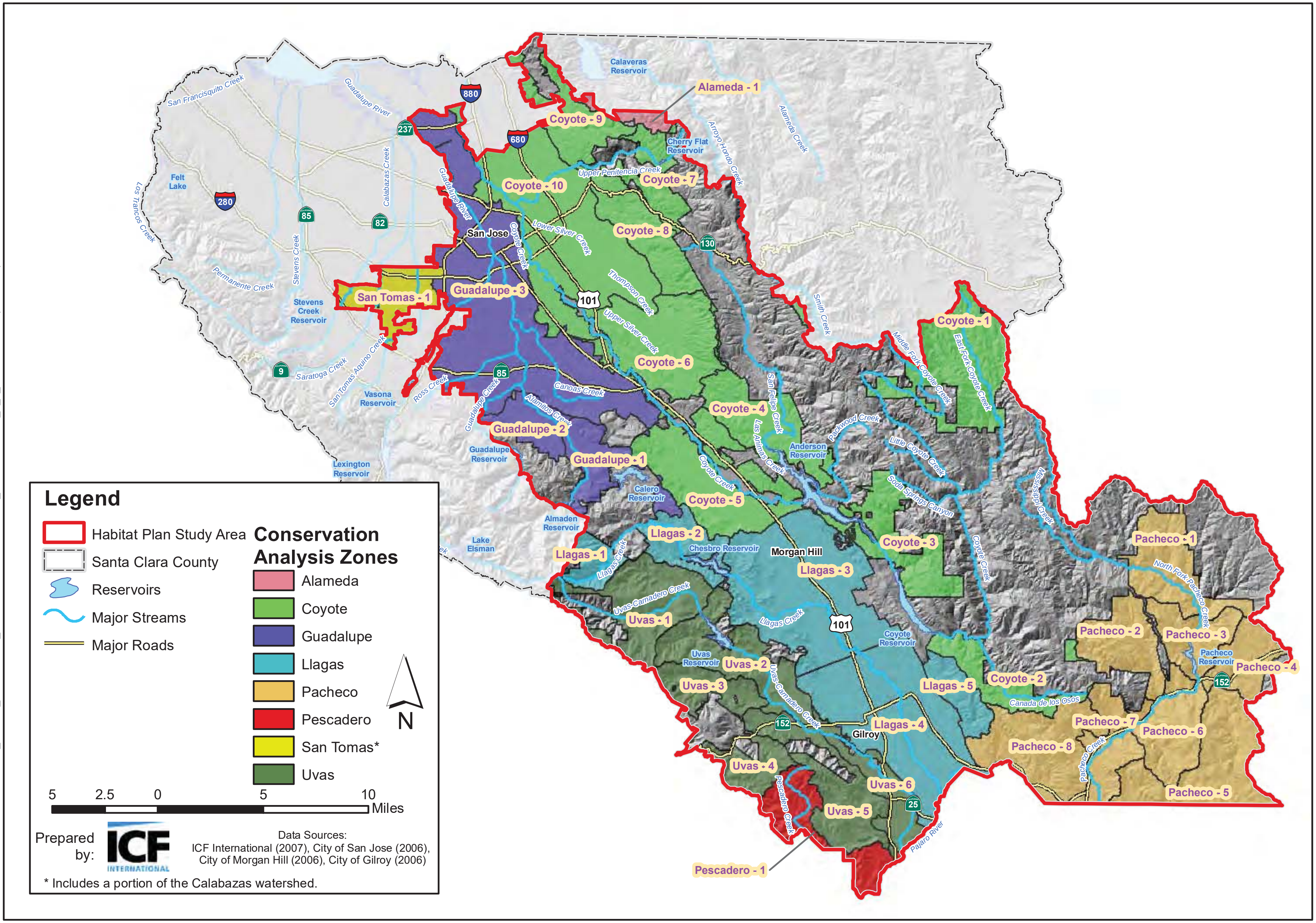

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Figure 5-5
Conservation Analysis Zones

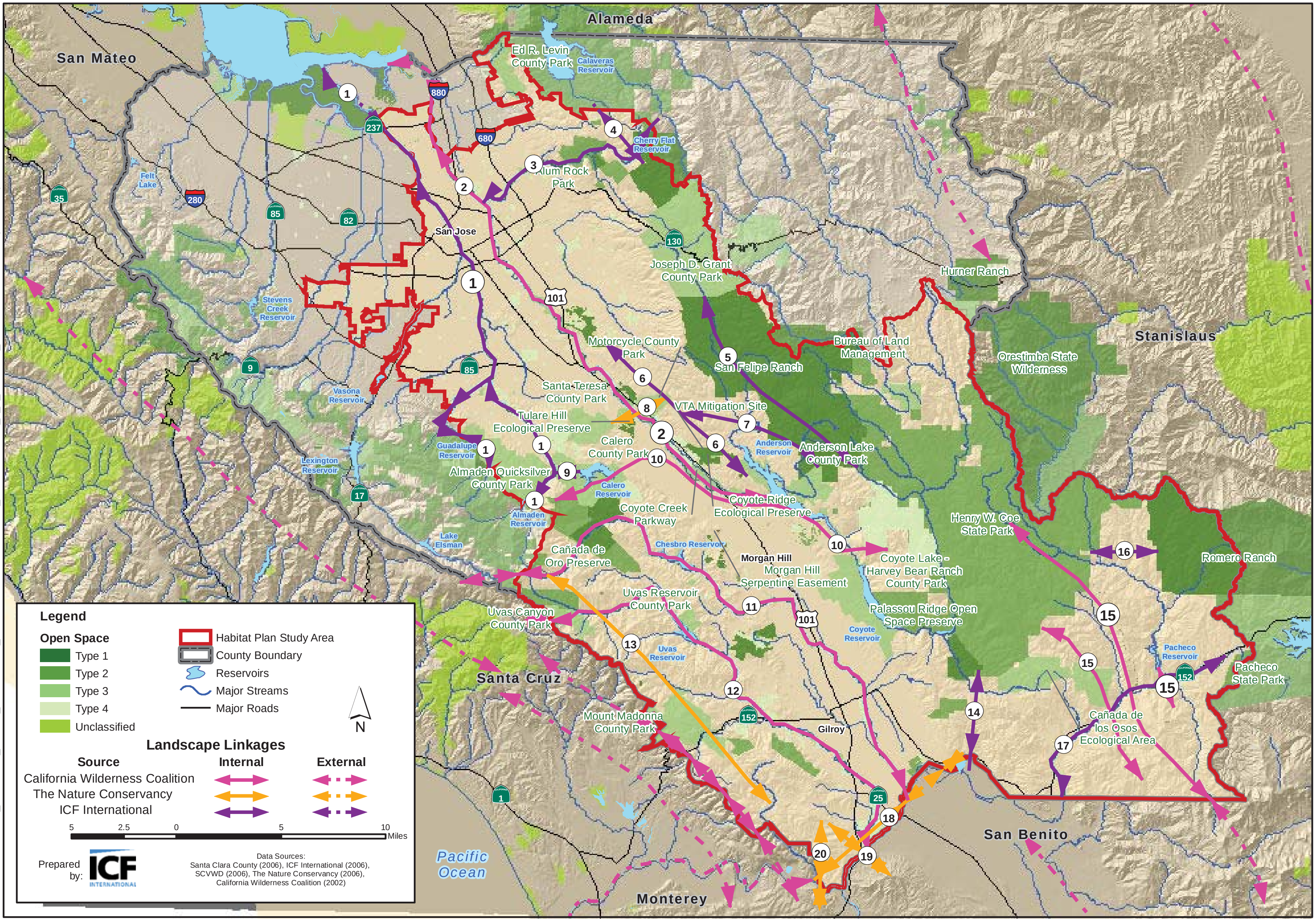

Figure 5-6
Potential Landscape Linkages in and Near the Study Area

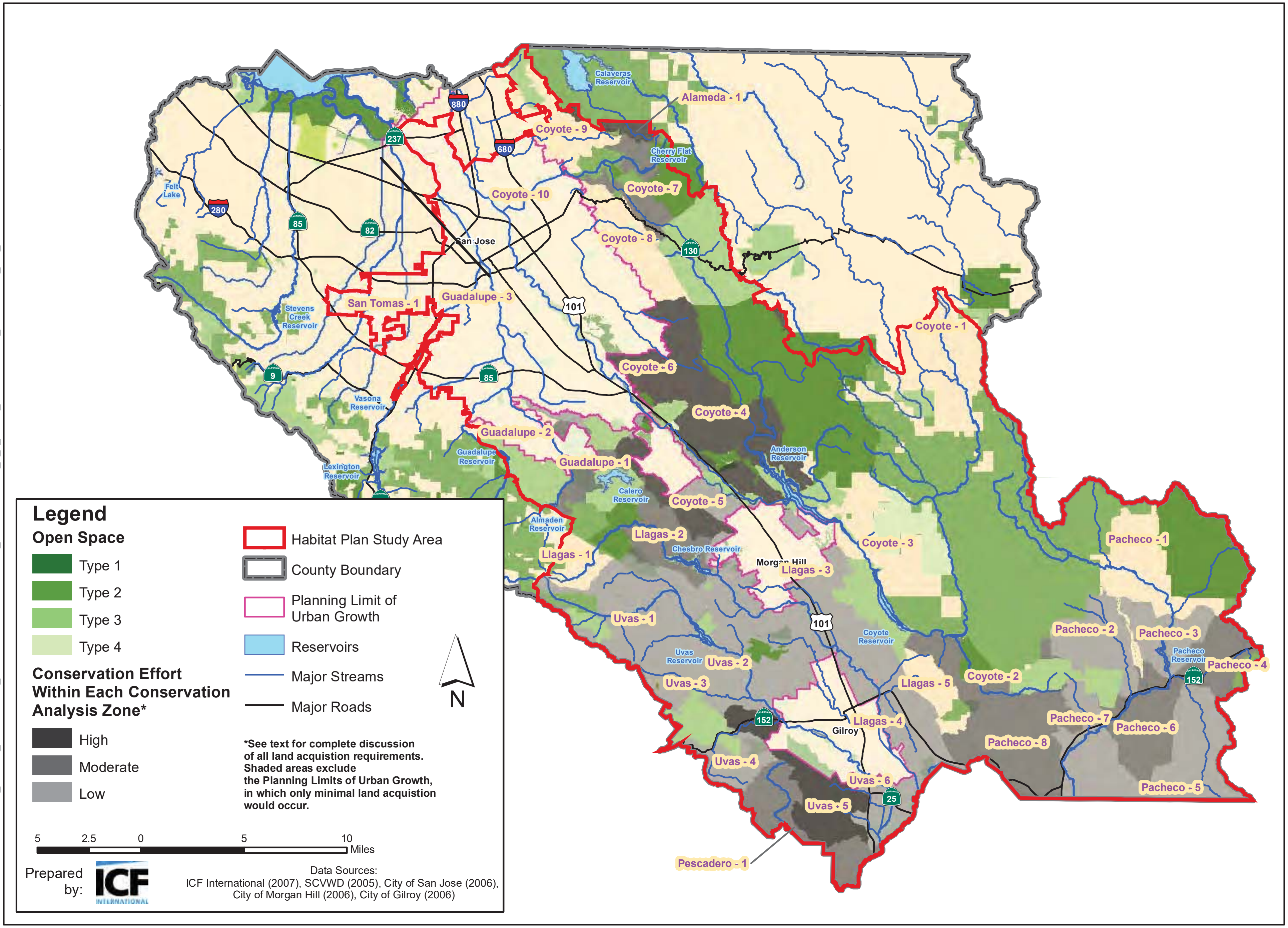

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Figure 5-7
Land Acquisition Strategy

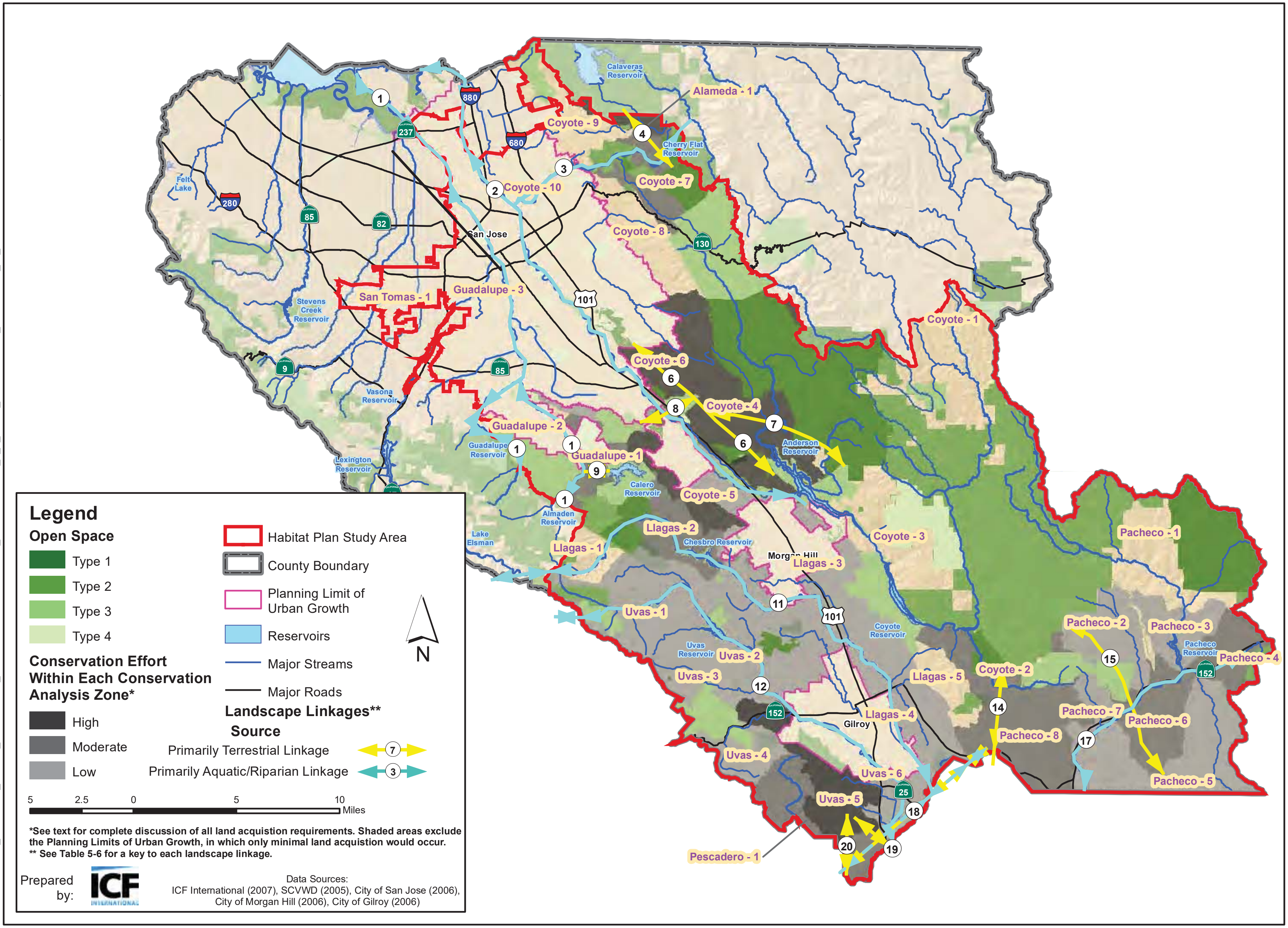

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Figure 5-8
Land Acquisition Strategy with Applicable Landscape Linkages