EXHIBIT D

FOURTH DRAFT

IMPACT ANALYSIS OF PLANNED FUTURE DEVELOPMENT ON GABBRO RARE PLANT SUITABLE AND OCCUPIED HABITAT IN EL DORADO COUNTY

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LIST OF ACRONYMS AND ABBREVIATIONS

°C	degrees Celsius
°F	degrees Fahrenheit
A	Agricultural
ac	acres
AE	Agricultural Exclusive
AL	Agricultural Lands
APN	Assessor's Parcel Number
C	Commercial
CEQA	California Environmental Quality Act
CESA	California Endangered Species Act
CDFW	California Department of Fish and Wildlife
cm	centimeters
CNDDB	California Natural Diversity Database
CNPS	California Native Plant Society
DFG	California Department of Fish and Game (now California Department of Fish and Wildlife)
DU	dwelling unit
EDCGP	*El Dorado County General Plan*
ESA	Endangered Species Act
FE	Endangered under the federal Endangered Species Act
FP	footprint
FT	Threatened under the federal Endangered Species Act
GR	growth ratio
GIS	geographic information system
HDR	High Density Residential
HP	habitat proportion
I	Industrial
KHA	Kimley-Horn and Associates
LDR	Low Density Residential
m^2	square meters
MDR	Medium Density Residential
MFR	Multi-family Residential
MR	Mineral Resources
NC	not calculated
NPPA	Native Plant Protection Act
NR	Natural Resource
NRCS	Natural Resources Conservation Service
OS	Open Space
PA	Planned Agricultural
PF	Public Facility
RA	Residential Agricultural
RD	Research and Development
RE	Residential Estate
RR	Rural Residential

SA	Select Agricultural
SE	Endangered under the California Endangered Species Act
SR	Rare under the Native Plant Protection Act
TAZ	traffic analysis zone
TPZ	Timber Preserve
TR	Tourist Recreation
USDA	U.S. Department of Agriculture
USFWS	U.S. Fish and Wildlife Service

CHAPTER 1. INTRODUCTION

This document provides a first draft of an impact analysis of planned future development in El Dorado County on rare plant species (also referred to as "gabbro" rare plants). This draft impact analysis is the initial step in the development of a mitigation plan in support of an application for a permit under Section 2081 of the California Endangered Species Act (CESA) and an analysis for compliance with the California Environmental Quality Act (CEQA) and Native Plant Protection Act (NPPA).[1]

The following species of rare plants are addressed in this analysis (federal and state listing status):[2]

- Stebbins' morning-glory (*Calystegia stebbinsii*) (FE/SE)
- El Dorado bedstraw (*Galium californicum* ssp. *sierrae*) (FE/SR)
- Pine Hill ceanothus (*Ceanothus roderickii*) (FE/SR)
- Pine Hill flannelbush (*Fremontodendron californicum* ssp. *decumbens*) (FE/SR)
- Layne's butterweed (*Senecio layneae*) (FT/SR)
- Red Hills soaproot (*Chlorogalum grandiflorum*) (not listed)
- El Dorado mule-ears (*Wyethia reticulata*) (not listed)
- Bisbee Peak rush-rose (*Helianthemum suffrutescens*) (not listed)[3]

The development of the impact analysis included the gathering of existing, available information on the ecological requirements, status, and distribution of the rare plants and the gathering of existing geographic information system (GIS) data on vegetation, soils, rare plants distributions, and planned future development in El Dorado County. Ecological conditions that support habitat for these plants and ecological profiles of each species were developed from this existing information to provide the ecological context for the assessment of impacts on each species by planned future development (see Appendix A.2, *Biological Background Information*). The impact analysis relied heavily on the GIS data and the intersection of the planned future development footprints with modeled suitable habitat and known occupied habitat of the plant species.

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1 The authority of the U.S. Fish and Wildlife Service to regulate federally listed plant species on private property is limited. As such, El Dorado County does not intend to seek take authorizations under the ESA from the USFWS.

2 Listing status: FE = endangered under ESA; FT = Threatened under ESA; SE = Endangered under CESA; SR = Rare under NPPA.

3 Note that Bisbee Peak rush-rose (*Helianthemum suffrutescens*) has been recently taxonomically reclassified as peak rush-rose (*Helianthemum scoparium*) (Jepson Flora Project 2012).

The Plan Area for which these impacts were assessed was determined by the combined extent of potential suitable habitat for all eight rare plants as shown in Figure 1-1. The land use designations in the Plan Area under the 2009 amendments to the County's general plan (*El Dorado County General Plan* [*EDCGP*] 2009a, 2009b) are shown in Figure 1-2 and the vegetation cover (Klein et al. 2007) within the Plan Area is shown in Figure 1-3.

The impact analysis is presented in Chapter 2, *Impact Analysis*, and the supporting ecological information on each of the eight species is provided in Appendix A, *Biological Background Information*. Cited references are provided in Chapter 3, *References*.

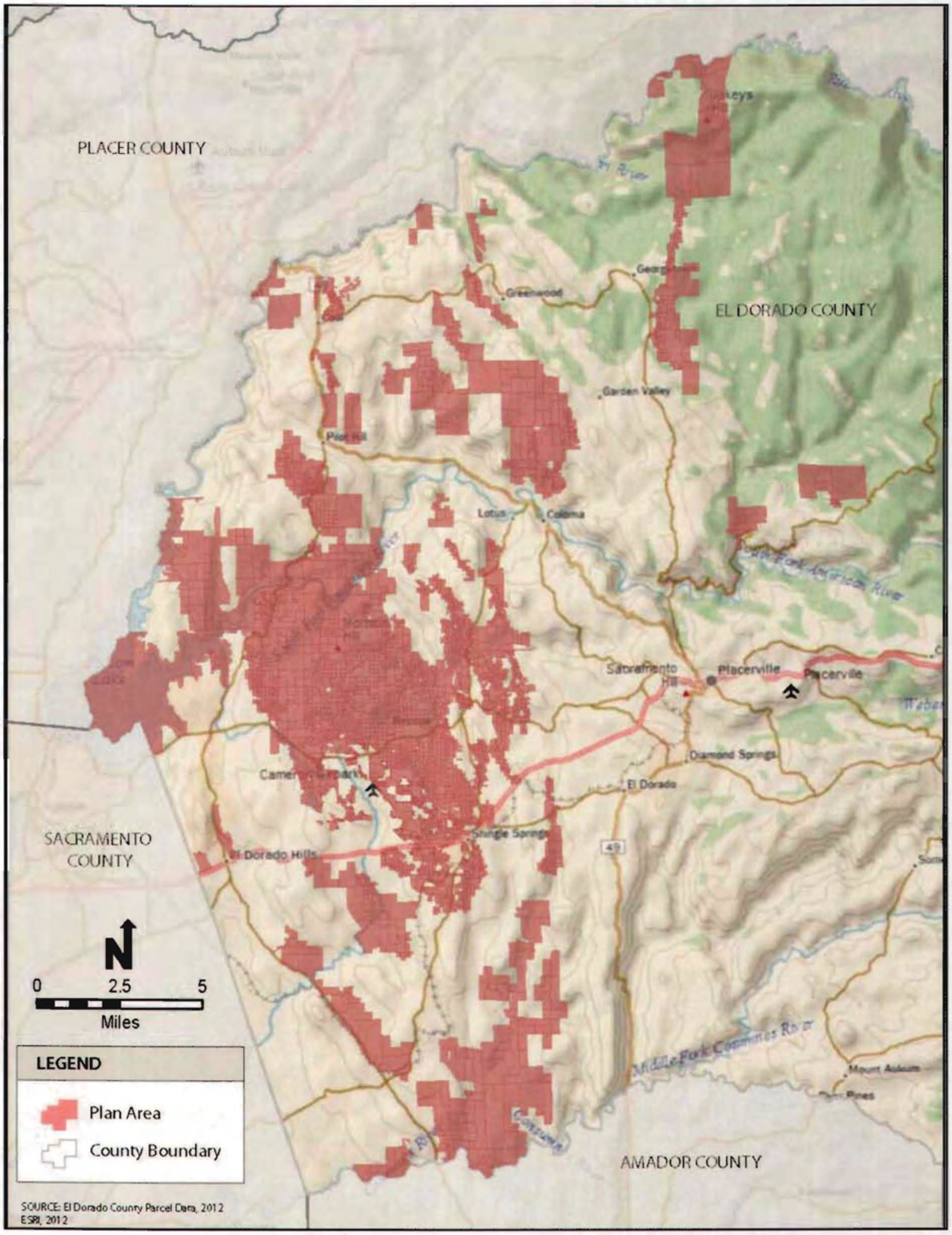

Figure 1-1. El Dorado County Rare Plant Plan Area

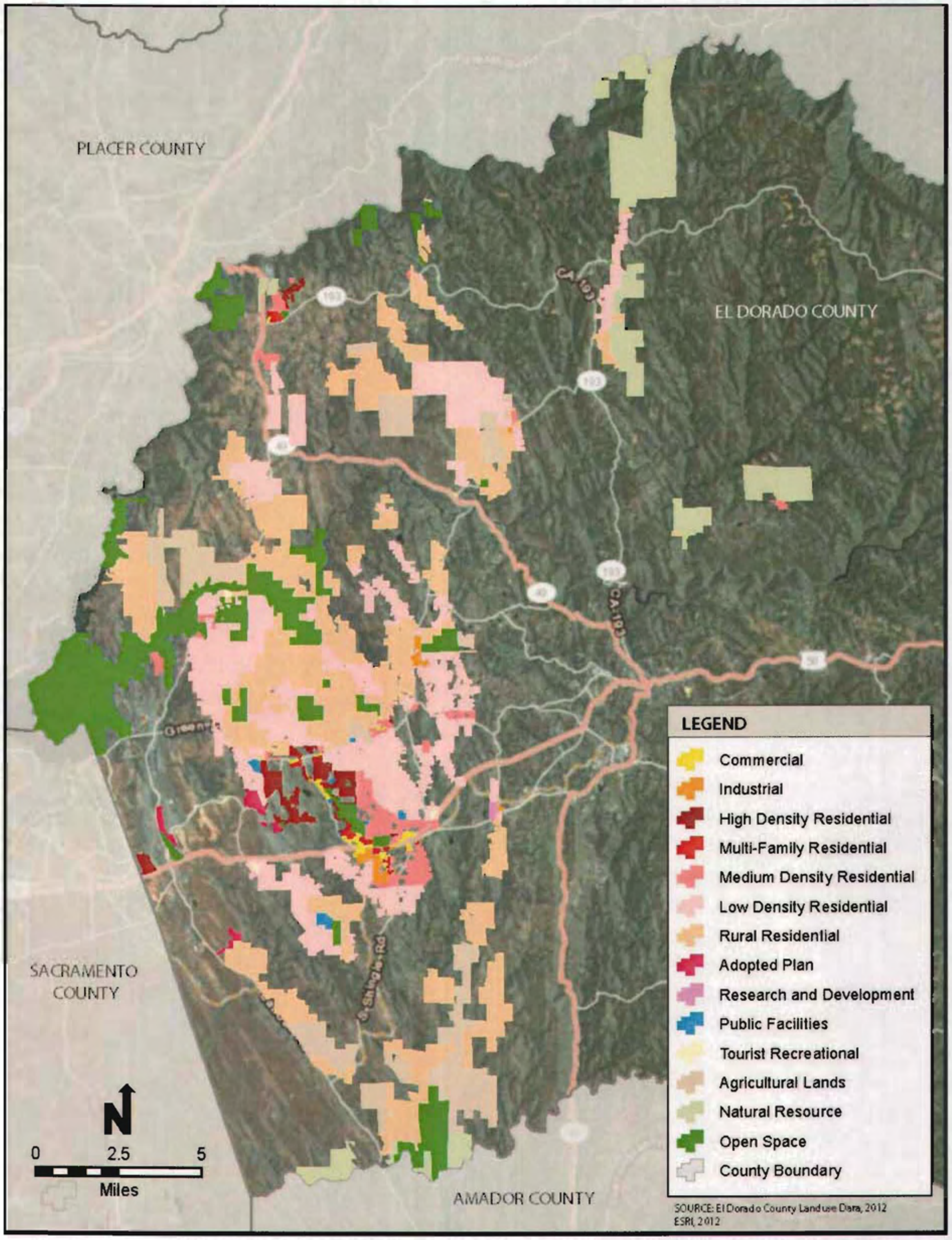

Figure 1-2. County Land Use Designations in the Plan Area (County General Plan)

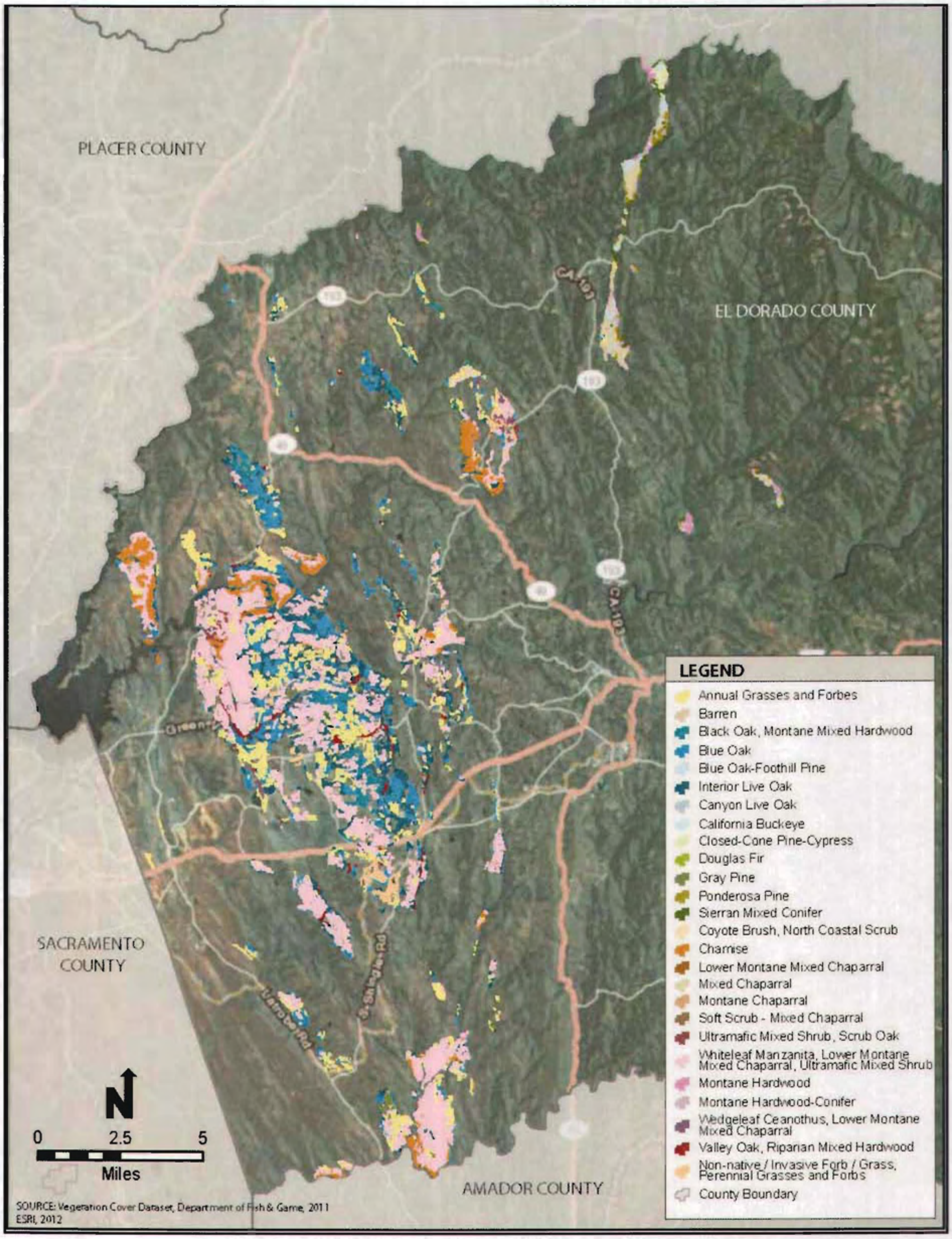

Figure 1-3. Vegetation Cover in the Plan Area

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CHAPTER 2. IMPACT ANALYSIS

2.1 CHARACTERIZATION OF HABITAT

2.1.1 Characterization of Suitable Habitat

Leidos developed a habitat model using GIS data to create a map of the estimated distribution of potential suitable habitat for the rare plant species. The components of the habitat model were chosen based on the results of research by Gogol-Prokurat (2009, 2011) who found that soil type (within gabbro and serpentine categories) is the best regional predictor for the occurrence of the eight rare plant species at a particular site and that vegetation community composition was the strongest predictor of the abundance of each species where it occurs.

GIS polygons of soils in the Argonaut, Rescue, and Serpentine Rockland series[4] (USDA NRCS 2012) in El Dorado County were used to develop the model of composite suitable habitat for all of the rare plant species (Figure 2-1). Using vegetation data developed by the California Department of Fish and Wildlife (CDFW) and the California Native Plant Society (CNPS), the habitat model was refined by removing vegetation associations that are typical of wetland and riparian areas that do not support the rare plants and by removing agriculture and developed areas that are not suitable rare plant habitat (Klein et. al 2007). The results of the rare plant suitable habitat model are depicted in Figure 2-2. The California Natural Diversity Database (CNDDB) (California Department of Fish and Game [DFG] 2012) records of occurrences were mapped for all eight rare plant species and overlaid on a model of composite suitable habitat for all of the species (figures with occurrences and suitable habitat are provided for each plant species in Appendix A, *Biological Background Information*). Occurrence data for the rare plant species indicate a good fit with the soils- and vegetation-based composite suitable habitat model.

Research by Wilson et al. (2009) suggests that the distribution of one of the plant species, El Dorado bedstraw, is generally found within the interior live oak (*Quercus wislizeni*) and black oak (*Quercus kelloggii*) vegetation association. CNDDB data, however, indicate occurrences of El Dorado bedstraw in other vegetation associations. Although mostly found in live oak and black oak woodlands, the suitable habitat model was not limited to this vegetation type and is therefore expected to substantially overestimate El Dorado bedstraw suitable habitat. Pine Hill flannelbush is only known from Pine Hill; but there were no additional vegetation or physical parameters to refine the model for this species, except its known locations, so the model substantially overestimates the extent of Pine Hill flannelbush suitable habitat. Because some of the rare plant species are found on both gabbro soils and serpentine soils (e.g., Red Hills soaproot and Layne's butterweed) or have the potential to occur on both soils, and because there are no additional parameters to further refine the modeled habitat for these species (e.g.,

[4] These soil series contain the gabbro and serpentine soil types that support the rare plant species.

vegetation associations), it was assumed that this modeled habitat reflects the combined extent of all potential suitable habitat for all eight rare plant species for purposes of the impact assessment. For more detail on soils and plant ecological requirements see Appendix A, *Biological Background Information.* Information provided in Appendix A on the distribution of each species' occurrences and habitat describes the baseline conditions for the rare plant species.

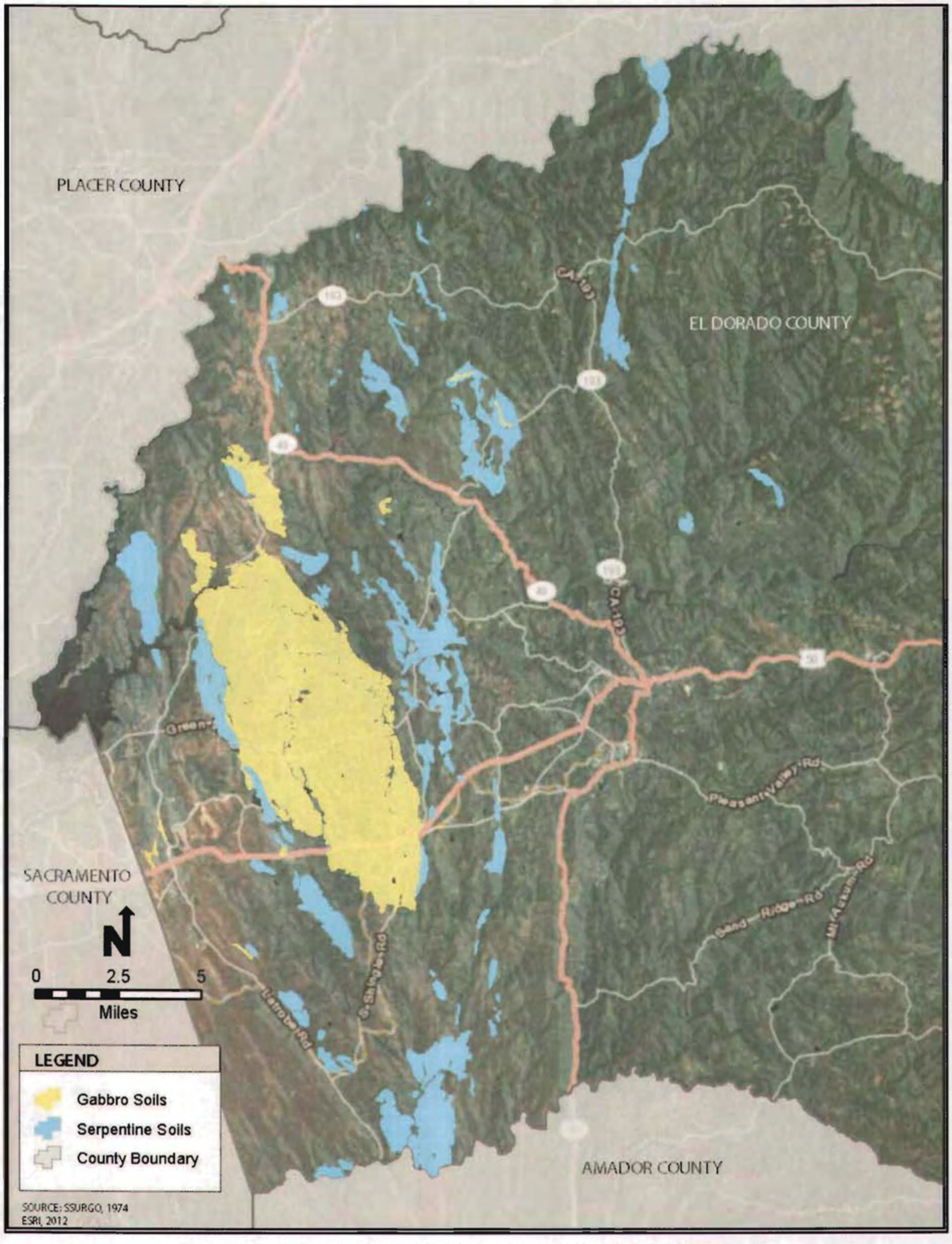

Figure 2-1. Gabbro and Serpentine Soils in the Plan Area

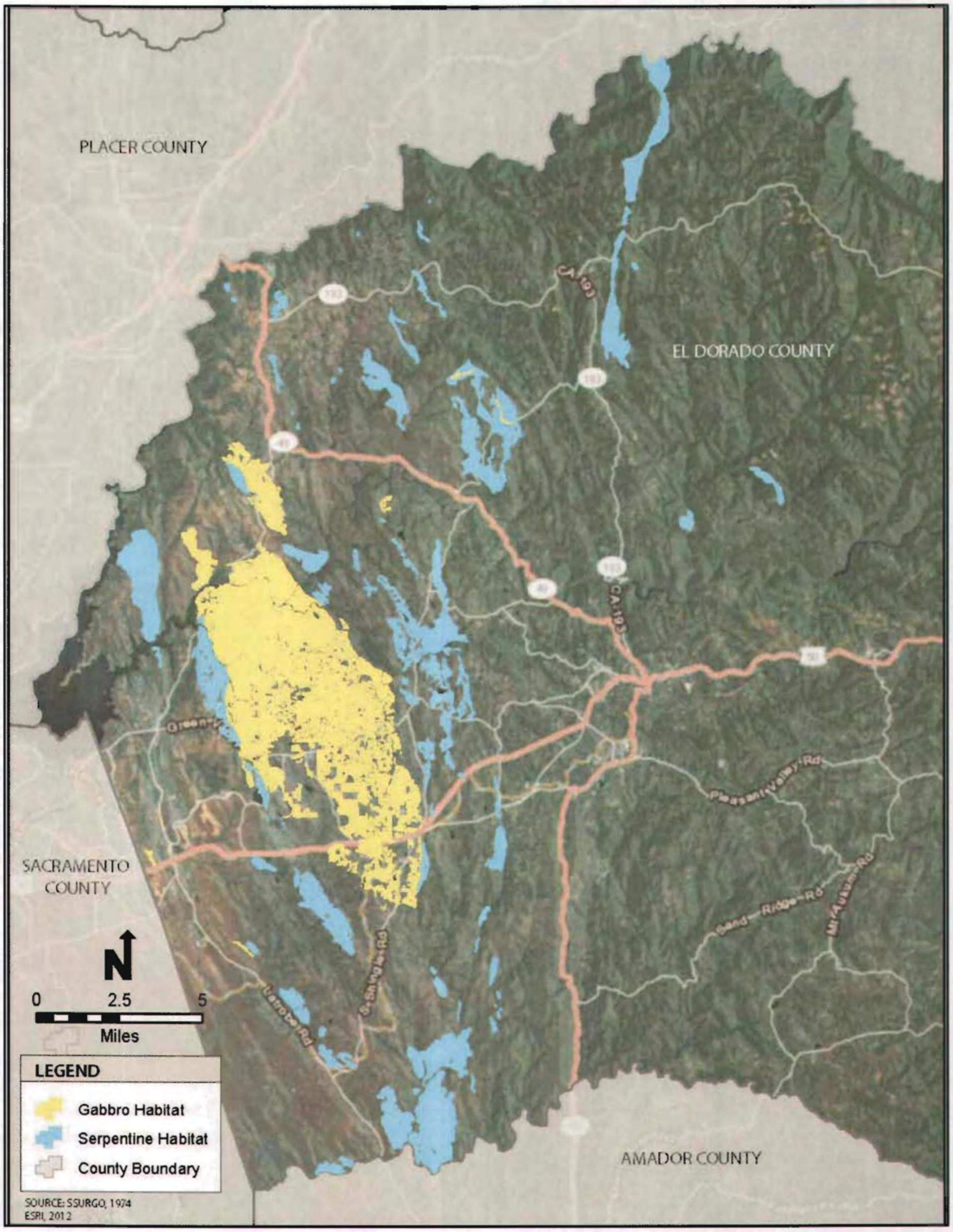

Figure 2-2. Modeled Rare Plant Suitable Habitat in the Plan Area

2.1.2 Characterization of Occupied Habitat

CNDDB GIS rare plant occurrence data (DFG 2012) were combined with other GIS rare plant occurrence data from various field surveys provided by the County to Leidos and overlaid on modeled suitable habitat to develop occupied habitat distributions for each of the eight species (see figures for individual species in Appendix A, *Biological Background Information*). The plant occurrence data is in polygon format, but some polygons are directly mapped boundaries by field biologists and others are circles based on accuracy estimates around a point (e.g., "within ¼-mile radius"). The area of overlap between an occurrence polygon and modeled suitable habitat is considered occupied habitat.

2.2 METHODS FOR ASSESSING IMPACTS ON HABITAT

2.2.1 Approach to Impacts on Modeled Suitable Habitat

The methods used to calculate the impacts of planned future development on modeled suitable habitat were adapted from that used by Economic & Planning Systems, Inc. (2002) to calculate the development build-out of the 1996 General Plan alternative that was adopted in the 2004 General Plan by the Board of Supervisors (Resolution No. 235-2004). A development growth ratio (GR) was generated and applied to the General Plan development build-out scenario to reflect 2035 household estimates. The GR was provided by the El Dorado County Development Services Department. Current land use designations, zoning districts, and maximum dwelling unit (DU) densities were obtained from the *EDCGP* (2009a, 2009b).

All parcels that intersected modeled suitable habitat were selected and parcels that are currently protected as part of the Pine Hill Preserve or under conservation easements were removed from the analysis. The parcels were then classified using the El Dorado Parcel GIS dataset as either undeveloped (vacant or unassigned) or developed for purposes of calculating maximum impacts at full build-out. The methods used in the impact analysis to estimate the potential loss of habitat on parcels of various land use designations and zoning are depicted in Figure 2-3.

ACRONYMS

ac	acre	I	Industrial	PF	Public Facility
AL	Agricultural Lands	LDR	Low Density Residential	RD	Research and Development
APN	Assessor's Parcel Number	MDR	Medium Density Residential	RR	Rural Residential
C	Commercial	MFR	Multi-family Residential	TPZ	Timber Preserve
DU	Dwelling Unit	NR	Natural Resource	TR	Tourist Recreation
HDR	High Density Residential	OS	Open Space		

Figure 2-3. Methods Flow Diagram

For undeveloped parcels, no impacts on habitat were assumed for parcels with land use classifications of Open Space (OS) and Timber Preserve (TPZ); parcels in public (e.g., U.S. Forest Service, Bureau of Land Management, State of California, and El Dorado County) or regulated utility (e.g., Pacific Gas & Electric) ownership; and parcels with existing roads because minimal future development is anticipated on these parcels.

Undeveloped parcels with land use designations of Commercial (C), Industrial (I), Public Facility (PF), Tourist Recreation (TR), Research and Development (RD), Multi-family Residential (MFR), High Density Residential (HDR), and Medium Density Residential (MDR) were assumed to result in 100 percent removal of habitat because these types of development typically cover the entire or nearly the entire parcel surface with buildings, pavement, and landscaping, or are susceptible to other types of disturbances. The development GR was not applied to these parcels as these land use designations were assumed to cover the full parcel.

Impacts for undeveloped parcels with land use designations of Low Density Residential (LDR), Rural Residential (RR), Agricultural Lands (AL), and Natural Resource (NR), were assessed for habitat within parcels using a combination of these land use designations with the appropriate zoning districts (see Table 2-1). Larger parcels are often bisected by land use designations and zoning districts that do not necessarily follow parcel boundaries, thus creating smaller areas within the legal parcel boundaries, which were defined as "hypothetical sub-parcels" ("sub-parcels"). The sub-parcels are the unit of analysis for this impact analysis and, because the actual locations of plots and development footprints within the sub-parcels is unknown until development occurs at some time in the future, the potential impacts are non-spatial at the scale of the sub-parcel. For sub-parcels, both the development footprints and modeled suitable habitat extents were converted into non–spatially explicit extents using a weighting formula. Future development impacts to undeveloped sub-parcels were calculated as follows (X = acreage specified in Table 2-1):

1. If the sub-parcel is less than X acres (ac), it is assumed to have a maximum of 1 DU, while if it is greater than or equal to 2 times X acres it can have more than 1 DU as well as the fractional part of a DU (e.g., 7.76 DUs).
2. The acreage of habitat on the sub-parcel is divided by the acreage of the sub-parcel to distribute the amount of habitat proportion (HP) across the entire sub-parcel.
3. A structure, infrastructure, and landscaping footprint (FP) of 1.5 acres[5] per DU is assumed.
4. The impact on modeled suitable habitat on a particular sub-parcel is then calculated as the product of DUs, habitat proportion, and footprint (DU x HP x FP = habitat impact).

[5] Footprint acreage of 1.5 acres per DU is a conservative value (i.e., a high estimate of footprint impact) to estimate impacts. This 1.5 acres/DU was recommended by the El Dorado County Development Services Department. Included in the 1.5 acres are the footprints of the house, landscaping, outbuildings, driveway, walkways, patios, pools, devegetated animal corrals, etc.

Table 2-1. Maximum Dwelling Unit Density per Acre by Land Use Designation and Zoning District

General Plan Land Use Designation and Zoning District Maximum Density (1 dwelling unit per X acres)[2]				
Zoning Districts[1]	Land Use Designations			
	Low Density Residential	*Rural Residential*	*Agricultural Lands*	*Natural Resource*
RE-5	5	-	-	-
RE-10	10	10	-	-
RA-20	20	20	20	-
RA-40	-	-	40	40
RA-60	-	-	60	60
RA-80	-	-	80	80
RA-160	-	-	160	160
A	10	-	10	-
SA-10	10	-	10	-
PA	20	20	20	-
AE	20	20	20	20
MR	-	40	40	-

[1] Residential Estate (RE), Residential Agricultural (RA), Agricultural (A), Select Agricultural (SA), Planned Agricultural (PA), Agricultural Exclusive (AE), Mineral Resources (MR).
[2] Values in the table are minimum acreage per DU and equal X for purposes of the impact calculation formulas.

Developed parcels with land use designations of LDR and RR that were within Residential Estate (RE) zoning districts RE-5 and RE-10 and Residential Agricultural (RA) district RA-20 were identified as parcels with infill development potential in order to calculate impacts for fully developed parcels to the maximum number of allowable dwelling units per acre (DU/ac). For developed sub-parcels, infill development potential impacts on habitat for sub-parcels with land use designations of LDR and RR that are within zoning districts RE-5, RE-10 and RA-20 were calculated as described above for undeveloped sub-parcels; then the amount of impact on habitat equivalent to 1 DU was subtracted from the total impact to calculate the adjusted impact for the potential infill development.

Developed parcels with all other land use designations (not LDR or RR) were assumed built to the full zoning allowable, therefore no additional impacts on habitat remaining in these parcels was assumed.

The 2035 GR was generated to reflect realistic growth estimates for 2035 relative to full build-out under the General Plan. The El Dorado County Development Services Department provided county-wide DU growth estimates for 2035, which were spatially related to traffic analysis zone studies conducted by the County traffic engineering contractor, Kimley-Horn and Associates (KHA). The GR represents the proportion of full General Plan build-out that would result by 2035 based the analysis conducted by KHA. In addition to the 2035 growth projections, theoretical full build-out household projections were provided by the County Development

Services Department that were related to the *EDCGP* Land Use Plan. A spatially explicit 2035 GR was derived between the 2035 growth projections and full build-out projections by assigning each of the County's comprehensive land use designations a DU build-out ratio value (Table 2-2).

The theoretical build-out ratios were assigned to the County's land use GIS layer and multiplied by the layer's associated acreage values to calculate a theoretical number of DUs reflective of the plan's build-out capacity. All calculated theoretical DU estimates were then assigned to a traffic analysis zone (TAZ) region and summed to generate a total number of dwellings per TAZ. The GR was finally derived by dividing the 2035 DU estimate by the theoretical DU build-out value. The GR value was then applied to DU estimates included within the impact calculations described in Section 2.2.3, *GIS Methodology*.

Table 2-2. County General Plan Theoretical Build-Out Ratios

Land Use Code	Theoretical Build-Out Ratio (1 dwelling unit/X acres)
Low Density Residential	0.200
Agricultural Lands	0.050
Open Space	NC
Rural Residential	0.100
Natural Resource	0.025
Public Facility	NC
Adopted Plan	NC
Tourist Recreation	NC
Research and Development	NC

NC – not calculated

2.2.2 Approach to Impacts on Occupied Habitat

Impacts on occupied habitat were calculated using the same methods as those described above for modeled suitable habitat. Where impacts are identified on occupied habitat, it was assumed that the plant occurrences in that habitat were adversely affected.

2.2.3 GIS Methodology

The approach described in Section 2.2.1, *Approach to Impacts on Modeled Suitable Habitat* was implemented using GIS. To assess impacts on rare plants, a geospatial analysis was conducted using the following four steps:

1. Development of rare plant suitable habitat model,
2. Development of parcel impact extents,

3. Calculation of potential impacts on rare plant suitable habitat, and
4. Calculation of impacts on rare plant species occupied habitat.

2.2.3.1 Development of Rare Plant Suitable Habitat Model

The rare plant suitable habitat GIS layer was developed in two stages. First, the El Dorado County SSURGO soils GIS dataset (U.S. Department of Agriculture [USDA] Natural Resources Conservation Service [NRCS] 1974) was used to extract all soils classified in the map units listed in Table 2-3.

Table 2-3. Soils Units that Represent Gabbro and Serpentine Soils

Map Unit Name
Argonaut Clay Loam, 3 to 9 Percent Slopes[1]
Rescue Clay, Clayey Variant
Rescue Extremely Stony Sandy Loam, 3 to 50 Percent Slopes, Eroded
Rescue Sandy Loam, 15 to 30 Percent Slopes
Rescue Sandy Loam, 2 to 9 Percent Slopes
Rescue Sandy Loam, 9 to 15 Percent Slopes
Rescue Very Stony Sandy Loam, 15 to 30 Percent Slopes
Rescue Very Stony Sandy Loam, 3 to 15 Percent Slopes
Rescue Very Stony Sandy Loam, 30 to 50 Percent Slopes
Serpentine Rock Land

[1] This soil unit is not reported as being derived from gabbro or serpentine soil, but in the Plan Area it occurs in small drainages immediately downslope from gabbro soils and El Dorado bedstraw occurrences are reported on this particular soil unit.

Second, a combination of soil map units and vegetation cover was analyzed to further refine the gabbro/serpentine soil units that would be potential suitable habitat. The soils in Table 2-3 were intersected with CDFW's California Northern Sierra Nevada Foothills Vegetation Project vegetation land cover GIS dataset (DFG 2011). There was no CDFW vegetation coverage in the Georgetown and Volcano areas, so to address these areas the California Vegetation datasets were used that included vegetation tile 20-05 and vegetation tile 20-00 (USDA Forest Service 2009a, 2009b). Land cover types that do not function as suitable habitat because they are typical of wetland and riparian areas; in agricultural use or developed areas; or streams, lakes, or ponds were excluded from the model (Table 2-4).

Table 2-4. Vegetation Types Excluded from Gabbro/Serpentine Rare Plant Habitat

Vegetation Unit Name
Agriculture, excluding fallow and irrigated pasture
Alnus rhombifolia
Arid west freshwater emergent marsh
Built-up and urban disturbance

Table 2-4. Vegetation Types Excluded from Gabbro/Serpentine Rare Plant Habitat, Cont'd

Vegetation Unit Name
California warm temperate marsh/seep group
Irrigated pasture lands
Juglans hindsii
Perennial stream channel
Populus fremontii
Reservoirs
River and lacustrine flats and streambeds
Salix exigua
Salix laevigata
Salix lasiolepis
Small earthen dam ponds and natural lakes
Undefined areas with little or no vegetation
Urban window
Vernal pools and California annual and perennial grassland matrix

Source: USDA Forest Service 2012

2.2.3.2 Development of Parcel Impact Extents

Planned future development impacts on rare plant suitable habitat were estimated by selecting parcels from the El Dorado County Parcel GIS dataset that spatially overlapped the rare plant suitable habitat GIS layer. The selected parcels were then intersected with the El Dorado County Land Use and Zoning GIS datasets to provide additional information on the development potential of each parcel. A particular parcel's development status and future development potential were identified by a combination of parcel vacancy/development, structural improvements, land use classification and zoning classification data. Frequently on larger parcels (typically greater than 10 acres), individual parcels could have multiple land use classifications and zoning district overlays which, from a land use perspective, divided the parcels into smaller components. These smaller components were designated as sub-parcels for purposes of the impact analysis (see explanation in Section 2.2.1, *Approach to Impacts on Modeled Suitable Habitat*). The assumptions used to assess the development status and future potential development are also described in Section 2.2.1.

2.2.3.3 Calculation of Potential Impacts on Rare Plant Suitable Habitat

To estimate the potential maximum acreage of impact on modeled rare plant suitable habitat resulting from planned future development, the selected parcels that overlapped with habitat were assigned the numerical codes that represent the development status and potential for future development (Table 2-5).

Table 2-5. Parcel Development Types and Associated Codes

Development Type	Development Code
Pine Hill Preserve and other conservation lands	-9999
Open Space and parcels in public/utility ownership[1]	-9999
Existing built-out parcels	-99
Existing development with infill potential	1
Future development on land use/zoning types that allow for future subdivision	10
Future development on land use/zoning types that are assumed will be fully built out	100

[1] In the County Parcel GIS database, the parcels identified with Assessor's Parcel Number (APN) Status of 1, 2, 6, and 11 were included as public and utility ownership, including federal, state, and county lands; PG&E land; existing roads in residential developments; and other similar uses.

Sub-parcels that had been assigned a development code of -9999 or -99 were assumed to have no future development impacts. Sub-parcels assigned a development code of 1 were considered to be existing development but still had development infill potential based on zoning regulations and associated parcel acreage. Parcels less than 5 acres with existing development were assumed to be built out. The acreage of habitat within each sub-parcel was distributed based on the following equation:

Impacts (acres) = ((DU-Existing DU)*GR) * FP *(HP/SP)

Where

DU = total number of potential dwelling units on the sub-parcel
Existing DU = Existing dwelling units on the sub-parcel (assumed to be 1)
GR = 2035 growth ratio
FP= Development footprint acreage per DU (assumed to be 1.5 acres)
HP = Proportion of acreage of modeled suitable habitat or occupied habitat
SP= Sub-parcel acreage

The existing DU (Existing DU) was subtracted from the total number of DUs to calculate impacts resulting from infill potential, because impacts from existing DUs have already occurred.

Sub-parcels assigned a development code of 10 were considered to have future development potential based on land use and zoning descriptions. These sub-parcels do not currently have any development. The acreage of habitat that fell within each sub-parcel was distributed based on the following equation:

Impacts (acres) = (DU*GR) * FP * (HP/SP)

Sub-parcels assigned a development code of 100 were considered to have future development potential based on land use and zoning descriptions. These sub-parcels were assumed to be fully built out in future years, thus future development would completely remove all habitat.

2.2.3.4 *Calculation of Potential Impacts on Rare Plant Occupied Habitat*

Impacts on rare plant occupied habitat were assessed in the same manner as modeled rare plant suitable habitat. However, instead of using the suitable habitat acreage (HP) in the equations, the acreage of occupied habitat was substituted. Information to identify occupied habitat was compiled for each of the rare plant species from GIS datasets from CNDDB records, Bureau of Land Management plant surveys, and various data compiled by the U.S. Fish and Wildlife Service (USFWS) and provided to the County (for more detail see Section A.2, *Plant Species Ecological Accounts*).

2.3 RESULTS OF THE IMPACT ANALYSIS

2.3.1 Potential Impacts on Modeled Suitable Habitat

Potential future maximum impacts on modeled suitable habitat by soil type are the same for each of the eight rare plant species because a composite habitat model was used to represent suitable habitat for all of the species (Table 2-6).

Table 2-6. Potential Future Impacts on Rare Plant Suitable Habitat and Amount of Habitat in Protected Status

Type of Suitable Habitat	Total Existing Suitable Habitat (acres)	Habitat Within Existing Protected Lands (acres)	Habitat Not within Protected Lands (acres)	Potential Future Impacts (acres) [1]	Percent Potential Impact on Total Habitat
Gabbro habitat	18,297	4,614	13,683	1,662	9.1
Serpentine habitat	16,017	43	15,974	648	4.0
Total habitat	**34,314**	**4,657**	**29,657**	**2,310**	**6.7**

[1] Assuming an impact footprint of 1.5 acres per DU.

Impacts identified in Table 2-6 for gabbro habitat (1,662 acres) reflect potential future impacts on rare plants that appear to be wholly or mostly restricted to gabbro habitat in El Dorado County. These species are Stebbins' morning-glory, El Dorado bedstraw, Pine Hill ceanothus, Pine Hill flannelbush, El Dorado mule-ears, and Bisbee Peak rush-rose. Impacts identified in Table 2-6 for the total habitat (both gabbro and serpentine habitat) (2,310 acres) reflect potential future impacts on rare plants that are frequently found on both gabbro and serpentine habitat in El Dorado County. These species are Layne's butterweed and Red Hills soaproot.

2.3.2 Potential Impacts to Known Occupied Habitat

Potential impacts on known occupied habitat are provided in Table 2-7.

Table 2-7. Potential Future Impacts on Known Occupied Habitat by Species

Species	Total Known Occupied Habitat (acres)	Potential Future Impacts on Known Occupied Habitat (acres)[1]	Percent Potential Impact on Total Habitat
Stebbins' morning-glory	962	62.8	6.5
El Dorado bedstraw	636	138.0	21.7
Pine Hill ceanothus	1,902	117.4	6.2
Pine Hill flannelbush	248	5.1	2.1
Layne's butterweed	1,530	103.9	6.8
Red Hills soaproot	579	100.2	17.3
El Dorado mule-ears	2,142	133.9	6.3
Bisbee Peak rush-rose	784	109.0	13.9

[1] Assuming an impact footprint of 1.5 acres per DU.

2.4 Discussion of Results

The results of this analysis indicate that future development in El Dorado County as projected in the *EDCGP* (2004 with 2009 amendments) and estimated through 2035 would result in the removal of approximately 2,310 acres of potentially suitable habitat for the eight rare plant species, assuming 1.5 acres of impact per DU (Table 2-6). Impacts on known occupied habitat are over 100 acres each for six of the eight species and 62.8 acres for the state-listed endangered Stebbins' morning-glory (Table 2-7). These impact estimates are likely high as the assumptions used in the analysis likely over estimate the extent of occupied and suitable habitat. In addition the build-out scenario assumes a higher amount of removal of habitat for development of each parcel than is likely to result.

It is not clear if a sufficient portion of the remaining area (currently unprotected habitat not affected by potential future development) within the modeled suitable habitat (Table 2-6) is of suitable quality, patch size, and distribution to be used as part of a mitigation program designed to offset impacts of future development on the rare plants. Much of this remaining 27,347 acres (29,657 existing acres less 2,310 acres of impact) of modeled gabbro and serpentine habitat is on parcels with existing development or on relatively small parcels (less than 10 acres) which may not be available or suitable for use in mitigation. Ledios will develop a mitigation plan to determine the extent of suitable mitigation lands available and the extent of habitat mitigation necessary to address these impacts. More evaluation is necessary before any conclusions can be reached.

CHAPTER 3. REFERENCES

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APPENDIX A
BIOLOGICAL BACKGROUND INFORMATION

APPENDIX A. BIOLOGICAL BACKGROUND INFORMATION

A.1 Geology, Soils, and Fire Disturbance–Driven Plant Communities

A.1.1 Geology and Soils

The plant communities in which the eight rare plant species are found are generally restricted to soils that have developed over specific geological formations. In particular, they are generally found on either gabbro or serpentinite geological formations, although some of the species are also found on soils developed from various types of metamorphic rock. Except for the Pine Hill intrusive complex, gabbro in the Sierra Nevada foothills is rare (Springer 1980, 1989; Alexander et al. 2007). Gabbro has a variable chemical composition and the Pine Hill intrusive complex is a spatially layered heterogeneous mixture (imagine an onion on its side cut in half from leaves to roots) and in some areas has been significantly thermally altered. Unaltered and altered gabbro weather differently and therefore form slightly different soils. Additionally, the Pine Hill intrusive complex lies between two north-to-south trending ribbons of ultramafic serpentinized rock. The serpentinized rock along the west wall of the complex was metamorphosed by the heat of the intrusive complex while the ribbon lying to the east was not (Springer 1980, 1989). Serpentinite geological formations are not extensive in the Sierra Nevada and run sporadically from Tulare County to El Dorado County as a single ribbon, diverging at the southern end of the Pine Hill intrusive complex into two sporadic bands (lower elevation and higher elevation) that continue northward to Plumas and Butte counties. Serpentinite north of those counties is part of the Cascade Range (Alexander et al. 2007).

Soils derived from serpentinite and other similar minerals are known for their infertility, which is thought to be due to a low ratio of calcium to magnesium (Alexander et al. 2007). Similarly, soils developed from gabbro are known to be very infertile (Alexander et al. 2007). Gabbro soils appear to be infertile because of their low phosphorous and high iron contents, as no other causes are readily apparent (Hunter and Horenstein 1992). Additionally, gabbro soils tend to be coarse-textured, which limits their water-holding capacity (Hunter and Horenstein 1992; Alexander 1993, 2008). Alexander (2008) sampled three sites with three different vegetation types in the immediate vicinity of Pine Hill and found that 1) all had loamy surface textures with the first two being very stony, 2) all three had clay loams immediately above bedrock, and 3) the chaparral site dominated by re-sprouting species (explained below) had a thick organic soil horizon and abundant surface organic matter.

Alexander (1993) explains that gabbro soil texture is finer than that of granite because gabbro lacks biotite. Gabbro soils are more friable and less erodible because of their high iron content and dispersed humus. The high iron content also prevents phosphorus from being available to plants, resulting in low fertility. The nutrient balance is only slightly less favorable than that of other igneous rocks such as diorite, and much better than serpentine (Alexander 1993).

The effects of infertile gabbro soils are most apparent where wet season precipitation is low (10–20 inches) and plants growing on gabbro under those conditions appear stunted compared to other rock types (Oberbauer 1993).

A.1.2 Black Oak Woodland Vegetation and Ecological Factors

Black oak woodland vegetation (with associated chaparral shrub species) is generally found in the Plan Area on north-facing slopes and in shallow drainages (Griffin 1988, Stephens 1997, Wilson et al. 2009). This vegetation type has been formally described as the "*Quercus kelloggii/ Pinus ponderosa/ Arctostaphylos viscida* association" (Klein et al. 2007). This vegetation type is determined by fire return interval which from 1850 to 1952 averaged eight years in areas adjacent to oak woodlands with nearly continuous grass fuel continuity (Stephens 1997). The fire patterns since fire suppression began in the 1950s have shifted from frequent low- to mid-intensity fires to infrequent high-intensity fires (Stephens 1997). This change has fundamentally altered pyrodiversity (intensity, frequency, seasonality, and patchiness of fire events) (Stephens 1997), and the structure and species composition of black oak woodlands are changing in response to the altered fire dynamics.

A.1.3 Chaparral Vegetation and Ecological Factors

General

The chaparral vegetation of southern California has been studied for over 100 years and intensively studied for the last 40 years. Unfortunately, those studies are not directly applicable to the chaparral in El Dorado County because of its substantially lower soil productivity that significantly affects fire dynamics, the dominant disturbance regime of chaparral vegetation. Pyrodiversity and its resultant effects on vegetation are dependent on climate, weather patterns, fuel loads, and fuel distribution. Fuel loads and fuel distribution are dependent on soil characteristics, plant species characteristics, the responses of the plant species to soil characteristics, and weather patterns. Following a fire event there are a number of different vegetative outcomes (seral stages) that can occur as post-fire vegetation reestablishes. Each potential outcome is the result of pre-fire conditions, conditions during the fire, and post-fire conditions; and the combined effects of all of those factors vary spatially across a landscape at different scales, adding another level of complexity.

The fact that the general pattern of chaparral response to fire in southern California is dependent on soil fertility has only been very recently acknowledged. Keeley et al. (2008) found that fire severity across 250 sites in southern California after the extensive 2003 fire season was not correlated with any site environmental parameters except soil texture (sand content) and soil fertility (total nitrogen and phosphorus). The sites spanned sedimentary, granitic, gabbroic, and volcanic geology. As noted in Section A.1.1, *Geology and Soils*, gabbro and volcanic rock weather to finer texture soils and gabbro is low in phosphorus. Vegetation cover in the first year (biomass) was weakly correlated with fire intensity but more strongly correlated with elevation and substrate (soil texture) (Keeley et al. 2008). Essentially, Keeley et al. (2008) found that vegetation on infertile soils burned differently and recovered differently than vegetation growing on more fertile soils, and did not fit the general pattern described for southern California chaparral. There is only one study (Safford and Harrison 2004, 2008) comparing chaparral growing on low-fertility soil (serpentine) and higher-fertility soils (sandstone) that describes some of the vegetation differences driven by soil fertility differences, and their findings are discussed in the *Infertile Soils* section below.

Fire

Fires, under natural conditions in southern California chaparral, occur predominately during Santa Ana foehn winds[6] in the autumn, are of large extent, are stand-replacing, and do not produce a fine-grain age patch vegetation structure (Keeley and Zedler 2008, Keeley et al. 2012). The initial flame front passes rather quickly and may be patchily distributed, but secondary ignitions from downed burning branches create a hot surface fire that burns and smolders for hours afterwards (Odion and Davis 2000). In essence, the flame front flash-burns the leaves and twigs and heats the whole area rather uniformly but briefly. The ignited larger branches of the shrubs soon fall to the ground, and the piles of downed coarser fuels that are spatially distributed under pre-fire shrubs create a patchwork of superheated soil that determines the post-fire pattern of survival of plants that can re-sprout from underground tissues and the survival and germination responses of seeds lying dormant in the soil seed bank.

These types of fires are not expected in the gabbro chaparral of El Dorado County under historical fire regime as discussed in the *Infertile Soils* section below. However, it is unclear how 60 years of fire suppression has altered the historical fire regime and how a return to that historical fire regime can be accomplished.

Plant Species' Responses to Fire

While all plant species in chaparral vegetation ultimately originate from seed, there are a number of different responses to fire. Some species persist for very long periods, perhaps centuries, by re-sprouting, and only very infrequently establish from seed during the long intervals between fires; other species persist only as dormant seed during the long intervals between fires, and many species are some complex combination of those two endpoints (Keeley et al. 2006, Keeley and Davis 2007, Keeley et al. 2012). Two types of chaparral have been recognized: sprouting chaparral (mesic) and seeding chaparral (xeric) (Wilson et al. 2009; Gogol-Prokurat 2009, 2011).

Odion and Davis (2000) have conducted the most precise study of the effects of fine-scale fire heterogeneity on chaparral vegetation. They found that there are three factors that control the

[6] Foehn winds are warm, dry winds that flow down mountain slopes and create critical fire-weather conditions.

location and densities of seedlings after a fire: 1) fire intensity (primary and secondary), 2) seed dispersal, and 3) seed burial depth. Their primary finding was that the pattern of heating due to secondary heating (smoldering branches that had fallen to the ground after the initial flame front passed) determined the spatial distribution of surviving seed and re-sprouting tissue regardless of their pre-burn distribution.

In their survey of the chaparral literature, Keeley and Davis (2007) concluded that populations of post-fire obligate seeders are at risk of extirpation from short fire return intervals, because they have insufficient time to establish a soil seed bank of a large enough size to persist during the high-seedling-mortality period and replace the population of adults that were present on the site. Post-fire seeding *Ceanothus* species appear to require fire return intervals of at least 20 years while post-fire seeding *Arctostaphylos* species require return intervals of much greater than 20 years. Post-fire sprouting species such as species of *Heteromeles*, *Rhamnus*, and *Cercocarpus* produce only short-lived seed and when fire occurs there is essentially no seedling recruitment; these species persist through re-sprouting and sporadic seedling recruitment during fire-free intervals (Keeley and Davis 2007).

The chaparral vegetation in the Plan Area generally falls into two categories: post-fire sprouters on north aspects and in drainages, and post-fire seeders elsewhere (Wilson et al. 2009; Gogol-Prokurat 2009, 2011). These categories are defined by the dominant shrubs in each vegetation type but the subdominant species, such as all of the rare plant species, tend to be complex combinations of the two endpoints. Additionally, there is no clear demarcation between sprouting and seeding syndromes (Keeley and Zedler 2008, Keeley et al. 2012). Finally, as discussed in *Infertile Soils*, the response of the vegetation and species on infertile soils is different from the general patterns described for southern California and the dynamics of the seral stages are largely unknown.

Herbivory

Species in the genus *Ceanothus* appear to be especially susceptible to herbivory at the seed and seedling stages compared to other species such as chamise (Mills 1986). O'Neil and Parker (2005) found that *Ceanothus* seed banks are dynamic, and high levels of post-dispersal seed predation and reduced seed viability with age keep seed numbers in the seed bank relatively constant instead of increasing through time. Some of the seed predation is likely due to selective harvesting by harvester ants (*Pogonomyrmex subnitidus*) (Zammit and Zedler 1988).

Soil Depth, Bedrock, and Rooting Patterns

Sprouting species in multiple genera (*Archtostaphylos*, *Ceanothus*, *Heteromeles*, and *Quercus*) and species that combine sprouting and seeding (*Adenostoma*) root extensively in the soil as well as deeply into fractured rock. In contrast, seeding species (*Archtostaphylos* and *Ceanothus*) produce only extensive and shallow roots in the soil that do not root into fractures in rock (Hellmers et al. 1955).

Frost Heave

Frost heave–caused mortality of chaparral seedlings has the potential to greatly alter the post-fire vegetation dynamics and is much more pronounced on burned sites and areas without shrub cover. In an early study of frost heave effects in areas of chaparral in the Kern River watershed (cleared and bare, cleared and grass, and undisturbed), it was found that bare soil froze at air temperatures of 31 degrees Fahrenheit (°F), grass-covered soils at 29°F, and the authors estimated that shrub-covered soils would freeze at 14°F, as the soil did not freeze under shrubs during the period of the study (Anderson 1947). In another early study, south aspects suffered frost heaving more than other aspects and seedlings in the cotyledon stage were more vulnerable than seedlings in the two-leaf stage (Biswell et al. 1953). Chamise germinated earlier and seedling survival was 14 percent by February 6 on a northeast exposure. *Ceanothus* began germinating on February 6 and by March 28, survival was 23 percent. Overall, of the approximately 230 seedlings followed, only seven survived to the end of the frost period on March 28 for a survival rate of approximately 5 percent, and those plants survived through June 25. On a southeast aspect both species suffered approximately equally; there was a 57 percent survival through March 28 and survival declined to 25 percent by June 25. In the following season survival was 39 percent on the south aspect and 19 percent averaged across the other aspects (Biswell et al. 1953).

The Plan Area is in California Climate Zone 9 (University of California Cooperative Extension [UCCE] 1989), with typical winter lows between 26°F and 35°F and extreme cold snaps between 0°F and 18°F. Snow cover is very infrequent and of very short duration, and the coldest low temperatures occur on clear, cloudless nights. Because the majority of the rare plants establish seedlings during the first post-fire winter, they will experience the most severe frost heave conditions and seedlings will likely suffer significant mortality.

Infertile Soils

Chaparral species growing on highly infertile gabbro soils are likely to have experienced a very different fire regime because growth rates and fuel structure ultimately determine the intensity, frequency, and patchiness of fire disturbances. In effect, low-productivity chaparral is likely to be a higher-light environment (i.e., have more open canopy) with fewer fast-growing, short-lived species than in higher-productivity chaparral. This is exactly what Safford and Harrison (2004, 2009) found in serpentine chaparral. In their study, pre-fire shrub cover was higher on non-serpentine and more spatially heterogeneous on serpentine soil. The mean time to the last fire was much greater on serpentine (74 years versus 19 years) and fire severity was much less on serpentine. Post-fire recovery of serpentine shrub biomass was 18 percent of that of non-serpentine. The contribution of post-fire seeder species to pre-fire shrub cover was more than twice as high in serpentine. The best explanation for the difference in fire response between serpentine and non-serpentine chaparral is that lower soil fertility leads to more open vegetation and lesser release from above-ground competition following fire. Annual forbs were sparsely present on serpentine before it burned but were not present as adults on pre-burn non-serpentine.

Ceanothus species, whose seeds required fire to germinate on non-serpentine soils, were able to maintain low but constant levels of recruitment on serpentine soils. Non-serpentine chaparral also recovered most of its pre-fire biomass in three years, but serpentine biomass recovered very slowly (Safford and Harrison 2004, 2008).

The patterns that Safford and Harrison (2004, 2008) observed for serpentine chaparral appear to apply to the gabbro soils chaparral of the Plan Area. Boyd (2007) found that chaparral that had been cut for fuel breaks in 1969 had not recovered enough to burn by 1984 (15 years) (Boyd 2007). Burge and Manos (2011) found that Pine Hill ceanothus occurs on the less fertile soils of the slopes, while the closely related but widely distributed buckbrush (*Ceanothus cuneatus* var. *cuneatus*) occurs in more fertile gabbro soils and (possibly more mesic) soils at the bottom of slopes (Burge and Manos 2011).

Safford and Harrison (2004, 2008) found a mean fire return interval for serpentine chaparral of 74 years, which from anecdotal evidence appears to be similar to chaparral in the Plan Area that has recently burned. Long fire return intervals were probably the natural condition of chaparral as Keeley et al. (2005) found that fire return intervals of mature stands in the Sierra Nevada are at least 50–60 years and that fire return intervals of at least 92 years do not appreciably change the species diversity of post-fire seeding *Ceanothus*. The finding of Stephens (1997) that the black oak woodland in the Plan Area experienced a mean fire return interval of eight years between 1850 and 1952 suggests that both soil infertility and spatial heterogeneity control the fire return intervals in the chaparral, and that the pyrodiversity Stephens described has shifted from frequent low- to mid-intensity fires to infrequent high-intensity fires (Stephens 1997). If this is the case for the gabbro chaparral as well, then gabbro chaparral under historical fire regimes likely had a fine-grain age patch structure, which is very different from the processes in southern California chaparral (Keeley and Zedler 2008, Keeley et al. 2012).

A.2 PLANT SPECIES ECOLOGICAL ACCOUNTS

A.2.1 Stebbins' Morning-Glory

Description

Stebbins' morning-glory (*Calystegia stebbinsii*) is a trailing or climbing (less than 1 meter) herbaceous perennial from a rhizome or woody caudex with creamy yellow flowers that are produced from April through July (Jepson Flora Project 2012).

Distribution

Stebbins' morning-glory occurs on the gabbro soils in the Pine Hill area in both chaparral types (Gogol-Prokurat 2009, 2011) and on serpentine soils in Nevada County (California Department of Fish and Game [DFG] 2012). See Figure A-1 for its distribution in the Plan Area.

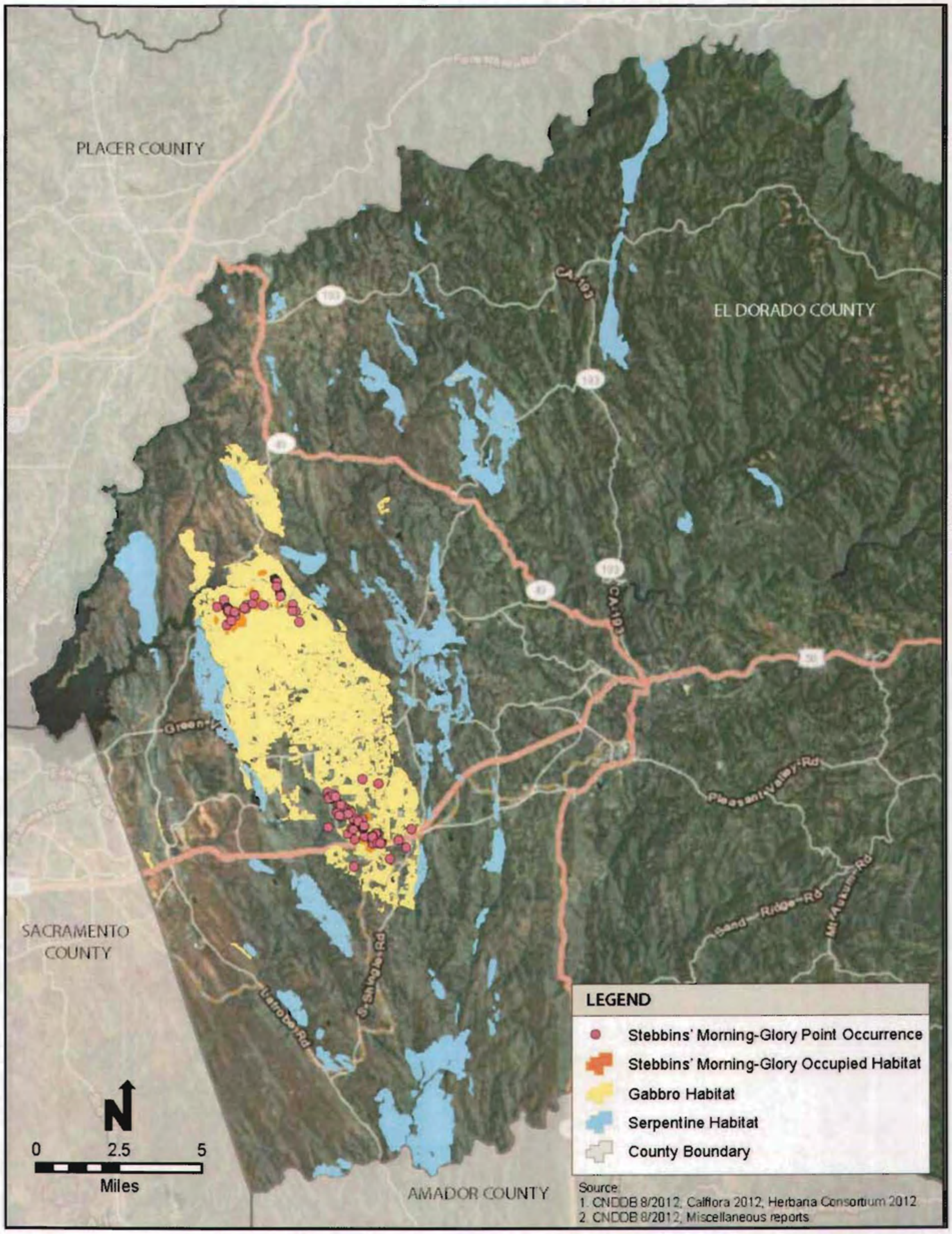

Figure A-1. Stebbins' Morning-Glory Recorded Occurrences and Occupied Habitat within the Plan Area

Demography and Ecology

Nosal (1997) conducted studies of Stebbins' morning-glory in which data were collected on the number of flowering plants, number of non-flowering plants, number of stems per flowering plant, and number of seed capsules produced on stems within each plot sampled. Seed production ranged from an average of 20.6 seeds per square meter (m^2) at Grass Valley to 380 seeds/m^2 at Salmon Falls. Plant density ranged from an average of 1.09 plants/m^2 at Grass Valley to 12.1 plants/m^2 at Salmon Falls. The average number of stems per plant ranged from 1.59 to 2.07. Recruitment (the number of non-flowering plants) varied from 0.038 plants/m^2 per year at Grass Valley to 0.97 plants/m^2 per year at Shingle Springs (Nosal 1997). Nosal also found that Stebbins' morning-glory seed germinated readily only after either scarification or heat treatments.

Ayers (2011) also studied Stebbins' morning-glory and found that while it was not present as vegetative plants in Salmon Falls Site C and Salmon Falls Site D prior to burning, but post-fire seedling densities the first spring were 25 seedlings/m^2. Ayers found that 75 percent of the seedlings had died by the end of the second spring, and by 2006 plant densities had dropped to about 0.02 plants/m^2. In the third year, the surviving plants began spreading vegetatively and over half the surviving plants were flowering (Ayers 2011).

In studies in southern California, Keeley (2007) found that native perennials such as morning glory (*Calystegia macrostegia*), deer weed (*Lotus scoparius*), and rock rose (*Helianthemum scoparium*) are widespread in the early seral post-fire stage of chaparral (Keeley 2007). This suggests that Stebbins' morning-glory may also be an early seral post-fire specialist and persist at a site through a long-lived dormant seed bank.

A similar species, serpentine hillside morning-glory (*Calystegia collina*) has a sporophytic self-incompatibility breeding system with few mating-type alleles.[7] In that study, the availability of pollinators was not responsible for seed set differences between large and small populations (Wolf et al. 2000). Instead, it was likely that the availability of genetically compatible pollen (mating-type alleles) was more important and it was independent of other measures of genetic diversity. The abundance of other populations of serpentine hillside morning-glory within the foraging distance of its pollinators appeared to be more important (Wolf et al. 2000). The combination of a population structure that persists primarily as a dormant seed bank, the self-incompatibility, and variable pollinator identity and behavior in response to vegetation changes will lead to complex pollination and seed production dynamics (Essenberg 2012a, 2012b) in both serpentine hillside morning-glory and Stebbins' morning-glory. Nosal observed that Stebbins' morning-glory is pollinated by insects and that 80 percent of visits were made by Hymenoptera (bees and wasps) with the Halictidae (solitary bees) and the Apidae (honey bees and bumble bees) being the most important families (Nosal 1997). Additionally, Gogol-Prokurat

[7] In sporophytic self-incompatibility, if the pollen grain (male tissue) is genetically incompatible (allele type) with the pistil (female tissue), the pollen grain cannot grow and fertilize an ovule (egg), so no seed is produced.

found that seed set in Stebbins' morning-glory pollen was limited in small populations (Gogol-Prokurat 2009, 2011).

A.2.2 El Dorado Bedstraw

Description

El Dorado bedstraw (*Galium californicum* ssp. *sierra*) is a small, perennial herbaceous plant (7–14 centimeters [cm]) with weak, slender, and cushion-like to weakly tufted non-woody stems (Jepson Flora Project 2012). The species is dioecious (separate male and female plants), produces very small, yellowish flowers in May and June, and its seed are contained in tiny berries (Hickman 1993, Soza and Olmstead 2010, Calflora 2012).

Distribution

El Dorado bedstraw is endemic to El Dorado County in the immediate vicinity of the Pine Hills gabbro soils area and is found in black oak woodland and in the transition from black oak woodland to obligate sprouting chaparral (Wilson et al. 2009, DFG 2012). See Figure A-2 for its distribution in the Plan Area.

Demography and Ecology

Very little is known about El Dorado bedstraw. In general, the small, fragrant flowers of the genus *Galium* are pollinated by a variety of butterflies, moths, beetles, flies, ants, wasps, and short- or long-tongued bees (Batra 1984). The tiny berries are most likely eaten by small animals (possibly lizards or rodents), which function as seed dispersal agents (Soza and Olmstead 2010). Dispersal of fleshy fruit-like berries by animals can target patches of isolated habitat very effectively, but the distance and rates of dispersal depend on the movement and dispersal patterns of the animals (Matlack 1994).

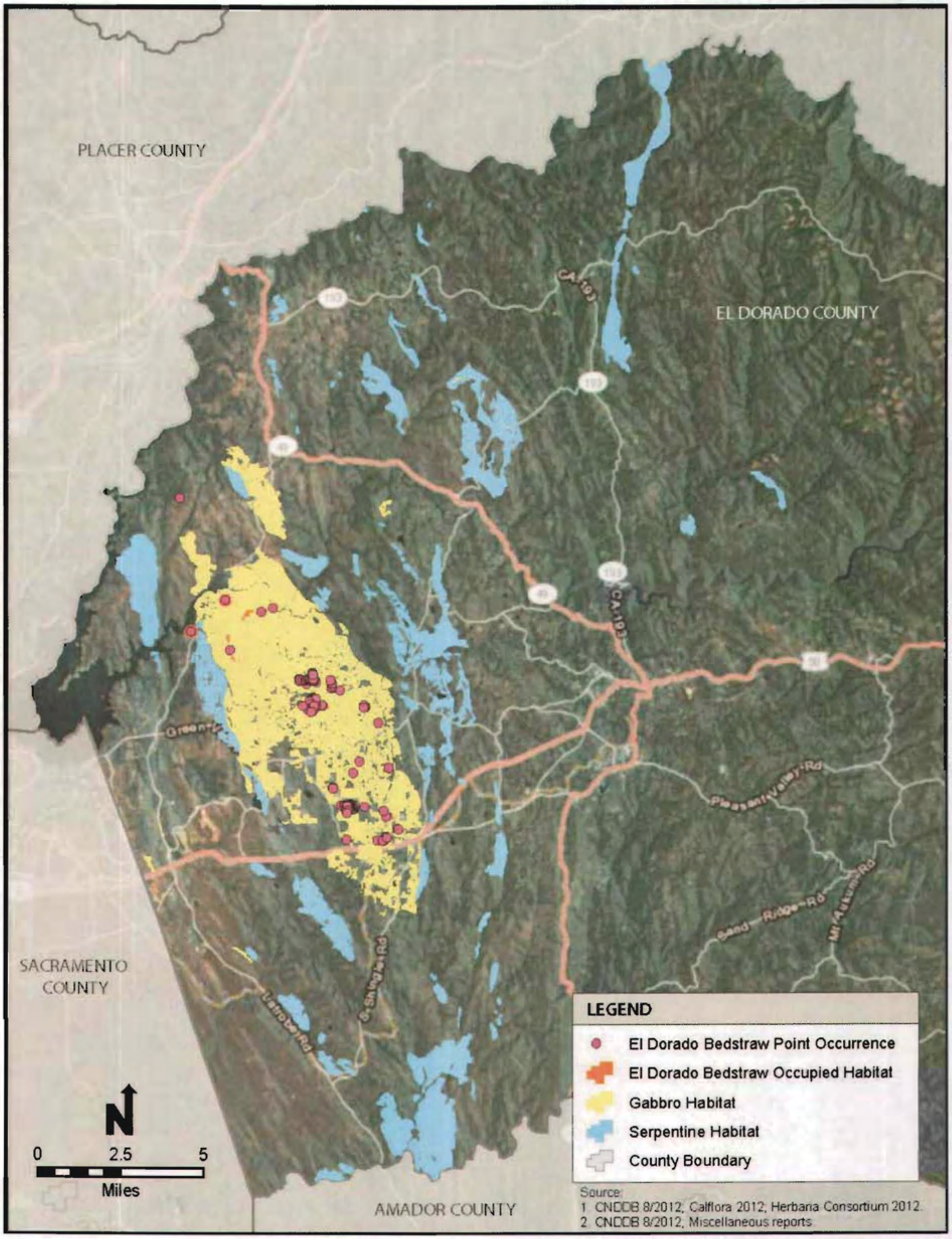

Figure A-2. El Dorado Bedstraw Recorded Occurrences and Occupied Habitat within the Plan Area

A.2.3 Pine Hill Ceanothus

Description

Pine Hill ceanothus (*Ceanothus roderickii*) is a small (less than 0.5 meter tall) mat- to mound-like shrub with spreading (to 3 meters), arched branches that often root where their tips touch the soil (Jepson Flora Project 2012). Its white flowers are tinged with blue and are produced from April through June (Jepson Flora Project 2012).

Distribution

Pine Hill ceanothus has only been reported from the gabbro soils in the Pine Hill area and it occurs in both types of chaparral (Wilson et al. 2007; Gogol-Prokurat 2009, 2011; DFG 2012). Pine Hill ceanothus and the closely related but widely distributed buckbrush (*Ceanothus cuneatus* var. *cuneatus*) both occur on gabbro soils in the Pine Hill area, but buckbrush occurs in more fertile (and possibly more mesic) soils at the bottom of slopes while Pine Hill ceanothus occurs on the less fertile soils of the slopes (Burge and Manos 2011). See Figure A-3 for its distribution in the Plan Area.

Demography and Ecology

Boyd (2007) conducted burn experiments on Pine Hill in a stand of chaparral that had been cut for fuel breaks in 1969 and had not recovered enough to burn by 1984 (15 years). There wasn't sufficient fuel on the site to carry a burn, so cut branches from other sites were piled 0.75 meter deep on the 2-meter-by-2-meter plots and ignited. Boyd cites Odion and Davis (2000) as finding that fire causes seed death but does not mention that his burning method was exactly the type of burn Odion and Davis (2000) described as causing the highest seed mortality. For this reason, it is likely that Boyd's reported post-burn seedling numbers do not reflect natural fire responses.

Insect herbivory caused high seedling mortality but clonal spread through stem layering (beginning four years post-burn) increased the number of individuals in the plots after the post-fire flush of seedlings had died (Boyd 2007). Flowering began in the plots six years after the burn.

Ayers' 2011 study found that Pine Hill ceanothus was present at low density on all sites before fire and suffered complete mortality from the burns. Seedlings germinated during the wet season after the burn and suffered high mortality (3–7/m^2 as Boyd found) during the first year. At the Salmon Falls site, all seedlings were dead by the end of the second post-fire season. Pine Hill ceanothus cover increased gradually over time through branch layering. Approximately 7 percent of the branches were flowering eight years after the burns. Ayers (2011) noted that plants growing under a mature canopy of tall chaparral flower sparsely. Seed germination required heat and cold stratification although 5 percent of the seed germinated without the heat treatment (Ayers 2011).

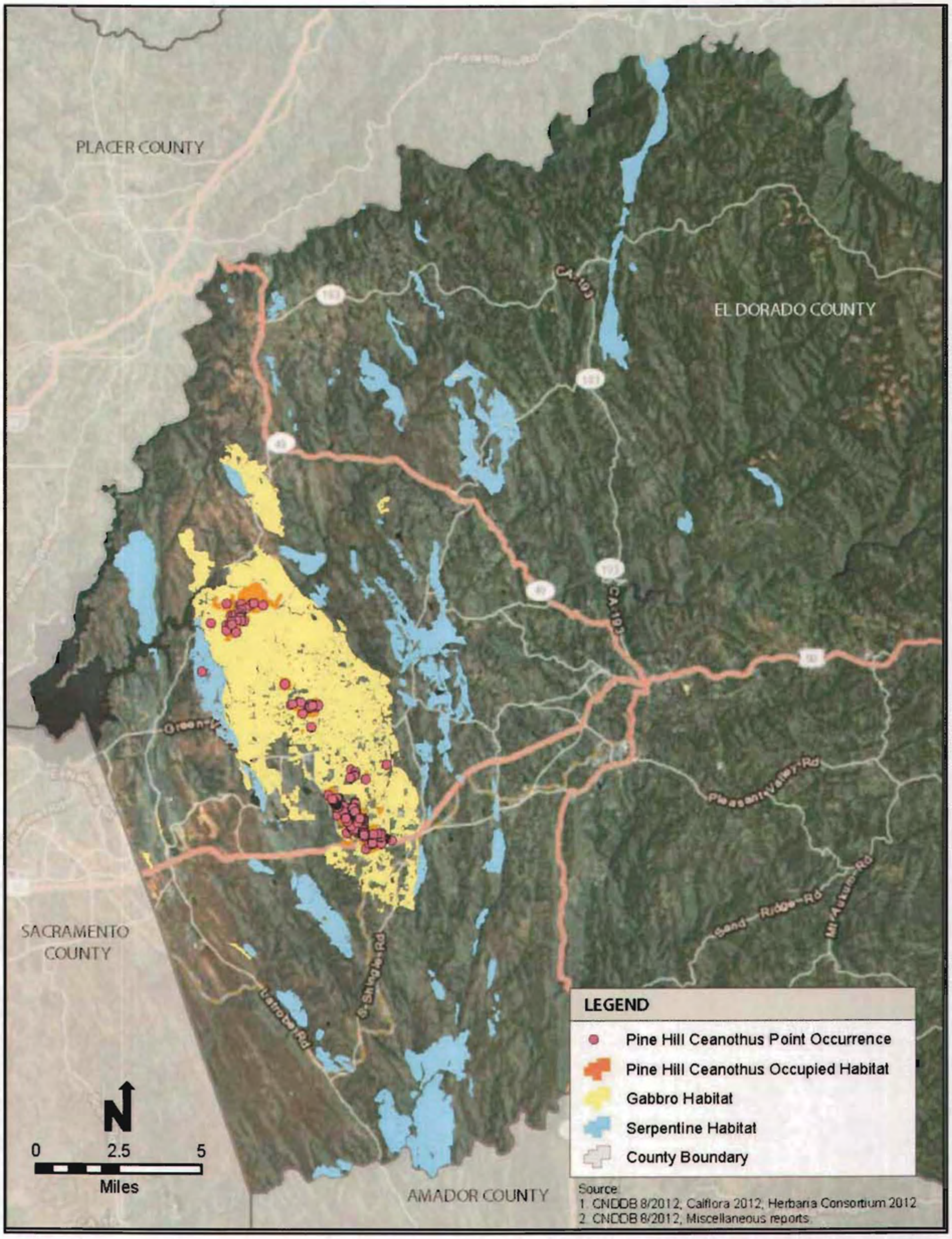

Figure A-3. Pine Hill Ceanothus Recorded Occurrences and Occupied Habitat within the Plan Area

In a germination experiment, seeds treated with a combination of heat and cold had the best germination rate (86.6 percent germination) while seeds treated only with cold had a 20 percent germination rate (James 1996). One-year-old seeds germinated at a rate significantly lower than two-year-old seeds (James 1996). Species in the genus *Ceanothus* produce explosive seed capsules that shoot seeds several feet from the parent shrub as the capsules dry and rupture (Keeley and Davis 2007).

Species in the genus *Ceanothus* are generally self-incompatible (Raven 1973), but plant breeding systems of self-incompatible species are not necessarily constant and respond to a number of factors, including flower age and environmental conditions (Richards 1997, Karron et al. 2012). The pollination of Pine Hill ceanothus is primarily by flies, gnats, bees, and wasps that were not specific to Pine Hill ceanothus and were observed visiting other plants (James 1996).

A.2.4 Pine Hill Flannelbush

Description

Pine Hill flannelbush (*Fremontodendron decumbens*) is a decumbent to upright shrub (less than 2 meters) with coppery-orange flowers that are produced from April to July and which produce seed with an orange appendage (elaiosome) that is attractive to harvester ants (Boyd and Serafini 1992, Boyd 2001, Jepson Flora Project 2012).

Distribution

Pine Hill flannelbush occurs on the gabbro soils of Pine Hill and adjacent areas and on lower elevation serpentine soil in Nevada County (CCH 2012, DFG 2012). (See Alexander et al. 2007 for a description of the Sierra Motherlode serpentine belt.) See Figure A-4 for its distribution in the Plan Area.

Demography and Ecology

In 1982, Boyd and Serafini (1992) conducted a demographic study of Pine Hill flannelbush in a 70-meter-wide swath that was cut through the population in 1969 for a fire break across the ridges. They found that moth larvae attack flower buds, flowers, and fruits. Only 1.8 percent of flower buds survived to produce seeds and 90 percent of the seeds produced were eaten by rodents. Insects killed most of the seedlings and water stress apparently killed the seedlings that the insects and rodents did not kill. The plants that had been cut when the fire break was made produced root sprouts at various distances from the adults (Boyd and Serafini 1992).

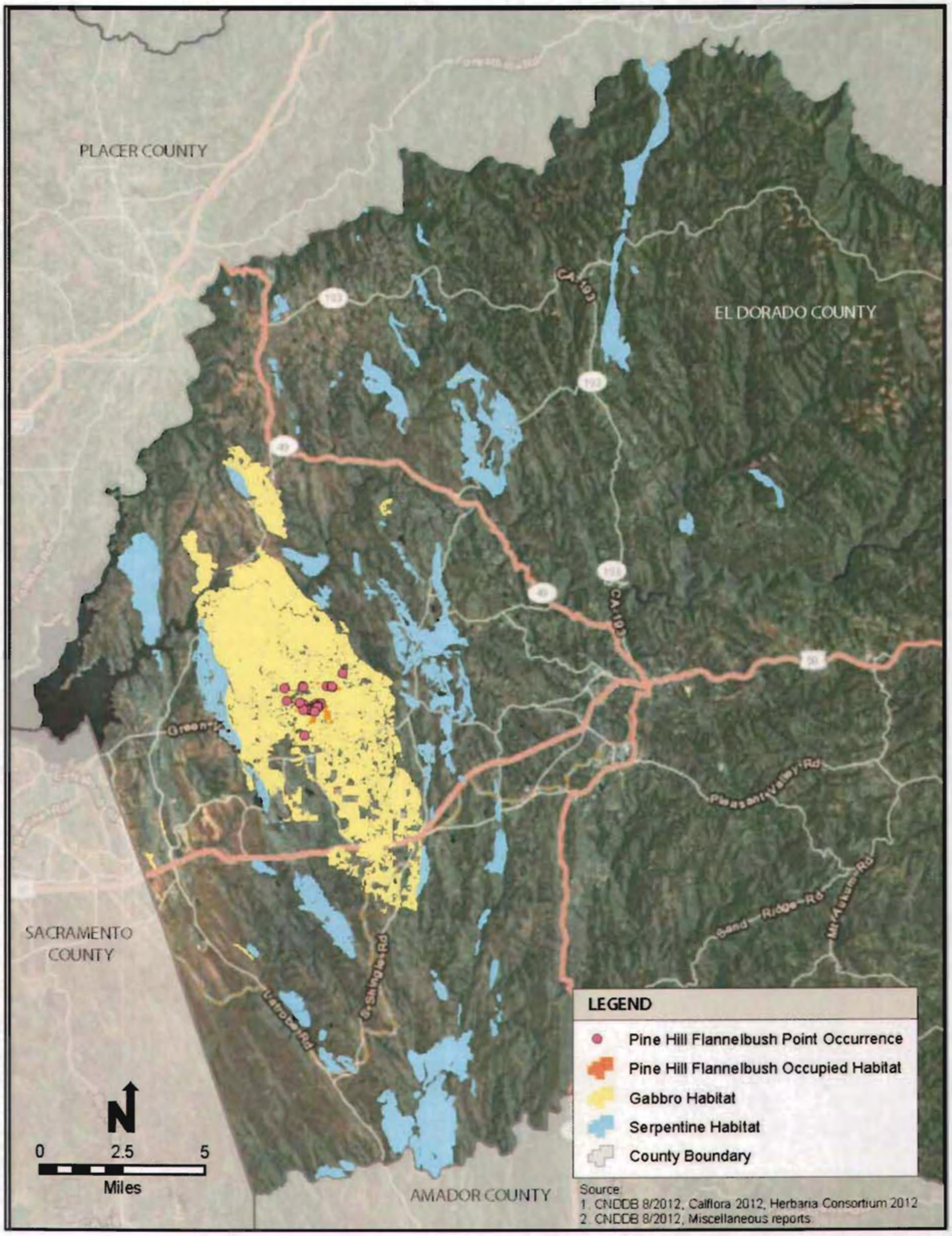

Figure A-4. Pine Hill Flannelbush Recorded Occurrences and Occupied Habitat within the Plan Area

Harvester ants (*Messor andrei*) are attracted to elaiosomes of seeds and disperse seed to their nests where they remove the elaiosomes and discard the seed. Boyd (1996) found that the ants do not affect germination rates and seeds at nests are subjected to higher levels of herbivory by rodents. Only heat and cold stratification were necessary to cue germination in the field despite laboratory tests that indicated that smoke was also required (Boyd and Serafini 1992).

Boyd did not test for breeding system type but found that pollen transfer by insects is required for seed set (Boyd 1994). Primary pollinator was *Tetralonia stretchii*, a native, solitary, ground-nesting bee (Boyd 1994).

A.2.5 Layne's Butterweed

Description

Layne's butterweed (*Packera layneae*) is a herbaceous perennial with stout, erect stems (40–70 cm) from a taproot (Jepson Flora Project 2012). It produces yellow flowers from April to August (Calflora 2012).

Distribution

Occurrences are sporadic but widespread in the central and northern Sierra Nevada foothills on the gabbro soils of the Pine Hills area and on lower elevation serpentine soils of Butte, El Dorado, Placer, Tuolumne, and Yuba counties in the Motherlode serpentine belt (Alexander et al. 2007, CCH 2012, DFG 2012). See Figure A-5 for its distribution in the Plan Area.

Demography and Ecology

Reported occurrences of Layne's butterweed vary from 10 to over 1,000 individuals (DFG 2012). It is restricted to chaparral and adjacent open woodlands (DFG 2012, Calflora 2012) and has been reported from both sprouting and seeding chaparral (Klein et al. 2007; Wilson et al. 2007; Gogol-Prokurat 2009, 2011). A related species, Gander's Ragwort (*Packera gander*), is a rare gabbro endemic species (Alexander et al. 2007, DFG 2012) from San Diego County that Keeley found to be growing (with a cover of 25 percent) and flowering beneath a mature chaparral canopy (Keeley 1974).

Layne's butterweed is insect-pollinated (Marsh 2000, Marsh and Ayers 2002).

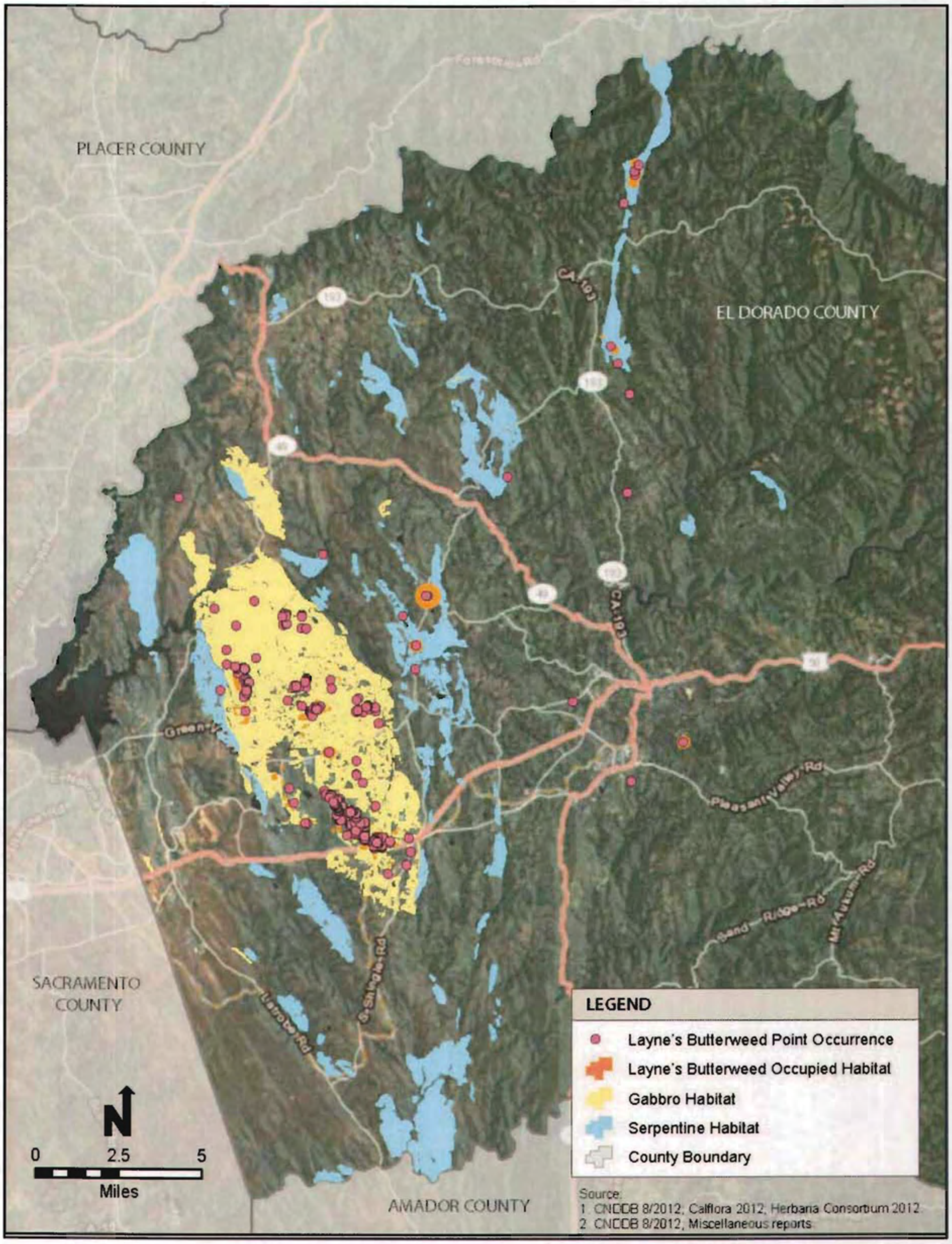

Figure A-5. Layne's Butterweed Recorded Occurrences and Occupied Habitat within the Plan Area

A.2.6 Red Hills Soaproot

Description

Red Hills soaproot (*Chlorogalum grandiflorum*) is a herbaceous perennial from a large bulb (5–7 cm) that produces a tall (1 meter) flowering stalk with white flowers that open in the evening from May to June (Jepson Flora Project 2012).

Distribution

Red Hills soaproot is widely distributed on soils derived from gabbro, serpentinite, mixed metamorphic rocks, and Tuscan lahars from Butte, Placer, El Dorado, Amador, Calaveras, and Tuolumne counties; and it occurs in chaparral, blue oak woodlands, mixed conifer forests and canyon live oak forests (DFG 2012). See Figure A-6 for its distribution in the Plan Area.

Demography and Ecology

Reported occurrences vary from 10 to over 1,000 individuals (DFG 2012). Red Hills soaproot has not been studied but is morphologically similar to common soap plant (*Chlorogalum pomeridianum*), which has been studied in chaparral vegetation in southern California. Soap plant only flowers in gaps in mature chaparral or in post-fire chaparral and produces non-dormant seed. All soap plant seeds germinate or are eaten by seed predators within the first two wet seasons, and to a lesser extent the third, post-fire.

The plants then persist and grow under the canopy until the next fire which may be at least 30 to 70 years (Tyler and Borchert 2007). In southern California, when herbaceous perennials similar to Red Hills soaproot flower beneath the chaparral canopy, they are subjected to intense herbivory (Keeley et al. 1981).

Because the flowers of Red Hills soaproot open at night (Jepson Flora Project 2012), they are likely moth-pollinated.

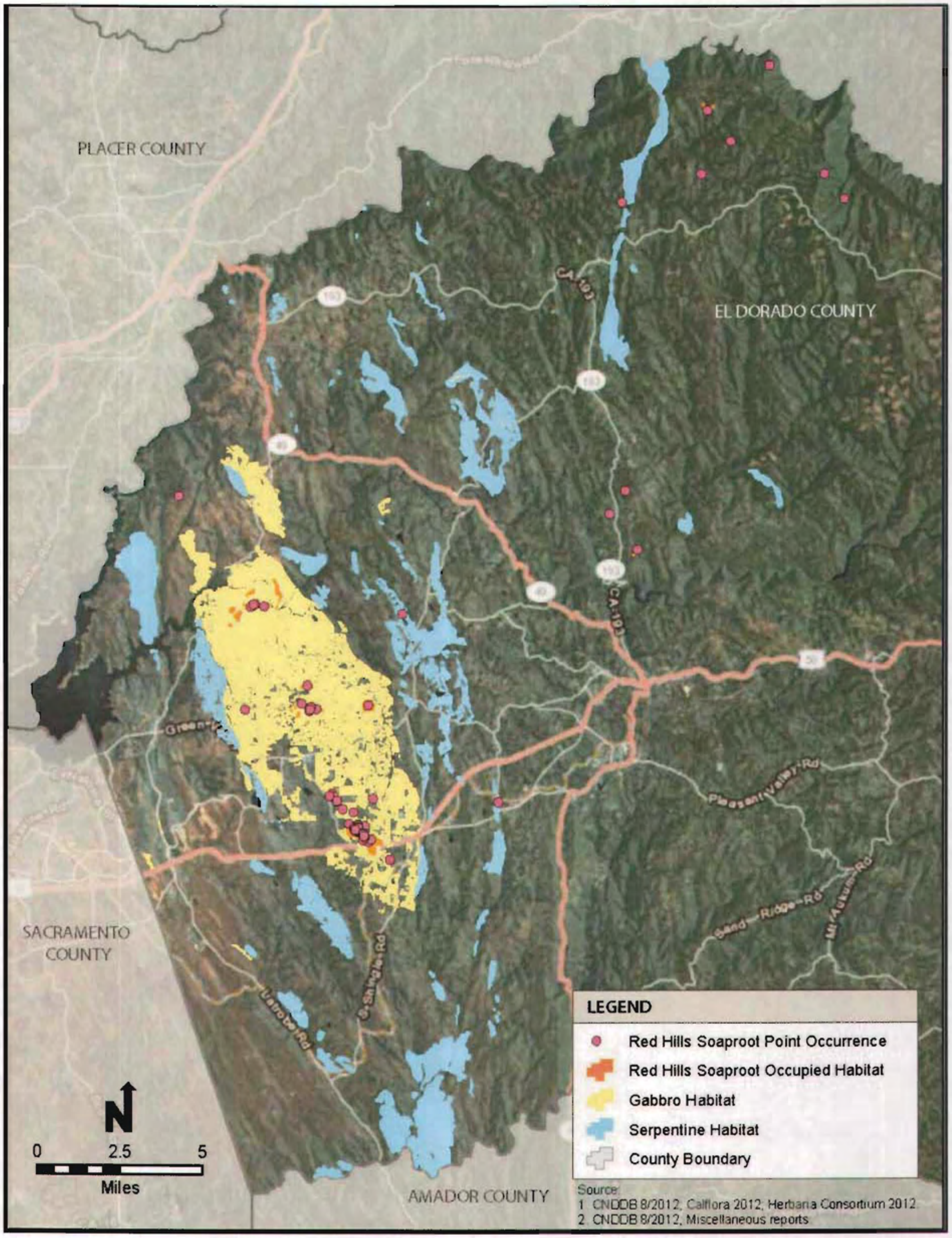

Figure A-6. Red Hills Soaproot Recorded Occurrences and Occupied Habitat within the Plan Area

A.2.7 El Dorado Mule-Ears

Description

El Dorado mule-ears (*Wyethia reticulata)* is a herbaceous perennial with erect stems (40–70 cm) from deep taproots and spreading rhizomes and produces yellow flowers from May through August (Hickman 1993, Ayers 1997, Jepson Flora Project 2012).

Distribution

Occurrences have been primarily reported on the gabbro soils of El Dorado County with additional records, one from each of Yuba and Shasta counties, on serpentine soils (Consortium of California Herbaria [CCH] 2012, DFG 2012). It is found in black oak woodland and both seeding and sprouting chaparral (Gogol-Prokurat 2009, 2011). See Figure A-7 for its distribution in the Plan Area.

Demography and Ecology

In chaparral, El Dorado mule-ears flowers profusely the spring after a fire (twentyfold increase); flowering drops by about 75 percent the following year, and in subsequent years drops to very low levels (Ayers 2011). In areas where the vegetation transitions to black oak woodland, flowering drops off more slowly (Ayers 2011). Seedling density increased dramatically two wet seasons after the fire, apparently in response to seed production during the first post-fire spring bloom (Ayers 2011). Its seed do not require heat or smoke to germinate and are killed at relatively low soil temperatures (65 degrees Celsius [°C]) (Ayers 2011). Seedlings experience great mortality during their first season and their density drops to very low levels in the second season. Occurrences of El Dorado mule-ears consist of a relatively small number of clones, each of which covers tens to hundreds of square miles (Ayres and Ryan 1997).

El Dorado mule-ears has a self-incompatible breeding system and is pollinated primarily by bees (Ayers 1997). The self-incompatibility is most likely sporophytic self-incompatibility[8] with an unknown number of mating-type alleles. Plant breeding systems of self-incompatible species are not necessarily constant and respond to a number of factors, including flower age and environmental conditions (Richards 1997, Karron et al. 2012). The combination of a clonal population structure that flowers sporadically in response to fire, self-incompatible breeding system, and variable pollinator type and behavior will lead to complex pollination and seed production dynamics (Essenberg 2012a, 2012b).

[8] In sporophytic self-incompatibility, if the pollen grain (male tissue) is genetically incompatible (allele type) with the pistil (female tissue), the pollen grain cannot grow and fertilize an ovule (egg), so no seed is produced.

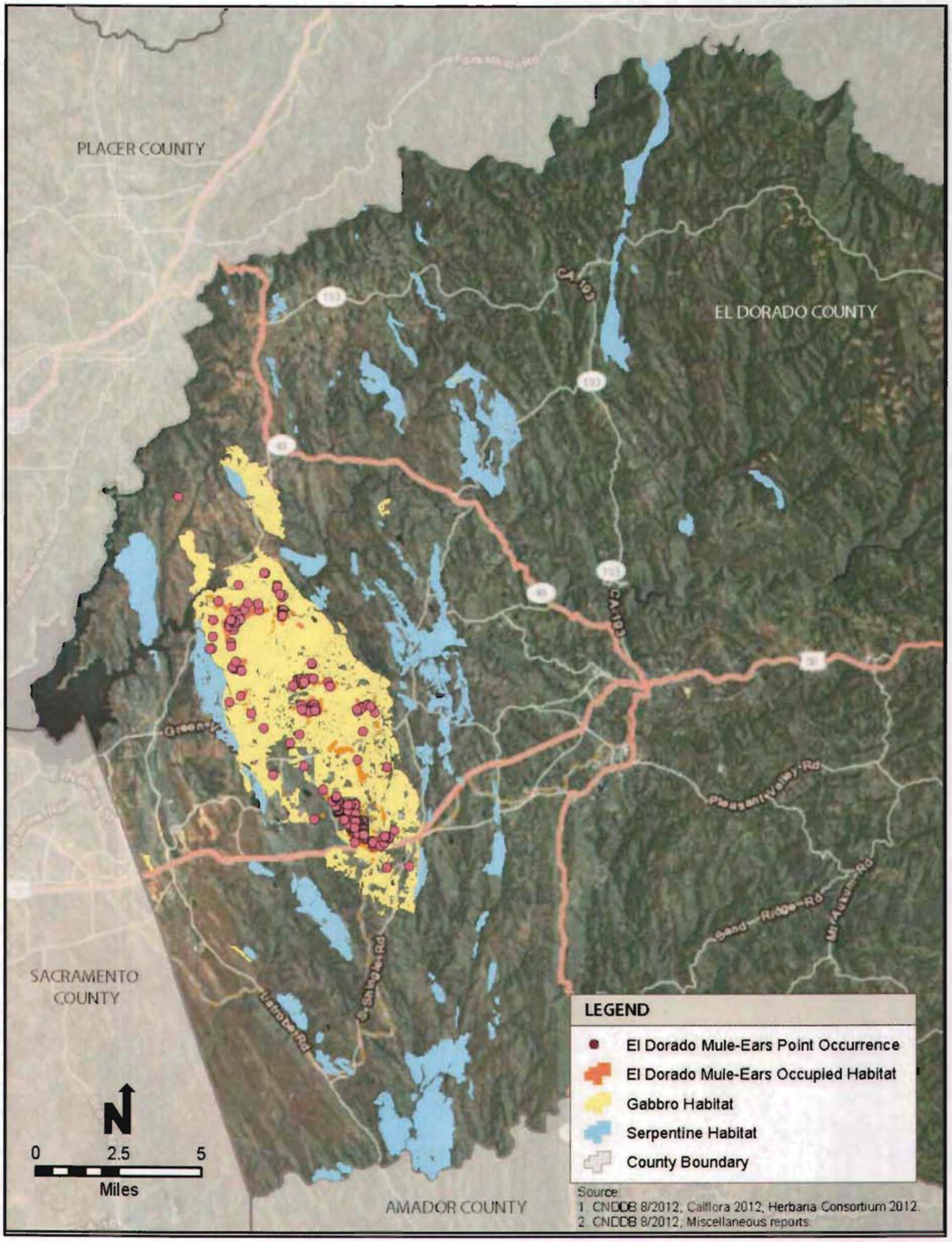

Figure A-7. El Dorado Mule-Ears Recorded Occurrences and Occupied Habitat within the Plan Area

A.2.8 Bisbee Peak Rush-Rose (Peak Rush-Rose)

Description

Bisbee Peak rush-rose (*Helianthemum suffrutescens*) has recently been taxonomically reclassified into peak rush-rose (*Helianthemum scoparium*) (Jepson Flora Project 2012), resulting in a greatly expanded distribution and change in characterization from a rare species to a common species. This account describes peak rush-rose. Peak rush-rose is an evergreen perennial with erect stems (12–65 cm) that are slightly woody at their bases (suffrutescent) and sparsely leaved under dry conditions (Hickman 1993, Jepson Flora Project 2012). The flowers have yellow petals and bloom from April through June (Calflora 2012).

Distribution

Peak rush-rose is found on dry sandy or rocky soil of hills, slopes, ridges below 1,500 meters in elevation in the North Coast ranges, the northern Sierra Nevada foothills, the northern high Sierra Nevada, the San Joaquin Valley, central western California, and southwestern California. See Figure A-8 for its distribution in the Plan Area.

Demography and Ecology

Peak rush-rose produces a dormant soil seed bank that is cued to germinate by the heat of fires, but some seeds germinate during exceptional rainfall years long after fire (Keeley and Davis 2007, Odion and Davis 2000). It has very small seeds that do not emerge from depths below 2.5 cm and are killed by fire-heating of the soil when near the surface (Odion and Davis 2000). Native perennials such peak rush-rose, deer weed (*Lotus scoparius*), and morning glory (*Calystegia macrostegia*) are widespread in the early seral post-fire stage of chaparral (Keeley 2007). In particular, suffrutescents like peak rush-rose are weakly woody species with dormant buds aboveground that generally recruit from a seed bank and are short-lived (5–10 years) (Keeley and Davis 2007). During the first year after a burn it is small, but by the third year it greatly increases in size and becomes a dominant species (Keeley et al. 1981, Keeley et al. 1985). It is considered a "fire perennial" and is normally absent under mature chaparral, although it occurs on rock outcrops and in openings between shrubs (Keeley et al. 1981, Keeley et al. 1985). Peak rush-rose seedlings establish $60/m^2$ in cleared chaparral without fire and only two seedlings/m^2 in uncleared chaparral (McPherson and Muller 1969). Peak rush-rose persists on dry rocky ridges as stems with few leaves and flowers and is not frequent in dense chaparral until after a fire, when it occurs as dense populations of leafy and abundantly flowering plants (Dittman 2009).

Pollination biology and plant breeding system are often determinants of plant population size and the spatial distribution of populations, but these characteristics have not been studied for peak rush-rose. However, a related species, island rush-rose (*Helianthemum greenei*), is self-compatible and capable of producing seed without pollinators, but seed set is significantly higher with pollen transfer among flowers of the same plants suggesting that insect pollination would also significantly increase seed set (McKeachern et al. 1997).

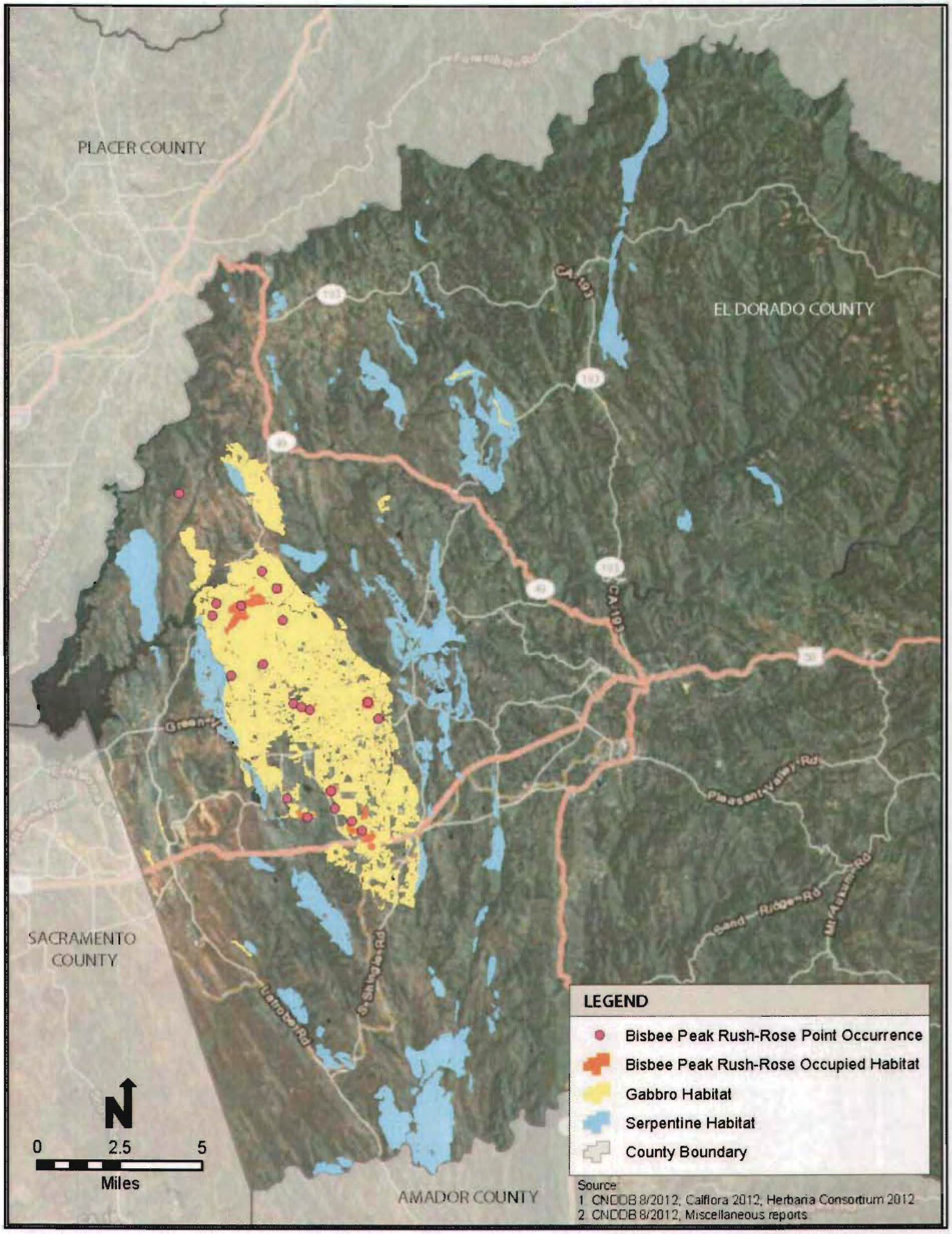

Figure A-8. Bisbee Peak Rush-Rose Recorded Occurrences and Occupied Habitat within the Plan Area

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