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MEMORANDUM

DATE: April 30, 2007 Agenda of: April 12, 2007

TO: Planning Commission Item #: 10.

FROM: Jason R. Hade, AICP, Senior Planner

SUBJECT: TM05-1398-A/Thousand Oaks, Unit 3, Revised Map Public Comments

In order to address environmental issues previously raised at a hearing of December 14, 2006, a revised mitigated negative declaration was prepared and re-circulated for 30-days. The comment period closed on March 29, and three comment letters were received from the following individuals/groups: Douglas West (Attachment 1); Mike Meinz (Attachment 2); and Susan Britting, Ph.D., El Dorado Chapter California Native Plant Society (Attachment 3). The following is a staff analysis of each of the comments received:

In his letter, Mr. West raises concerns regarding proposed septic system impacts to water quality. As noted within the Hydrology and Water Quality section of the prepared environmental document, the septic system was reviewed and approved by the El Dorado County Environmental Management Department, Environmental Health Division, on October 10, 2006. There is no evidence that the cumulative effect of two new septic systems in conjunction with other existing septic systems in the project area will degrade the water quality in the area.

In a letter dated March 26, 2007, Mr. Meinz raises issues concerning the El Dorado bedstraw and water quality. He raised the same issues in his previous comments of November 30, 2006. As the project is located within rare plant mitigation area 1, payment of mitigation area 1 fees reduces the impact to less than significant. However, in an effort to further reduce potential project impacts to the El Dorado bedstraw, the applicant has agreed to implement the mitigation measures identified within the Biological Resources section of the prepared environmental document. The water quality concern is addressed above.

In her letter dated March 28, 2007, Ms. Britting, representing the El Dorado Chapter of the California Native Plant Society, raises concerns regarding the adequacy of the proposed mitigation measures to reduce project impacts on the El Dorado bedstraw. As stated above, payment of the mitigation area 1 fees reduces the impact to less than significant. The applicant has agreed to the additional mitigation measures to further reduce potential project impacts. As

ATTACHMENT 8

such, the comments submitted regarding the adequacy of the transplantation mitigation measures and attached information is irrelevant. Staff disagrees with the opinions provided within the comment letters.

Conclusion: Staff believes the issues raised in the comment letters have been adequately addressed within the revised mitigated negative declaration. No significant environmental issues have been raised in the comments that have not already been addressed.

cc: Larry Appel, Deputy Director, Planning Services
Peter Maurer, Principal Planner
Paula Frantz, Deputy County Counsel
Fred Sanford, Environmental Management Department

ATTACHMENT 1

Mr. Hade,

I am writing in opposition to the Tentative Subdivision Map TM05-1398/ Thousand Oaks, Unit 3 and the negative declaration for this project.

I reside across the pond from Lot 1 at 4000 Meder Rd (Lot 10). One of my major concerns with the above project is the location of the septic system for Lot 1. An ephemeral stream flows in this location during the rainy season. I have collected rainfall data at this location for the past five years (2002 to 2006). In analyzing these data and knowing the topography of the area, I think there is adequate information to call the placement of the septic system into question.

I averaged rainfall data from January through April during the past 5 years. I chose this time frame because, in a normal year, the soil profile should be at field capacity, or nearly so, and the pond is usually full and overflowing by the beginning of January. Average precipitation during this period was 21.1 in. I also looked at the range of daily precipitation totals and discovered that, on average, a 0.25 or greater in./day precipitation event occurred every 4.8 days and a 0.5 or greater in./day precipitation event occurred every 7 days.

Assuming that the ephemeral stream drains an area one acre in size above the proposed septic system area, 21.1 in. of rainfall equals 1.76 acre feet or 527,000 gallons of drainage.

I have observed and photographed the stream after a rain event. It intersects the septic area approximately at the midpoint of its long axis, flows through the Southeast corner of the Vassallo property and continues downhill into the pond.

It's my understanding that the average sized septic system leach field holds about 19000 gallons. Assuming that the system is completely empty, it would take only 3.5% of the drainage volume above to fill the leach field.

This leads me to the following conclusions:

1) There is no doubt that an ephemeral stream exists and that it will directly impact the septic system of Lot 1.

2) There is more than a sufficient volume of water that feeds into the stream to fill the leach lines and transport effluent downstream and into the pond.

3) This will impact not only Lot 1, but also the Vassallo's and perhaps many more properties adjacent to and downstream from the pond.

Even if my estimate of the drainage area above the septic system is incorrect, hundreds of thousands of gallons of water will flow across the surface of and, to a lesser extent, percolate into the proposed septic system. In my opinion, approval of this plan constitutes approval of a pollution source.

I urge you to reconsider the negative declaration for this proposal.

Thank you.

Sincerely,

L. Douglas West

Photo taken over Vassallo fence looking at the Thomas' barn. Stream is visible in lower foreground.

Stream flowing under Vassallo fence.

Stream flowing on Vassallo property.

Stream has exited Vassallo property and is flowing downhill to the pond.

ATTACHMENT 2

March 26, 2007

Mr. Jason Hade
Senior Planner
El Dorado County Planning Commission
2850 Fairland Court
Placerville, CA 95667

Dear Mr. Jason Hade,

Subject: Tentative Map 05-1398/ Thousand Oaks, Unit 3; APN 070-300-15; Set Back and Lot Shape - General Plan Design Waivers.

I was disappointed to discover that your February 13, 2007 revised Mitigated Negative Declaration for Thousand Oaks, Unit 3 still does not adequately address the impact to two public trust issues: the El Dorado bedstraw *(Galium californicum ssp.* sierrae) and public health (water quality) (See my November 30, 2006 and January 17, 2007 comment letters).

El Dorado bedstraw The El Dorado bedstraw is plant only found in El Dorado County and is listed "endangered" and "rare" under the federal and state endangered species acts. Your proposed mitigation to relocate the El Dorado bedstraw from Lot #1 to another site on Lot #2 has no merit. It would result in a net lost of habitat and you have presented no scientific evidence demonstrating that transplanting has any chance of success. As such, construction on Lot #1 "substantial reduces and restricts habitat" and ultimately threatens to eliminate this sensitive native plant community. Ironically, the set back requirements under the new General Plan would protect El Dorado bedstraw while the proposed setback wavier pushes the El Dorado bedstraw to the brink of extinction.

Public Health/Water Quality The impact to surface water quality that would result from construction of a new septic system in Lot #1 has not been adequately addressed. The construction of a new septic system that overlaps an intermittent (ephemeral) stream has the potential for "substantially degrading water quality". It is a hallow argument that the proposed septic system design was reviewed and approved by the El Dorado County Environmental Management Department, Environmental Health Division because no factual on sight evidence was made available to support that conclusion. On November of 2006, I spoke with Fred Sanford via telephone about this project and he had no knowledge that the proposed septic system in Lot # 1 was located on top of ephemeral stream tributary to Kelley Creek. He had no knowledge that the existing subdivision septic systems commonly overflow during rain events and that home owners pick up the odor of raw sewage. He had no water quality data from downstream ponds to support his conclusion that there is no danger to public health. Therefore, the Environmental Health Division letter has no credibility.

An important fact of history is that the initial planning staff report recommended against allowing General Plan design and setback waivers. The General Plan Setback requirements were developed to protect aquatic and riparian resources and were honored by every existing home owner in the subdivision. Relative Thousand Oaks, Unit 3 subdivision, under the General Plan setback requirements, El Dorado bedstraw habitat would be protected and no septic system would be allowed in an ephemeral stream. As a thirty year resident of Shingle Springs, I strongly recommend that the County respects its public trust responsibility and not approve the Thousand Oaks, Unit 3 General Plan design and setback waivers.

Respectfully,

Mike Meinz
Environmental Scientist (Retired)
3356 Hacienda Road
Shingle Springs, CA 95682
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cc: Rusty Dupray
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ATTACHMENT 3

California Native Plant Society

PO Box 377 • Coloma • California • 95613

March 28, 2007

Jason Hade
Senior Planner
El Dorado County Planning Services
2850 Fairland Court
Placerville, CA 95667

Re: Comments on Tentative Subdivision Map TM05-1398/Thousand Oaks

Dear Mr. Hade:

These comments are submitted on behalf of the El Dorado Chapter of the California Native Plant Society (CNPS).

I am a professional biologist with over 14 years experience evaluating native plant resources in El Dorado County. I have served as an expert on the Plant and Wildlife Technical Advisory Committee for El Dorado County providing expertise on native plant and habitat issues. I have also provided technical assistance to state and federal wildlife agencies regarding field identification and habitat information for the rare plants in the Pine Hill area.

The Thousand Oak Project occurs in the within the Gabbro Soils Study area. As indicated in the Biological Resources Report (Sycamore Environmental Consulting, Inc. 2005), approximately 221 plants of the rare plant *Galium californicum* spp. *sierrae* (El Dorado bedstraw) are found on this site. Eighty of these rare plants will be adversely affected by the project. This species is listed as endangered under the Federal Endangered Species Act and listed as rare by the State of California.

The memo to the Planning Commission (February 13, 2007) identifies three mitigation measures designed to reduce impacts to El Dorado bedstraw to less than significant (Mitigation Measures 3, 4 and 5). These mitigation measures fail to reduce impacts to less than significant for a number of reasons.

First, the mitigation measures rely on practices for which the outcome is unknown. There is no information presented to verify the likely success of the propagation method (seed collection and sowing) or transplantation method described. I am not aware of any information or studies that support the claim that El Dorado bedstraw can be successfully propagated by sowing seed directly to a natural site. I am also not aware of any instances where El Dorado bedstraw has been successfully transplanted to a new site.

Transplantation efforts of rare plant species have had mixed success rates. Howald (1996)[1], in a review of forty-one translocation projects in California, found that 13 were determined by the project proponent to be unsuccessful, 7 had limited or partial success, 5 were successful, and the remainder were either in the planning stages or listed as ongoing. Of the 25 projects for which the project proponent was able to make a conclusion about success, only 20% of them were deemed "successful." "Success" in these cases was defined as the project proponent saw fit. As a result, it is not possible to know if their criteria for success are the same as the expectation stated for this project, i.e. no net loss of individuals. Information from the literature indicates that the success of transplantation projects, such as proposed in the amended MND, is far from assured.

Falk et al. (1996, p. 467)[2] point to a general lack of information available on the biology of rare plant species selected for reintroduction and note that "the published literature will rarely be sufficient to answer all relevant questions abut the ecology of a rare plant species proposed for reintroduction. Since these ecological relationships are especially germane to the process of reintroduction, it is unlikely that the practioner will have the desired scientific basis in hand. This leaves reintroduction planners in the position of making more or less educated guesses about the response of species, and makes the practice of restoration generally one of informed speculation. This predicament is most troubling in circumstances in which "failure" has significant consequences, such as critically threatened species, those for which limited resource material is available, or any situation involving the destructive tradeoff with an existing natural population." These very concerns have lead Falk et al. (2006, p. 456) and others to conclude that "reintroductions are fraught with uncertainty and difficulties and should be viewed as experiments. As such, it is unwise to rely on "successful" outcomes, given the risks of failure are significant."

Thus, the there is no information in the mitigated negative declaration to support the claim that the mitigation measures for El Dorado bedstraw will be successful. There is, however, significant information in the literature to indicate that the outcome of the mitigation measures is uncertain and that such efforts are considered by professionals to be experimental. Evidence of the success of the proposed mitigation measures to conserve El Dorado bedstraw should be provided in a revised environmental analysis. In the absence of specific documentation of success, the proposed mitigation methods are considered experimental and can not be relied upon to reduce impacts to this rare species to less than significant.

Second, even if generally one could conclude that propagation and transplanting techniques were available to reliably conserve these plants, there is insufficient site specific detail provided in the mitigation measures to ensure success. The measures do not specify how

---

[1] Howald, A. 1996. Translocation as a mitigation strategy: Lessons from California. In: Restoring Diversity: Strategies for Reintroduction of Endangered Plants. Falk, D. A., Millar, C. I, and Olwell, M. (eds.) Island Press, Covelo, California.

[2] Falk, D. A., Millar, C. I, and Olwell, M. 1996. Guidelines for developing a rare plant reintroduction plan. In: Restoring Diversity: Strategies for Reintroduction of Endangered Plants. Falk, D. A., Millar, C. I, and Olwell, M. (eds.) Island Press, Covelo, California.

or if the site will be prepared for planting, how the planting will be undertaken, or what the ongoing cultural practices will be for the site. The only requirement is for a "qualified botanist" to file letters stating that the seeds have been "properly sown," plants have been "properly transplanted." and to verify that the "plants are growing." In no instance has "proper" been defined in terms of performance measures over a reasonable amount of time (e.g. 100% survival after 5 years time).

As reported in Howald (1996, p. 311), the California Department of Fish and Game adopted translocation guidelines in 1990. "These guidelines call for

- A legally binding mitigation agreement that commits the project proponent to complete all aspects of the mitigation program
- A written mitigation plan that spells out in detail the technical components of the mitigation plan
- Project specific performance criteria that must be approved by the CDFG
- Monitoring for a period of at least five years
- Performance secured through a letter of credit or other negotiable security
- Long-term habitat protection and management that is funded through an endowment fund"

The proposed transplantation strategy for El Dorado bedstraw does not address any of these critical elements. In the absence of these standards, the proposal fails to clearly define the action to be undertaken, establish expectations and provide financial insurance that the outcomes will be achieved.

Third, even if the mitigation measures for propagating and transplanting were shown to have been successful elsewhere, the creation of a "deed restricted area" alone is not sufficient to protect the rare plants in perpetuity. Annual monitoring and enforcement of the deed restriction would be necessary to ensure that the resource is protected.

Fourth, measures to protect the approximately 123 plants occurring at the northern corner of the property are not addressed in the project plan. Activities in this area should also be limited to those that are compatible with the persistence of the rare plants occurring there.

The environmental analysis itself is also inadequate since it fails to assess the cumulative impacts of the loss of El Dorado bedstraw individuals and habitat to project related disturbances. The biological report notes that there are 7 occurrences located within the Shingle Springs quad, but fails to note that in total there are only 11 occurrences known for this rare plant. There is no discussion of the conservation status of these other occurrences, their locations relative to this occurrence or the effect that loss of these individuals may have on the range or distribution of this species. These effects should be addressed in a revised environmental analysis.

The environmental analysis and conditions for approval also do not mention that this project is located in Rare Plant Mitigation Zone 1 nor how this location relates to the mitigation requirements specified in the county's rare plant ordinance. Please explain how this project relates to the mitigation program created by El Dorado County in Chapter 17.71 of the ordinance code.

We ask that the Planning Commission deny approval of the revised mitigated negative declaration proposed by staff in the February 13, 2007 memo until such time as the environmental analysis addresses the concerns we have raised.

If you have further questions, please contact me at (530) 295-8210 or britting@earthlink.net.

Sincerely,

Susan Britting

Susan Britting, Ph.D.

Attachment 1 Howald, A. 1996. Translocation as a mitigation strategy: Lessons from California. In: Restoring Diversity: Strategies for Reintroduction of Endangered Plants. Falk, D. A., Millar, C. I, and Olwell, M. (eds.) Island Press, Covelo, California.

Attachment 2 Falk, D. A., Millar, C. I, and Olwell, M. 1996. Guidelines for developing a rare plant reintroduction plan. In: Restoring Diversity: Strategies for Reintroduction of Endangered Plants. Falk, D. A., Millar, C. I, and Olwell, M. (eds.) Island Press, Covelo, California.

We dedicate this book to all those whose life work is to protect and restore diversity.

Restoring Diversity

Strategies for Reintroduction of Endangered Plants

Edited by Donald A. Falk
Constance I. Millar
Margaret Olwell

Foreword by Reed F. Noss

Center for Plant Conservation
Missouri Botanical Garden

ISLAND PRESS
Washington, D.C. • Covelo, California

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We are deeply grateful to the Center's host institution, the Missouri Botanical Garden, and in particular its director, Peter Raven, for consistent and enthusiastic support of CPC generally and of this project in particular. Without his support, this project would have never come to fruition.

Special thanks are due to the staff, board, and Science Advisory Council of the Center for Plant Conservation, who organized and implemented the program. Staff members Marie Bruegmann and Gregory Wieland played the key roles in organizing the conference, with assistance from staff members Jeanne Cablish, Sheila Kilgore, Michael O'Neal, Grace Padberg, interim director Mick Richardson, and Science Advisory Council Chair Barbara Schaal (Washington University). We also thank CPC Executive Director Brien Meilleur for providing valuable assistance during the preparation and editing of this book.

Organization of the original study project and symposium, and initial work on the book, took place while two of us (Falk and Olwell) were on staff at the Center for Plant Conservation. Since major funding was acquired while we were still at the Center, and CPC provided much logistical support for all aspects of symposium and book development, we wish to acknowledge this relationship prominently. We thank the CPC, as well as Society for Ecological Restoration, and U.S.D.A. Forest Service, for granting us the time to complete the present work.

The twenty-five Participating Institutions of the Center for Plant Conservation constitute some of the best expertise in the biology of rare plant species to be found anywhere. Their staffs, who manage the National Collection of

California. Edited by J. E. Keeley. Los Angeles: Southern California Academy of Sciences.

U.S. Congress. 1995. "Department of the Interior and Related Agencies Appropriations Bill, 1996." *Committee Report* 104-125. July 28, 1995. 168 pages.

U.S. Fish and Wildlife Service. 1981. "U.S. Fish and Wildlife Service Mitigation Policy." *Federal Register* 46 (15): 7644–7663.

U.S. General Accounting Office. 1988. Endangered Species Management Improvements Could Enhance Recovery Programs. Report to the Chairman, Subcommittee on Fisheries and Wildlife Conservation and the Environment, Committee on Merchant Marine and Fisheries, House of Representatives. GAO/RCED-89-5.

Wilcove, D. S., J. McMillan, and K. C. Winston. 1993. "What Exactly Is an Endangered Species? An Analysis of the U.S. Endangered Species List: 1985–1991." *Conservation Biology* 7 (1): 87–93.

Yaffee, S. C. 1991. "Avoiding Endangered Species/Development Conflicts Through Interagency Consultation." In *Balancing on the Brink of Extinction: The Endangered Species Act and Lessons for the Future*. Edited by K. A. Kohm. Washington, D.C.: Island Press.

CHAPTER 13

Translocation As a Mitigation Strategy: Lessons from California

Ann M. Howald

One can spend a lifetime in California and never see all of its natural diversity: The low desert's ocotillo woodlands and palm oases; the South Coast, where sage-covered slopes rise above the surf; the Central Valley, home to remnant tule marshes and riparian forests; the Sierra Nevada's oak-covered foothills and hidden groves of giant sequoias; the Great Basin's western fringe, with its ancient salt lakes and stands of pinyon pine; and the North Coast, where stately redwoods shade ferny canyons and trillium hollows. These landscapes and the promises they hold have brought millions to the Golden State; they are the basis for California's mystique, for its history, and for its current crisis in endangered plant protection.

In California, land development has resulted in the permanent loss of thousands of acres of natural habitat and scores of populations of endangered plants. Translocation has been proposed as a method of reducing these losses. If translocation can be implemented successfully (that is, if an endangered plant population can be removed from one site and established as a self-sustaining entity in another natural site), then it could provide benefits far beyond those of mitigating development impacts. For example, translocation could be used to restore endangered plants to habitats where they have been lost as a result of reversible environmental changes, such as fire and drought. It could also be used to enhance the biological diversity of natural preserves and other protected wildlands. Establishing additional populations of endangered plants in natural sites could give those that have been reduced to only one population, such as marsh sandwort (*Arenaria paludicola*) and showy Indian clover (*Trifolium amoenum*), an important hedge against extinction. However, as previous efforts have made clear, translocations are risky. Our ecological ignorance of most endangered plants forces guesswork into

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U.S. General Accounting Office. 1988. Endangered Species Management Improvements Could Enhance Recovery Programs. Report to the Chairman, Subcommittee on Fisheries and Wildlife Conservation and the Environment, Committee on Merchant Marine and Fisheries, House of Representatives. GAO/RCED-89-5.

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CHAPTER 13

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In California, land development has resulted in the permanent loss of thousands of acres of natural habitat and scores of populations of endangered plants. Translocation has been proposed as a method of reducing these losses. If translocation can be implemented successfully (that is, if an endangered plant population can be removed from one site and established as a self-sustaining entity in another natural site), then it could provide benefits far beyond those of mitigating development impacts. For example, translocation could be used to restore endangered plants to habitats where they have been lost as a result of reversible environmental changes, such as fire and drought. It could also be used to enhance the biological diversity of natural preserves and other protected wildlands. Establishing additional populations of endangered plants in natural sites could give those that have been reduced to only one population, such as marsh sandwort (*Arenaria paludicola*) and showy Indian clover (*Trifolium amoenum*), an important hedge against extinction. However, as previous efforts have made clear, translocations are risky. Our ecological ignorance of most endangered plants forces guesswork into translocation projects. Impatience, economic constraints, and the desire for success, have resulted in less-than-ideal outcomes. In California, the use of translocation to mitigate endangered plant losses remains highly controversial.

How the "California Dream" Has Imperiled Rare Plants

The California flora boasts extremely high levels of diversity and endemism. As Raven (1977) has noted, the California Floristic Province "has more plant species than the central and eastern United States and adjacent Canada, an area more than ten times its size. (p. 111)" The 1978 findings of Raven and Axelrod that 30 percent of California's plant species are endemic to the state have scarcely needed revision even after new taxonomic treatments (Hickman 1993) and recent plant discoveries (Shevock, Ertter, and Taylor 1993; Shevock and Taylor 1987). The new Jepson Manual (Hickman 1993) describes 6,013 native California taxa, of which 31 percent are endemic.

In California, rare plants are found in every region, in nearly every habitat. Figure 13-1 shows the distribution of the more than nine thousand rare plant populations currently mapped by the California Natural Diversity Data Base (CNDDB), a computerized inventory that tracks the status of California's rare plants, animals, and natural communities.

Many of California's rare plants have become endangered due to direct loss of habitat from development, a result of the state's burgeoning population. Through the 1980s the state's population grew by about 2 percent per year, so that by 1990, one in every ten Americans was a Californian (Hoffman 1993). California's population is projected to increase to nearly 35 million by the year 2000, putting further strain on its rare plants. In addition to development, California's flora is imperiled by other human activities that have increased with population growth: agriculture, grazing, mining, off-road vehicle use, and the spread of invasive weeds (CDFG 1992a).

Significant losses of rare plants and their habitats already have occurred in California (Table 13-1). The California Department of Fish and Game (CDFG) and others have estimated habitat losses as high as 94 percent for interior wetlands (Jones and Stokes Associates 1987) and greater than 97 percent for vernal pools in the San Diego area (Bauder 1986). Estimates of the number of California plant species that have become extinct range from twenty-six in the Jepson Manual (Hickman 1993) to thirty-seven in the fifth edition of the California Native Plant Society's Inventory of Rare and Endangered Vascular Plants (Skinner and Pavlik 1993). The Center for Plant Conservation's California Endangered Plant Task Force has identified 143 California plant taxa that are at risk of extinction in the next five to ten years if

FIGURE 13-1. Known locations of rare plants in California.

TABLE 13.1. Losses of habitats, endangered plant species, and endangered plant populations in California.

Resource type	Amount lost
Habitat Type	
Central valley riparian woodland[1]	89 percent
Coastal wetlands	80 percent
Interior wetlands	94 percent
Central valley vernal pools	66 percent
San Diego county vernal pools[2]	97 percent
Endangered plant species	
Extinct[3]	26–37 species
At risk of extinction in 5–10 years[4]	143 species
Endangered plant populations[5]	
Extirpated	256 populations
Probably extirpated	254 populations

1. Estimated losses since 1800 (Jones and Stokes Associates 1987).
2. Estimated losses through 1990 (Bauder 1986).
3. Hickman 1993; Skinner and Pavlik 1993.
4. Center for Plant Conservation 1993.
5. California Natural Diversity Data Base 1993.

actions are not taken to reverse their declines (Center for Plant Conservation 1993). The California Natural Diversity Data Base (1993a) has data to show that more than 250 populations of endangered plants have been extirpated for certain, and another 250 or so are thought to be extirpated.

In response to these threats, the U.S. Fish and Wildlife Service (FWS) and the CDFG already have listed 220 California plant taxa as endangered, threatened, or rare. The service is actively pursuing the listing of another 126 candidates that appear to be eligible for listing (FWS 1993). There is compelling evidence that many other California plants meet the criteria for state or federal listing. For example, the fifth edition of the California Native Plant Society's Inventory lists 841 California taxa that are considered "rare and endangered" (Skinner and Pavlik 1993).

Why Translocation?

Resource agencies such as the CDFG and the FWS are engaged in an ongoing search to identify the most effective methods of mitigating endangered

plant losses (Howald 1993). Translocation is frequently used, although it is not the preferred mitigation method of resource agencies, according to pertinent environmental legislation and agency policies. Both the California Environmental Quality Act (CEQA Section 15370) and the National Environmental Policy Act (NEPA) regulations (40CFR 1508.20) identify the following as mitigation:

- *Avoiding* an impact altogether by not taking a certain action or parts of an action
- *Minimizing* impacts by limiting the degree or magnitude of the action and its implementation
- *Rectifying* the impact by repairing, rehabilitating, or restoring the affected environment
- *Reducing* or eliminating the impact over time by preservation and maintenance operations during the life of the action
- *Compensating* for the impact by replacing or providing substitute resources or environments

Avoidance: The First Priority

NEPA regulations stipulate that avoidance is to be given first priority in reducing project impacts. Many agencies, such as the U.S. Army Corps of Engineers, the U.S. Environmental Protection Agency, the FWS, and other federal agencies responsible for protecting wetlands and endangered species follow this guidance in their reviews of development projects that could harm wetlands and endangered plants. The Sacramento Endangered Species Office of the FWS regularly recommends avoidance rather than compensation, because endangered species' populations and their habitats can't be duplicated, and the long-term viability of these species is seriously threatened as a result of past habitat losses. The CDFG, as the state's trustee agency for natural resources, regularly requests avoidance as its preferred means of mitigation through comments it provides on projects undergoing CEQA review. The CDFG requires developers to demonstrate that avoidance is not feasible before approving translocation projects for state-listed plants (Howald and Wickenheiser 1990).

In spite of resource agency preferences for avoidance, CEQA "lead" agencies, which in many cases are local (county and city) government agencies, frequently do not require project applicants to avoid endangered plant populations. (In California, local governments exercise final control over most development projects through zoning and permitting.) In many cases where impacts to endangered plants are deemed significant under CEQA and therefore require mitigation, lead agencies often turn to translocation as a form of compensation, even though compensation has the lowest priority of the five mitigation alternatives outlined in CEQA and NEPA. (Another form of compensation is protection through acquiring existing natural habitat, sometimes accompanied by restoration.) Translocations typically have consisted of efforts to relocate threatened populations to new sites, sometimes including attempts to "create" the special habitats they require (Howald 1993). Since 1983, CDFG records show that more than sixty development projects have used translocation to mitigate adverse impacts to endangered plants (Fiedler 1991). Another option lead agencies exercise is to allow the project to proceed without mitigation by adopting "overriding considerations," which permit economic or other needs to take precedence over the need to avoid environmental damage.

In relatively few cases do state and federal agencies have the authority to require avoidance. Examples include (1) Army Corps–regulated projects proposed for wetlands that contain federally listed species where the FWS has classified the site as "Resource Category 1," meaning that the site's natural resources are considered unique and irreplaceable; and (2) projects for which a state or federal biological assessment (under provisions of Federal or California Endangered Species Acts) has determined that the project is likely to cause the extinction of a listed species.

"No-Net-Loss" and Endangered Plant Mitigation

The use of translocation to mitigate endangered plant impacts also can be viewed as an outgrowth of agency policies on wetlands. The Army Corps (Clean Water Act, Section 404) and the CDFG (Fish and Game Code, Wetlands Resources Policy) have policies that call for a "no-net-loss" approach to wetland mitigation. This approach requires that loss of wetlands be mitigated by replacement at a 1 to 1 or greater ratio through the creation of new wetlands, preferably the same kind as those lost. Implicit in the strategy is the assumption that the methodology exists to create naturally functioning wetlands—an assumption that has been challenged in California by those who have studied wetlands created for mitigation purposes (Zedler, Chapter Fourteen). Zedler (1991) has stated that "mitigation policies must be put on hold until constructed wetlands are proved capable of attracting and sustaining the full complement of native species. (p. 35)"

In California, the no-net-loss approach has been applied to endangered plants of both wetlands and uplands, although no policy specifically calls for this approach. Mitigation plans propose translocation to "replace" endangered plant populations on a more or less 1:1 basis. They require creation of a population of the same size in both area and numbers of individuals, often without regard for the carrying capacity of the translocation site or the biology of the translocated species.

The Complexity and Difficulty of Translocation

Support for translocation as a viable method of mitigating endangered plant losses has emerged from the favorable results of a few successful experimental translocations and reintroductions. However, the successes only underscore the difficulty of such efforts (and obscure the failures of other efforts). They suggest that it may be possible, under highly controlled and thoroughly monitored circumstances, to establish an endangered plant in a carefully selected new location or even in habitat that has been created expressly to support it. These experimental attempts include a vernal pool creation project in San Diego County (Zedler et al. 1993); the translocation of *Holocarpha macradenia* (Santa Cruz tarplant) in Contra Costa and Alameda counties (Havlik 1989); the introduction of *Oenothera deltoides* ssp. *howellii* (Antioch Dunes evening primrose) to three sites, including dunes at Brannon Island State Recreation Area (Matthews 1990); and the recovery of *Amsinckia grandiflora* (large-flowered fiddleneck) through reintroduction to sites within its historical range (Pavlik 1990).

As Zedler et al. (1993) report, in 1986 forty artificial basins were created in a chaparral environment in San Diego County to mitigate for the loss of *Pogogyne abramsii* (San Diego mesa mint), a state and federally endangered vernal pool endemic. Since their creation, the artificial pools have been monitored annually and compared with nearby natural vernal pools. The authors conclude that this project has resulted in "some degree of success" because many of the vernal pool plants, including the endangered *Pogogyne abramsii*, have become established and have reproduced in the created pools. Their data suggest it is possible to increase the biological diversity of a specific type of coastal chaparral by creating vernal pools within the chaparral matrix. They caution, however, that their monitoring period of five years is relatively short, and that their results may not be applicable in other habitats.

In the case of an ongoing seven-year recovery program for *Amsinckia grandiflora*, Pavlik (1991a, 1992; Chapter Six) has found that three or four out of seven experimental populations may have the potential to survive over the long term, although their survival probably will depend upon long-term management.

Special Problems of the Mitigation Context

Translocations of endangered plants to mitigate impacts to natural populations are burdened with unique problems. The same unanswered biological questions that impede research-based recovery efforts likewise hinder the design of mitigation-related translocations. At least as problematic as biological uncertainties (and often more so) is the need to fit a complicated biological experiment into a framework dictated by the scheduling requirements and financial constraints that accompany land-development projects (Howald 1993).

Fahselt (1988) discusses several objections to the use of transplantation as a conservation technique. Many of his points also are relevant to the use of translocation as a mitigation strategy. He notes that transplanting endangered plants into natural sites may result in degradation of a natural ecosystem that is itself rare. He points out the substantial costs of transplantation projects and suggests that the funds could be better spent protecting the natural ecosystems upon which endangered plants depend. He warns that transplantation advocates may undermine other protection efforts by giving the impression that moving plants from inconvenient sites is an easy and acceptable solution.

Translocating an endangered plant successfully is far from easy, especially when conducted as a form of mitigation. Imagine all that can go wrong in this realistic, although hypothetical, example. A mitigation-related translocation, poorly planned and hastily implemented, is installed at a site selected for reasons of expediency and budget rather than biological suitability. California's notoriously unpredictable rainy season begins with an early deluge that washes away both soil and seedlings. Even after a frantic round of ad hoc remediation, first-year results don't meet performance standards. Pressure to fix what is wrong, speed up the process, and create a "successful" outcome results in actions that clearly go beyond what is natural. Situations like this lead to biological crisis management, wasted time and money, and ultimate failure. They can force actions that do not benefit the species, the environment, or the success of the mitigation effort. Research projects certainly are not immune to pressures of this type, but the need to achieve a specific result within a narrowly defined time frame generally is lacking. Failure in research—rather than a biological and financial catastrophe—is a potential and acceptable outcome.

Lack of Baseline Information

A translocation that stands a good chance of success relies upon a comprehensive knowledge of the ecological and reproductive requirements of the species. One notable example is the experimental reintroductions of *Amsinckia grandiflora* by Pavlik (1991b; Chapter Six). For many plants, especially endangered plants, such information is unknown or is limited to what is derived from short-term field observations of one or a few populations. Many plants now recognized as endangered are found in unusual habitats (such as vernal pools and serpentine areas) and are therefore thought to require unusual soil types, reduced competition, specific pollinators or hosts, or other specialized environmental factors. Understanding these requirements and applying the findings to translocation efforts may require a research program

of several years' duration—a commitment of time and money that can be difficult to obtain in the context of mitigation.

Time constraints imposed by a project's lead agency and by the developer (neither of whom want responsibility for mitigation efforts that extend beyond the construction phase of a project) mean that preproject research to fill baseline data gaps and small-scale experiments to identify effective techniques may be viewed as unrelated to mitigation and as unnecessary extra costs, though these activities could increase the possibilities for successful mitigation.

Lack of Critical Review for Methods and Procedures

Although translocations of endangered plants have been taking place in California for more than ten years, there has not been a comprehensive review of translocation methods. Such a review would provide a basis for selecting the most appropriate methods and for further testing of those that appear most promising. Although no single method or procedure is likely to be shown the most effective in all cases, the translocation design process would be greatly improved if a comparative analysis of methods were available. Planting methods have ranged from direct transplants of whole plants (Hall 1987) and broadcasting of seeds into unmodified habitat (Havlik 1989) to precision-planting of seeds in relocatable plots subjected to a variety of pretreatments (Pavlik 1990). These methods have produced widely varying results. Site selection procedures have resulted in the use of botanical gardens and open space areas chosen without regard to the ecological requirements of the species (Hall 1987), while in other cases sites have been chosen because they contained habitats that appeared to mimic the natural habitat of the species (Havlik 1989; Pavlik and Heisler 1988). Clearly, the choice of methods can strongly influence a translocation's outcome.

Critical review of methods has been stymied by a lack of project documentation. Many projects, especially earlier efforts that could offer valuable opportunities for review of long-term results, were not documented thoroughly enough to permit critical review. Hall (1987) found that in five out of the fifteen mitigation projects she reviewed, documentation was incomplete or inaccurate, or the written records had been lost or misplaced. When available, written documentation of mitigation projects often is in the form of unpublished reports that are not easy to obtain (Fiedler 1991).

No Widely Accepted Performance or Success Standards

The issue of determining how to set standards, both for *performance* (approved methods of carrying out a project) and *success* (criteria by which the outcome of the project will be judged), is unquestionably the most difficult task that agencies face in overseeing mitigation-related translocations. Agencies with mandated responsibility for setting these standards have so far been unable to act, possibly because the studies, analyses, and critical reviews needed to support standards haven't been conducted. As a result, mitigation projects involving translocations and habitat creation have been implemented and evaluated without the benefit of agreed-upon goals for performance and success. A project's "success" or lack thereof has most often been defined and determined by the organization that implemented and monitored it. The question remains open as to whether success standards for mitigation projects should be different from those used for reintroductions conducted for research purposes.

As Pavlik discusses in Chapter Six, deciding what constitutes success in a research-based reintroduction is not a simple matter. He notes that, in this context, success must not imply finality, perfection, or victory, but rather is unpredictable, with no clear endpoint. He has identified a framework for developing a definition of success that could be project-specific yet encourage consistency in design and measurement so that projects on very different plants and habitats could be evaluated and compared. His approach uses four components of a definition of success: abundance, extent (distribution), resilience, and persistence. For each component, he suggests several measurable factors that could be used in crafting a definition. If applied to mitigation-related translocations, Pavlik's approach would be a significant departure from past practices that have ranged from no success criteria to project-specific success criteria that used relatively simple measures, such as estimated abundance and distribution of the "target" species. Most determinations of success have been made after fewer than five years of monitoring, although it may take decades for a translocated population to be subjected to the full range of California's climatic variation.

Cost Factors

Mitigation-related translocations can be expensive, especially if they are done correctly. Although reliable data on these costs are difficult to obtain, the limited information available suggests significant costs are involved. Mitigation funding becomes a particularly significant issue when a small-scale development project encounters the need for a large-scale mitigation effort, such as creating an off-site habitat. In much of California, high real-estate values mean that finding and acquiring a suitable mitigation site represents a significant investment. Developers regularly claim that mitigation costs make their projects financially infeasible (Dunn 1993), and elected officials, particularly those with pro-growth agendas, are reluctant to impose hefty mitigation fees, especially on developers of small-scale projects.

Because mitigation projects are often implemented by companies with a profit motive, mitigation costs are subject to the economics of the marketplace, where competition results in developers' cutting project costs to achieve the lowest bid. Such cost-cutting can compromise the viability of the

mitigation effort if it leads to inadequate planning, design, implementation, monitoring, or maintenance or to selection of a mitigation site that is too small to accommodate the project. This is especially problematic in the absence of clear regulatory guidelines for endangered species mitigation.

Long-term management costs also can be significant. The Center for Natural Lands Management (CNLM) is currently completing an analysis of long-term management costs for the U.S. Environmental Protection Agency (CNLM 1994). The center has data to show that, when overall costs are considered, building in areas of high biological sensitivity is not cost effective. Their study indicates that it is more economical to direct development to areas of lower biological sensitivity than to pay the costs of finding, purchasing, and maintaining over the long term an off-site mitigation area.

Uncertain Outcomes

Experiments with highly complex biological systems are subject to inherent risks. In spite of the best efforts, failure is always a possibility. When mitigation-related translocations fail, intense dissatisfaction may be felt by developers who have spent a lot of money, by agencies who have invested scarce resources to provide oversight and guidance, and by conservationists who have trusted others to protect and conserve irreplaceable natural resources. Although the risks can scarcely be eliminated, the value of these projects would be increased if they were viewed as experimental and thus not likely to provide full mitigation. They would also be more valuable if thorough, long-term monitoring were required, so that even if the translocation is itself a failure the effort is not, because it has produced information that will guide future decisions.

So far, little progress has been made in modifying the mitigation process in California so that it actually delivers what CEQA intended—reduction of impacts to a level of insignificance. In 1989, legislation (Assembly Bill 3180) that requires mitigation monitoring took effect, but its intent seems to be to determine whether mitigation measures were carried out at all rather than to discern success in reducing project impacts. Strengthening any of CEQA's provisions to protect endangered species doesn't appear likely in the near future. In 1993 the California legislature adopted three bills (Assembly Bill 1888, Senate Bills 659 and 919) that weaken the environmental review process by reducing review requirements, shortening review periods, and limiting resource agencies' ability to comment, among other measures.

Mitigation-Related Translocations in California

Critical evaluation of mitigation-related translocations in California has been hindered by the lack of generally accepted definitions of translocation success (Pavlik, Chapter Six) and by inadequate documentation and monitoring.

Monitoring of most projects has lasted less than five years and has lacked rigor (Sutter, Chapter Ten). Hall (1987) reviewed fifteen mitigation-related translocations in San Diego County that involved ten endangered plant species (Table 13-2). She found that only four projects were 100 percent successful (although "success" was generally undefined), and eleven projects had success levels of 50 percent or less. In her study, the aspect of mitigation that was most often neglected was monitoring. To improve success rates she recommended that mitigation-related translocation projects be subject to peer review and bonding requirements and that longer maintenance and monitoring periods be required.

A more recent questionnaire-based survey commissioned by the California Department of Fish and Game (Fiedler 1991) identified forty-five mitigation-related translocations involving thirty-two species that were initiated between 1983 and 1989 (Table 13-3). These translocations were conducted to mitigate the impacts of forty development projects. This survey included some of the same projects that Hall reviewed. The success levels shown in the table are based mainly on the evaluations of those who conducted the projects. Few of the projects utilized specific, measurable criteria for success and, although more recently initiated projects have placed greater emphasis on monitoring and documentation, most have relied on monitoring methodologies that are qualitative, unrepeatable, or unrepresentative. In addition, monitoring has been carried out over too few years to allow reliable evaluation of success.

Case Studies

The following examples illustrate the outcomes of mitigation-related translocations in California. These two examples summarize the findings from a group of projects involving endangered plants found in vernal pools in Sonoma County and a project concerned with *Holocarpha macradenia* (Santa Cruz tarplant), an annual of coastal grasslands. While certain aspects are unique, other mitigation-related translocations in California have experienced similar problems.

Santa Rosa Plain (Sonoma County) Vernal Pools

Vernal pools are seasonal wetlands that fill with water during the winter rainy season and dry out as summer approaches (Zedler 1987). They are found in several parts of California, including the Santa Rosa Plain in Sonoma County, north of San Francisco Bay. They support numerous species of endemic plants, invertebrates, and amphibians and are visited regularly by waterfowl, shorebirds, and other wildlife (Zedler 1987). The Army Corps considers them to be wetlands regulated under Section 404 of the Clean Water

TABLE 13-2. Evaluation of mitigation-related translocation, San Diego County, California, 1986 (Hall 1987).

Case no/species	Success (%)	Technique	Environment	Documentation	Maintenance	Monitoring	Total
1. *Acanthomintha ilicifolia*	0	1	1	0	0	0	2
2. *Acanthomintha ilicifolia*	100	1	1	1	1	1	5
3. *Acanthomintha ilicifolia*	100	1	1	1	1	1	5
4. *Ambrosia pumila*	0	0	0	1	0	0	1
5. *Dudleya attenuata orcuttii*	0	1	0	0	0	0	1
6. *Brodiaea filifolia*	0	1	0	0	0	0	1
7. *Brodiaea filifolia*	100	1	1	0	1	1	4
8. *Baccharis vanessae*	10	1	0	1	0	1	3
9. *Baccharis vanessae*	10	1	1	1	1	1	5
10. *Arctostaphylos glandulosa crassifolia*	50	1	1	1	1	0	4
11. *Monardella linoides viminea*	10	1	0	1	0	0	2
12. *Monardella linoides viminea*	50	1	1	1	0	1	4
13. *Ferocactus viridescens*	100	1	1	1	0	1	4
14. *Opuntia parryi serpentina*	0	0	0	1	0	0	1
15. *Hemizonia conjugens*	0	1	1	0	0	0	2

1 = Satisfactory completion
0 = Deficiency adversely affected project outcome

TABLE 13-3. Mitigation-related translocations in California, 1983–1989.

Species name	Year initiated	Project name/proponent	Success
Acanthomintha ilicifolia	1988	1. Westview/Pardee Company	Ongoing
A. ilicifolia	1988	2. Palos Vista/Shea Homes	~Ongoing
A. ilicifolia	1989	3. Sabre Springs/Pardee Company	Ongoing
A. ilicifolia	1985	4. Indian Hill 5. Las Brisas 6. Spyglass/Unknown	Limited
Antennaria flagellaris	1983	7. None/Bureau of Land Management	Not successful
Blennosperma bakeri	1989	8. Montclair Park/Christopherson Homes	Not successful
B. bakeri	1989	9. San Miguel Estates I/Cobblestone Development Corporation	Ongoing
Brodiaea filifolia	1988	10. San Marcos College Area Specific Plan/Baldwin Company	Ongoing
Brodiaea insignis	1989	11. Kaweah Reservoir Dam Expansion/Calif. Dept. of Water Resources	Planning stage
Calochortus greenei	1989	12. None/Siskiyou County	Not successful
Chorizanthe howellii	1989	13. None/Univ. of Calif., Davis	Ongoing
Cirsium occidentale var. *compactum*	1986	14. Little Pico Bridge Replacement and Piedras Blancas Shoulder Widening/Calif. Dept. of Transportation	Partial
Croton wigginsii	Unknown	15. None/Bureau of Land Management	Not successful
Eriastrum densifolium ssp. *sanctorum*	1988	16. Santa Ana Woollystar Relocation Project/Calif. Dept. of Transportation	Not successful
Eriophyllum mohavense	1988	17. Luz SEGS VII/Calif. Energy Commission	Not successful
Eryngium aristulatum var. *parishii*	1986	18. Del Mar Mesa Vernal Pools/Calif. Dept. of Transportation	Partial
Erysimum capitatum var. *angustatum*	1989	19. Vaca Dixon-Contra Costa 230-kv Reconductoring Project/Pacific Gas and Electric Co.	Partial
Erysimum menziesii	1989	None/Univ. of Calif., Davis	Ongoing
E. menziesii	1987	20. Spanish Bay Golf Course/Unnamed	Not successful
E. menziesii	1988	21. None/Unnamed timber company	Ongoing
Erysimum teretifolium	Unknown	22. Olympia Quarry Revegetation/Lone Star Industries	Planning stage
Gilia tenuiflora ssp. *arenaria*	1987	Spanish Bay Golf Course/Unnamed	Not successful
Hemizonia increscens ssp. *villosa*	1988	23. Gaviota Interim Marine Terminal/Texaco	Ongoing
Hemizonia minthornii	1988	24. Twin Lakes Tank No. 2/Las Virgenes Municipal Water District	Not successful

TABLE 13-3. (Continued)

Species name	Year initiated	Project name/proponent	Success
H. minthornii	Unknown	25. Woolsey Canyon Development/Chateau Builders	Planning stage
Holocarpha macradenia	1986	26. Hilltop Commons Development/Nylen Company	Successful
Lasthenia burkei	1984	27. Airport Blvd. Business Park/Unnamed	Successful
L. burkei	1986	28. Sonoma Co. Airport Expansion/Sonoma Co. Airport	Successful
L. burkei	1989	San Miguel Estates I/Cobblestone Development Corporation	Ongoing
L. burkei	1988	29. Area 31 Waste Water Storage Pond/Sonoma Co. Public Works	Partial
Lilaeopsis masonii	1989	30. Baker Slough Bank Revetment Calif. Dept. of Water Resources	Ongoing
L. masonii	Unknown	31. None/Calif. Dept. of Parks and Recreation	Planning stage
Lupinus milo-bakeri	1985	32. None/Calif. Dept. of Transportation	Not successful
Lupinus tidestromii var. *tidestromii*	1985	Spanish Bay Golf Course/Unnamed	Unknown
Mahonia nevinii	1988	33. Vesting Tentative Tract No. 23267/RANPAC Corporation	Unknown
Monardella linoides ssp. *viminea*	1983	34. None/Calif. Dept. of Transportation	Not successful
Oenothera deltoides ssp. *howellii*	1989	Vaca Dixon-Contra Costa 230-kv Reconductoring Project/Pacific Gas and Electric Co.	Partial
Opuntia basilaris var. *treleasei*	1983	35. Kern River Cogeneration Power Plant/Calif. Energy Commission	Successful
O. basilaris var. *treleasei*	1989	36. Sycamore Cogeneration Project/Sycamore Cogeneration Company	Unknown
Orcuttia viscida	Unknown	37. Sunrise/Douglas Wetland Creation Program/Unnamed	Ongoing
Pentachaeta lyonii	1988	38. Lake Sherwood Golf Course/Unnamed	Not successful
Pogogyne abramsii	1986	Del Mar Mesa Vernal Pools/Calif. Dept. of Transportation	Partial
Pseudobahia peirsonii	Unknown	39. Round Mountain Flood Control Project/Fresno Co. Metropolitan Flood Control District	Planning stage
Sedum albomarginatum	1986	40. Feather River Canyon Storm Damage Repair/Calif. Dept. of Transportation	Not successful
Sidalcea pedata	1988	41. *Sidalcea pedata* Transplantation Project/K-Mart Corporation	Successful

Source: Fiedler 1991; CDFG file information

Act. The vernal pools of the Santa Rosa Plain support populations of three state and federally endangered plants: *Blennosperma bakeri* (Sonoma sunshine), *Limnanthes vinculans* (Sebastopol meadowfoam) and *Lasthenia burkei* (Burke's goldfields) (CNDDB 1993b; Waaland et al. 1989).

The Santa Rosa Plain is one of many areas in California where rapid expansion of urban centers has brought development into direct conflict with endangered plant protection (Snyder 1993; Benfell 1993). Mitigation typically has consisted of attempts to "create" new vernal pool habitat and relocate endangered plant populations into created habitat (Patterson 1990a). As with other translocation projects, critical evaluation of these projects has been hindered by inadequate documentation and lack of accepted success criteria. Even in cases where project-specific success criteria have been applied, short monitoring periods and qualitative monitoring techniques have made it difficult to evaluate the results of individual projects or compare one project to another. Table 13-4 summarizes key information from nine projects utilizing seven mitigation sites, and one proposed project. This table will be referred to throughout this section.

Vernal pool creation has been attempted in other regions of California where natural vernal pool habitats have different species composition, substrate, hardpan type, and surrounding community from those found within

TABLE 13-4. Santa Rosa Plain (Sonoma County) mitigation projects involving endangered plant translocation and vernal pool creation.

Project name	Year initiated	Translocated species	Species at mitigation site before mitigation	Size of mitigation site (ha)	Area of created pools (ha)	Monitoring period (years)	Success criteria	Comments
Airport Business Park[1]	1984	*Lasthenia burkei*	None	≈0.5	0.1	3	No. of plants	Regrading and supplemental seeding required.
Sonoma County Airport[2]	1986	*Lasthenia burkei*	*Lasthenia burkei*	n/a	0	3	None	Unquantified numbers of seeds were spread in existing swales and ditches.
Sonoma County Wastewater[3]	1988	*Lasthenia burkei*	*Lasthenia burkei*	4.8	1.3	5	Created wetlands meet corps criteria; no. of plants	Two of three created pools supported *Lasthenia* in 1992.
Montclair Park[4]	1989	*Blennosperma bakeri*	None	0.4	0.2	5	No. of plants; area of wetland	CDFG deemed failure in 1993; created pools failed to hold water after regrading; located in Sonoma Valley.
San Miguel Rancho/San Miguel Estates I (Alton Lane Mitigation Site)[5]	1989	*Lasthenia burkei* *Blennosperma bakeri*	*Lasthenia burkei* *Blennosperma bakeri*	11.6	3.2	5	No. of plants; area of wetland	Wetland created by excavating basins and berming swales; natural wetlands present at mitigation site.
Northpoint Village[6]	1991	*Limnanthes vinculans*	*Limnanthes vinculans*	3.1	0.2	5	Water-ponding capacity; no. of plants; plant height; flowers/plant	"Test" pools created without agency authorization or approval of mitigation plan; reshaping, regrading, reseeding proposed as remediation.
San Miguel Estates II (Alton Lane Mitigation Site)[7]	1992	*Lasthenia burkei* *Blennosperma bakeri*	*Lasthenia burkei* *Blennosperma bakeri*	11.6	21.0	5	No. of plants; area of wetland	Uplands disturbed when pools excavated after beginning of rainy season.
TMD-Brown (Alton Lane Mitigation Site)[8]	1992	*Lasthenia burkei* *Blennosperma bakeri*	*Blennosperma bakeri*	2.4	1.3	5	Water-ponding capacity; cover of wetlands plants; no. of endangered plants	Uplands disturbed when pools excaved after beginning of rainy season; endangered plant seeds *from mitigation site* used to inoculate created pools.
Graynor[9]	1992	*Lasthenia burkei*	*Lasthenia burkei*	0.4	0.2	5	Water-ponding capacity; no. of plants; area of wetlands	Seeds from another site used to enhance initial seeding effort.
Santa Rosa Air Center[10]	Proposed	*Limnanthes vinculans*	*Limnanthes vinculans*	20	4.4	5	No. of plants; area of wetland	Proposed mitigation would result in 44 percent wetland, 56 percent upland.

Sources: 1. Patterson 1990a 2. Patterson 1990a 3. Western Ecological services 1993 4. Patterson 1990b 5. Patterson 1990a; 1992b 6. Patterson 1990b 7. Patterson 1993 8. Monk and Associates 1993 9. Patterson 1992c 10. Patterson 1992a the Santa Rosa Plain (Ferren and Pritchett 1988; Zedler et al. 1993). Some of these projects have included strong research components (Ferren and Pritchett 1988; Zedler et al. 1993), but even these have been carried out to mitigate the loss of natural vernal pool habitat.

The construction methods used to create vernal pools are generally similar from project to project (Ferren and Pritchett 1988; Patterson 1990a). As described by Patterson (1990a), earth-moving equipment is used to create shallow depressions in poorly drained soils or to berm swales to increase the size and depth of the area of inundation. Grading and scraping are carried out during the dry season in order to avoid destruction of the seedlings of nearby native upland plants by movements of heavy equipment. Seeds and other materials (called inoculum) are removed from the source site by raking or vacuuming and are distributed, usually by hand-sowing, in the created depressions. Sometimes the uppermost layer of soil is collected from the source site and respread in the created basins. The intention is that the created basins, like natural vernal pools, will fill with water during the rainy season and later will support populations of plants and invertebrates derived from transported soil and inoculum, and local amphibians and other organisms will colonize the new breeding site. Some practitioners (Stromberg 1994) have employed extensive soil testing and elevation surveys to achieve desired ponding depths and hydrologic flow patterns, but these methods have not been used on the Santa Rosa Plain.

Establishing Standards for Success

In most cases, success criteria applied to Santa Rosa Plain vernal pool creation projects have been developed by those conducting the project, and they have focused on the "target" endangered species and the hectares of new wetland created (see Table 13-4). None of these projects has been evaluated for success on the basis of more complex measures associated with ecosystem functions, such as providing food-chain support, breeding sites, and habitat for nontarget vernal pool endemics, as has been suggested by Ferren and Gevirtz (1990). Nor have there been useful comparisons of created pools with control or "reference" vernal pools. Preoccupation with growing the same number of individuals of an endangered plant in the created habitat as had been counted (usually during one season) in the sacrificed natural habitat has led to the practice of reseeding mitigation sites repeatedly (Patterson 1990b, 1991a) in an attempt to grow more plants and reach "success" levels, without considering that the carrying capacity of a newly created vernal pool may be far lower (or far higher) than that of the natural site. Focus on numbers of plants and hectares of wetlands as success criteria may derive from the developers' and consultants' perceptions that the only requirement of mitigation is to replace what is specifically protected by law—state and federally listed plants and jurisdictional wetlands.

In California, no agency or other entity has yet proposed statewide standards for defining success either for vernal pool creation or for translocation of endangered plants. The difficulty of this task can't be overestimated. The functional requirements of complex wetlands that support endangered species aren't readily translatable into regulations. Yet a way must be found to evaluate mitigation success. As a first step, a task force of state and federal resource agency representatives is developing standards for vernal pool creation projects in Sacramento County that will be implemented by the Army Corps. Pavlik (Chapter Six) has identified the critical components of a biological definition of success for reintroductions of vascular plants of different life forms (such as annual herbs, perennial herbs, shrubs, and trees), but so far these ideas have not been translated into standards. Kentula et al. (1992) have outlined a strategy to improve decision making in wetland restoration and creation. This strategy, called the Wetland Research Program (WRP) Approach, could be used as a guide in developing performance, success, and monitoring standards for vernal pool creation projects. The WRP Approach emphasizes using natural sites as controls in evaluating created and restored sites.

Agency Attempts to "Regulate" Mitigation Projects

Attempts by the CDFG and other resource agencies to "regulate" the Santa Rosa projects illustrate the difficulties in keeping up with mitigation methods when there are no accepted standards of success or performance. Without accepted standards, each project requires the overseeing agency to defend anew its requests for monitoring, maintenance, and long-term protection—a process that cannot be completed adequately for all projects at current agency staffing levels. As a result, projects in Santa Rosa have proceeded without consistent requirements for implementation or results. In response to the lack of consistency in goals, methods, monitoring, long-term protection, and other aspects of mitigation-related translocation projects, in 1990 the CDFG adopted translocation guidelines (Howald and Wickenheiser 1990) that have served as a first step in regulating mitigation-related translocations of endangered plants. These guidelines call for

- A legally binding *mitigation agreement* that commits the project proponent to complete all aspects of the mitigation program
- A written *mitigation plan* that spells out in detail the technical components of the mitigation program
- Project-specific *performance criteria* that must be approved by the CDFG

- A *monitoring* period of at least five years
- *Performance secured* through a letter of credit or other negotiable security
- Long-term *habitat protection and management* that is funded through an endowment fund

Even though these guidelines lack the force of law, and their use is generally limited to projects under CEQA involving state or federally listed plant species, they could be reasonably effective if the staff needed to implement them were available. In California, the reality is that unmet agency staffing needs leave some mitigation projects with far less oversight than is needed to ensure that implementation and monitoring are proceeding according to plan.

The Need for Better Documentation and Quantitative Monitoring Methods

Most of the mitigation plans and monitoring reports for the Santa Rosa Plain projects have lacked specificity in one or more key elements, such as project design, implementation schedule, monitoring methods, or long-term management. For example, most project designs fail to provide detailed specifications for the size and shape of the created vernal pools. Although some include sketches of the proposed location and size of the created basins, none of the reports includes either preproject topographic maps showing the "before construction" topography or "as-built" maps showing the actual results of construction. This level of detail, recommended for wetlands creation by Kentula et al. (1992), is needed to evaluate whether vernal pool creation projects replicate natural vernal pool habitat. Too often these projects create fewer, larger, and deeper pools than the natural pools that were destroyed. As an example, an insufficiently described phase of vernal pool creation at the Alton Lane mitigation site resulted in created basins that were significantly larger and deeper than any existing local vernal pools. The project was initiated after the rainy season had begun (although the dry season is the recommended period for construction) (Patterson 1992b) and without informing either of the agencies overseeing the project. By the time the CDFG and the FWS became aware that the project was being installed, it was too late to force meaningful changes in design.

Many plans also lack quantitative, repeatable monitoring methods, as described by Patterson (1991a):

> [Typically the full description consists of] multiple visits during the growing season to record visual observations of water depth, [and] water quality and to check the progress of the pool vegetation. Two visits in spring (April to May) are used to record estimates of endangered plant numbers and vigor (height and flowers per plant), to document the vegetation character (floral composition and dominance, cover, richness, vigor) and overall pool ecology (use by birds, amphibians, insects, etc.). Colony numbers are estimated based on and extrapolated from small calibration plots (one square foot to several square meters) whereby a specific count of stems is made within the designated "quadrat" and the extent of plants at similar density is measured by pacing and visual gauging across homogeneous areas.

As this example illustrates, monitoring methods are not quantitative, and data analysis procedures are not provided. The monitoring results typically consist of a narrative description of pool vegetation and rough estimates of numbers of endangered plants present in each natural and created vernal pool. For mitigation sites that include pre-existing populations of endangered plants, the assumption is made that all plants growing in created habitat are a direct result of translocation. Also, in swales that contained endangered plants prior to mitigation-related enlargement, estimates of plant numbers attempt to separate plants resulting from mitigation from naturally occurring plants. However, the method for differentiating "mitigation plants" from "nonmitigation plants" is not described (Patterson 1991a). Estimates of cover, numbers of flowers per plant, plant height, and other measures, when given, are not supported by sampling data or statistical analysis (Patterson 1991a, 1992b). Estimates of the amount of wetland created lack verification that could be provided by conducting a wetland delineation according to the accepted federal method (Environmental Laboratory 1987).

The primary problem with the lack of rigor that characterizes most mitigation monitoring efforts on the Santa Rosa Plain is that it limits the potential for an impartial analysis by someone other than those who conducted the project. This has important implications when it comes to deciding whether the project proponent should be released from further responsibility for mitigation and whether there is a need for remediation. Also, comparisons of results of different projects cannot be made effectively without reliable data. Development of monitoring standards would improve the quality of monitoring and analysis of monitoring results. A more recent Santa Rosa project (Monk and Associates 1993) was required to provide cover estimates for "target" native plants in created vernal pools, but the monitoring of translocated endangered plants still does not go beyond estimates of population size and general observations of whether the plants are "fertile." (see Table 13-4.) In Chapter Ten, Sutter describes elements of a monitoring program that could be adapted to these mitigation projects. As new standards are proposed, resource agencies have a responsibility to inform the consultant community prior to instituting them so that those responsible for designing and monitoring mitigation projects have the opportunity to become properly trained and experienced.

Finding Suitable Mitigation Sites

Within the Santa Rosa Plain, as elsewhere in California, it has been difficult to find acceptable mitigation sites—ones that are large enough to permit long-term retention of habitat values, are close to the impact site (to minimize gene pool manipulation), have environmental conditions likely to support the target species, and are protectable over the long-term through purchase by the project proponent. Private land is sought for mitigation purposes because in California most public land is not available for this use. Policies of some agencies that manage public lands (such as the California Department of Parks and Recreation) do not permit their use to mitigate the impacts of private developments.

The scarcity of good mitigation sites within the Santa Rosa Plain and the desire to protect some existing vernal pool habitat as a component of mitigation has led to the use of sites that already contain natural vernal pools, including some with existing endangered plant populations (see Table 10-4). After mitigation is implemented, these sites contain both created and natural pools, in close proximity. For example, natural pools at the Alton Lane mitigation site are literally a stone's throw from pools that were created in 1989 (Patterson 1990a) and 1992. This site also includes natural swales that were bermed to increase the area of ponded water, thus significantly modifying the hydrology of these features.

Academic and agency scientists have expressed concerns over mitigation projects that have modified existing natural wetlands and have added created pools to sites that already contain natural vernal pools. One result of this practice is the overconversion of upland to wetland. At the Alton Lane mitigation site, the mitigation plan called for 4.2 hectares of wetland to be created on an 11.6-hectare site that already contained at least 1.0 hectare of wetland, resulting in a postcreation ratio of at least 5.2 hectares (45 percent) of wetland to 6.4 hectares (55 percent) of upland (Patterson 1992b).

For a project at the Santa Rosa Air Center, proposed mitigation is to create 4.4 hectares of vernal pool wetlands on a 20-hectare site that already contains 4.4 hectares of wetland, for a final ratio of 8.8 hectares of wetland (44 percent) to 11.2 hectares of upland (56 percent) (Patterson 1992a). These ratios of wetland to upland far exceed the 20 to 25 percent wetland component found at typical natural vernal pool sites within the Santa Rosa Plain (Waaland and Dixon, n.d.). Healthy uplands are an important part of the vernal pool

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ecosystem. They provide essential breeding sites for native bees that are "specialist" pollinators of vernal pool plants, and they provide habitat for other species with critical roles in vernal pool ecosystem function (Thorpe 1990; Fiedler and Laven, Chapter Seven).

Results of Unauthorized Movements of Endangered Plants

Although it is the intent of the CDFG and the USFWS to minimize the distances that endangered plant populations are moved during translocations and to decrease the manipulation of gene pools that can result from population movements, these goals are not always achieved. In Sonoma County two cases have been documented of unauthorized movements of state and federally listed endangered plants outside of their recorded natural ranges as a result of mitigation-related translocations. In the Montclair Park mitigation project, an attempt to create vernal pools to provide replacement habitat for *Blennosperma bakeri* resulted in the inadvertent movement of a second endangered plant, *Lasthenia burkei*, to a watershed where the latter species was previously unknown (Patterson 1990b; CNDDB 1993b). The explanation was that *Lasthenia* seeds were probably transported to the new site on the shoes of the consulting biologist after he had collected seeds of that species elsewhere for another project (Patterson 1990b). In 1993 the CDFG determined that the Montclair Park mitigation project was a failure because the created pools failed to pond water and failed to support sustainable populations of *Blennosperma bakeri*. The City of Sonoma plans to convert the site to another use, leaving unresolved the question of what to do with the out-of-range *Lasthenia* plants, which have reappeared in low numbers each year since 1990.

Another endangered plant, *Limnanthes vinculans*, was the subject in 1987 and 1992 of unauthorized translocations that moved plants north of the species' recorded natural range (Patterson 1989, 1994). In the 1987 incident, seeds collected without authorization from the CDFG's Laguna de Santa Rosa Ecological Reserve were introduced to a receptor site near the Sonoma County Airport, approximately five miles north of the northern limit of its recorded range (Waaland et al. 1989). The purpose was to determine if the airport site could be used as a mitigation area for this species (Patterson 1989). In this case, monitoring in 1988 did not detect the presence of *Limnanthes vinculans* at the airport site, and the experiment was terminated. In 1992 *Limnanthes vinculans* seed collected from a site not affected by development was added to the inoculum for newly constructed pools at the Alton Lane mitigation site without informing regulatory agencies or modifying the original mitigation agreement (Patterson 1994). The intention was to increase the biological diversity of the mitigation site. The consultant was not aware that these activities required special authorization.

These examples highlight the need for standards that would identify a basis for determining the ecogeographic and genetic limits that should be placed on movements of endangered plants in the course of a translocation attempt. Also needed are guidelines for dealing with inadvertant movements out of recorded natural range. One obvious concern is the confusion about authenticity that may result if out-of-range movements are not thoroughly documented.

Even when populations are moved minimal distances, concerns remain over genetic mixing of previously disjunct vernal pool plant populations. Several translocation receptor sites within the Santa Rosa Plain also contain natural vernal pools with existing populations of the translocated species. At present, no studies have been completed investigating the effects of bringing into contact through translocation populations of vernal pool endemics that were previously disjunct. The amount of interpopulation genetic diversity present in these plants is unknown, although an ongoing study is using electrophoresis to investigate this in *Blennosperma bakeri*. Bauder (1993) presents evidence that differences in selection pressure may have fostered genetic differentiation within vernal pool species from Southern California, and that these differences are important to the species' longevity. A debated but unresolved question is whether the mixing of gene pools of endangered plant populations from different microsites creates a beneficial effect by increasing heterozygosity or results in reduced fitness. This is an issue of special concern for the California flora, with its many narrowly endemic species and genera that contain many similar species with incomplete reproductive isolation (Raven and Axelrod 1978; Guerrant, Chapter Eight).

Another genetic concern is raised by the techniques used to collect seeds from source sites. Typically, seeds are collected by raking or vacuuming the current year's seed crop from the pool surface. Most vernal pool plants are annuals and, as Vivrette (1993) has noted, gene pools of annual plants in California often possess a genetic reservoir, in the form of a soil seed bank. These seed banks contain gene combinations derived from many years of varying environmental conditions. Collecting one or even several years' aboveground seed crops captures only a fraction of the real genetic diversity of a population and therefore puts the "new" translocated population at a disadvantage in dealing with future environmental variation.

The Outcome of "No-Net-Loss" Policies

No net benefit to the endangered plants of the Santa Rosa Plain has been achieved through the application of "no-net-loss" wetland policies. CDFG and Army Corps mitigation policies sometimes have the effect of minimizing on-site wetland loss through avoidance, but this often results in "postage

stamp" preserves of less than half a hectare, surrounded by houses. There is virtually no chance that these tiny preserves will protect natural resources over the long term. Lacking buffers and without the ability to preserve natural hydrology or maintain biological relationships with former uplands, these sites become degraded rapidly from trash-dumping, vandalism, and invasion by exotics (Howald 1993). The "no-net-loss" requirement to create new wetlands if any wetlands are destroyed, no matter how small or degraded, means that there is no incentive to protect and leave as is large parcels with relatively undisturbed habitat for endangered plants. Any habitat that is acquired, even that which contains natural vernal pools, will be used to create additional pools. This means that all sites that are protected through mitigation are changed in the process; none remains untouched. Many of these mitigation sites end up compromised or degraded, having lost natural functions and values.

The conservation community has been reluctant to accept an alternative approach to "no-net-loss"—for example, one that is willing to trade the loss of some smaller, less protectable sites for the acquisition and permanent protection of other large, high-quality natural sites. This reluctance may derive from an understandable unwillingness to accept the unmitigated loss of a population and its habitat. Unfortunately, when translocation efforts end in failure, the result is not only the complete loss of endangered plant populations but the continued lack of protection for the very few natural populations that remain (see Bean, Chapter Sixteen). A recent review of CEQA's effectiveness in protecting endangered plants notes that agencies "are attempting to move in the direction of obtaining off-site intact occupied habitat" for endangered plants, "acknowledging that some loss may be offset by the reduced fragmentation and isolation of populations, and the opportunity to protect communities or ecosystems rather than species" (Dennis 1994, pp. 10–11).

Long-Term Management Concerns

Within the Santa Rosa Plain and the nearby Sonoma Valley there are at least seven existing mitigation sites for vernal pools and endangered plants; preliminary plans have been developed for an additional site (see Table 13-4). Several others are planned. The long-term management requirements for most of these sites have not been spelled out, nor is there a comprehensive management plan for the group, although it is likely that even the most successfully implemented projects will require a consistent level of long-term oversight and maintenance. The proliferation of mitigation sites without long-term protection was one factor that led to the development of CDFG's translocation guidelines (Howald and Wickenheiser 1990). CDFG records show that, since 1980, at least fifty-five endangered plant mitigation sites have been established. Since the CDFG guidelines took effect, translocation projects requiring CDFG approval have included provisions for long-term site protection and maintenance.

According to the CDFG guidelines, long-term site protection consists of transferring the property in fee title or placing a conservation easement on the property, with the easement held (or the property owned) by an appropriate agency or conservation group. The Legal Advisor's Office of the CDFG has crafted language for a conservation easement specifically for this purpose. Long-term maintenance is ensured through the transfer of an endowment fund to the agency or conservation group that assumes long-term maintenance responsibilities. The amount of the endowment fund is calculated by estimating the average annual cost of maintaining the site, including expenses for fencing, exotics control, trash removal, and biological monitoring. The endowment fund does not cover expenses associated with education or public use. At CDFG, endowment fund monies are pooled and invested in secure interest-producing instruments such as certificates of deposit. Accumulated interest can be used to fund approved maintenance and protection activities. To date, about 4.4 million dollars have been deposited in this management fund from all mitigation projects, including those for plants and wildlife. In 1993 this fund generated approximately $200,000 for site monitoring and maintenance.

One option for the Santa Rosa Plain sites is management by the Center for Natural Lands Management, a private nonprofit corporation that provides long-term management for mitigation and compensation lands throughout the state. Recognizing California's growing need for management services for an expanding network of mitigation sites, the center's objectives are "to manage natural resource conservation lands in perpetuity . . . to protect and manage for biological diversity, to ensure intelligent and biologically sound mitigation projects . . . to promote through public education and awareness the values of resource conservation and maintaining diversity, and to encourage public involvement and volunteerism in resource conservation" (CNLM, 1993).

The center currently manages sixteen mitigation sites with endangered plants, including two preserves in the southern San Joaquin Valley that comprise thirty-one habitat management units supporting seven species of listed plants.

Santa Cruz Tarplant

Santa Cruz tarplant (*Holocarpha macradenia*) is a summer-blooming annual of coastal grasslands, with a historic distribution that included a northern component in Alameda and Contra Costa counties (part of the "East Bay" region of the San Francisco Bay area) and a southern component in Santa Cruz

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and Monterey counties. By the early 1980s urban and industrial development in the East Bay had resulted in the loss of all known populations of the tarplant in the northern part of the species' range. A population in the City of Pinole, thought at the time to be the largest in existence, was lost when a shopping center was built on the site (Rae 1981).

Havlik (1989) led a last-ditch effort to preserve some representation of Santa Cruz tarplant in the northern part of its range. He salvaged seeds and plants from three populations slated for destruction. The salvaged plants died, but the seeds were used in a series of twenty-two translocations on nearby public land, in habitat that appeared similar in soil type and plant composition to natural tarplant sites (Havlik 1987). Table 13-5 shows the results of annual estimates of population size conducted since 1982 (except 1989). Although these data must be interpreted loosely due to varying census methods and other factors, they indicate that through 1988 most translocation sites supported sizeable populations of tarplant. In 1990, with California well into a seven-year drought, the numbers plummeted (CNDDB 1990, 1991) and remained low until 1993, when some sites showed modest increases (CNDDB 1993c), possibly accounted for by the presence of soil seed banks. These results illustrate that the final outcome of a translocation may not be known for many years. Long-term monitoring is required if we are to find out how these introduced populations fare over time as they are exposed to the full range of California's local climatic variation.

In 1988 a remnant population of Santa Cruz tarplant was found on open land adjacent to the existing Pinole shopping center—land proposed at that time for a shopping center addition. CEQA review of the proposed project resulted in a Negative Declaration, an environmental document prepared when a project is found to result in no significant environmental impacts (or, as in this case, a project whose significant environmental impacts the developer agrees to mitigate "up front" as a part of the project). CDFG biologists sought avoidance of the population through an on-site preserve, but the developer's position that establishing a preserve would make the project financially infeasible was accepted by the CDFG's director.

In November of 1988 the developer signed an agreement committing to mitigate impacts to Santa Cruz tarplant "to the satisfaction of the California Department of Fish and Game" (CDFG 1988), although no specific mitigation plan had been submitted. Over the next four and a half years the CDFG attempted to secure the implementation of an acceptable translocation effort conducted according to CDFG guidelines. This attempt ended in June of 1993 when, after the original developer sold the project, the CDFG's director signed an agreement releasing the new owner from the responsibility of conducting the translocation and committing the CDFG to carry out the mitigation using funds provided by the original developer (CDFG 1993). The

Table 13-5. Census data for Santa Cruz tarplant (Holocarpha macradenia) translocations in Wildcat Canyon, Contra Costa County, California.

Pop no.	1982	1983	1984	1985	1986	1987	1988	1990	1991	1992	1993
1	100	175	1	47	30	250	130	nd	nd	0	0
2	600	1,200	900	2,600	3,000	1,750	5,100	1	1	5	463
3	100	130	25	125	50	300	450	112	15	2	35
4	300	400	400	550	250	100	375	1	nd	1	4
5	50	75	0	50	15	0	0	nd	nd	nd	0
6		300	125	700	700	500	800	nd	nd	nd	4,051
7		130	125	175	100	70	125	0	nd	0	0
8		115	85	34	15	0	15	nd	nd	nd	0
9			250	15	1,200d	200	600	nd	nd	nd	nd
10			0	100	100	100	60	nd	nd	0	16
11			400	1,600	275	1,600	4,000	3	3	18	133
12			750	600	1,050	1,200	800	8	nd		047
13			30	750	600	400	700	nd	nd	nd	11
14			2	7	10	nd	nd	nd	nd	nd	nd
15					750	250	300	1	nd	0	5
16					750	700	1,500	10	nd	0	160
17					30	325	500	12	nd	1	0
18					250	400	1,000	12	12	0	20
19					0	0	0	0	nd	0	0
20*					400	400	500	nd	nd	1,500	nd
21†					20	1	nd	nd	nd	nd	nd
22†						850	3,000	nd	nd	nd	nd

nd = no data *Located on Sobrante Ridge

† Located in the San Pablo Reservoir watershed

Sources: Havlik 1989; CNDDB 1990, 1991, 1992, 1993.

Pinole population of tarplant was destroyed in July of 1993 during construction of a shopping center addition.

This example teaches many lessons. Some deal with the straightforward problems that can arise in any well-intentioned mitigation effort. More important are the seemingly intractable conflicts that arise when a resource agency tries to oversee the solution of a complicated biological problem—one whose satisfactory resolution depends upon the cooperation of a second party that acts in an increasingly recalcitrant manner. Both types are discussed in the sections that follow. They show that the search for more effective means of resolving such situations must lead to recognition of the need for stronger legal protection for plants, alternative acceptable strategies to translocation, and national, agency-sanctioned guidelines for carrying out mitigation-related translocations.

Finding a Suitable Mitigation Site

The Pinole mitigation project provides an all-too-common example of the practical difficulties involved in finding a suitable mitigation site in an essentially urban landscape where property values are high and willing sellers are few. Although the CDFG provided the developer with biological selection criteria and an example of how these could be used (Pavlik and Heisler 1988), a systematic search for a suitable mitigation site was never conducted. One privately owned candidate site was located, but it was owned by another development company unwilling to sell it. As an alternative, the CDFG and the developer engaged in a lengthy negotiation with a local park district to secure permission to use some of their land, which already contained populations of Santa Cruz tarplant introduced by Havlik (1989). In the end this effort was unsuccessful, primarily due to opposition from conservation groups favoring avoidance, who opposed using public land to mitigate the impacts of private development.

Storage and Treatment of Seeds

While the search for a mitigation site was going on, and the details of the mitigation plan were being negotiated, seeds were collected each year from the remnant Pinole population (discovered in 1988). Seeds were collected by hand-picking individual seed heads as they matured. Harvested seed was stored in a trash can in the basement of the environmental consulting company hired to plan the mitigation program until alternate arrangements were requested by CDFG. Any loss of seed viability that may have resulted from these storage conditions was undocumented. Even though essentially all the seed produced by the remnant population was collected each year, new seedlings of this annual plant appeared each spring; in 1993 the population was estimated to be larger (more than five thousand individuals) than at any time since it was discovered in 1988, providing evidence of an extensive seed bank composed of seeds that break dormancy under a variety of conditions. The presence of a soil seed bank may explain some of the observed fluctuations in population size recorded in Table 13-5.

An early draft mitigation plan (LSA Associates 1990) proposed to increase or "bulk" the number of seeds available for the translocation by growing the plants in cultivation, although the seed thus produced would not have had the benefit of selection as it occurs under natural conditions.

If we assume that the success of translocation is largely dependent upon the viability of the propagules used to establish the new population, then proper treatment and storage of an irreplaceable seed source is of fundamental importance. Although the CDFG guidelines call for collection, storage, and treatment procedures that protect seed viability, suitable storage facilities are sometimes not readily available, and resource agency understaffing makes it often impossible to provide the level of oversight needed to assure that proper procedures are used.

Balancing Developer and Agency Goals

Mitigation efforts proceed most smoothly when CEQA lead agencies, developers, consultants, and regulatory agencies understand each other's goals and limitations and work cooperatively to reach an endpoint that satisfies the needs of all parties. In California, CEQA lead agencies are responsible for keeping the CEQA environmental review process on track and for providing adequate opportunity for public contribution to the review process. Developers must concentrate on acquiring the permits required for their project, proceeding as quickly as possible and keeping an eye on the bottom line. Consultants must provide the biological and technical expertise to design and implement mitigation programs. Agencies that manage natural resources must focus on long-term success in maintaining the health of the environment. An attitude of cooperation and respect for each other's divergent goals is essential if effective mitigation is to be achieved.

The saga of the Pinole mitigation project illustrates what happens when cooperation is lacking. In this case, attempts to reach a solution were on several occasions scuttled when the developer, who viewed CDFG's requests for information or additional mitigation plan specificity as unreasonable, used political pressure to avoid taking the steps necessary to develop a satisfactory mitigation plan. No one wins in such situations. A great deal of time and money is wasted, and, in the end, the environment suffers. The primary lesson is that we need stronger legislation to protect endangered plants and their habitats and more options for mitigating unavoidable impacts.

Conclusions and Recommendations

The California experience with using translocation to mitigate impacts to endangered plants shows that, although there are potential benefits, the current process has a number of problems with no quick or easy solutions. The "science" of translocation has its problems: lack of basic information about endangered plants, lack of accepted methods, difficulties in finding and obtaining a mitigation site, and the inherent risks of biological experiments. There are also problems with the regulation of translocation projects, such as lack of established standards for performance and success. There are problems with the framework imposed by the requirements of development projects and problems with the long-term management of mitigation sites. One

response is to throw out the process, but before we advocate that approach, we need to consider the alternatives.

At present, protection for endangered plants in California derives from a patchwork of overlapping and sometimes contradictory laws, policies, and guidelines of local, state, and federal agencies. Only under rare circumstances do endangered plants enjoy the level of legal protection that is required to render them truly secure (Bean, Chapter Sixteen; Berg, Chapter Twelve). Until that situation changes, translocation will remain one of a limited number of mitigation options. Given this scenario, for now it is in the best interests of endangered plant conservation to ensure that translocations, when performed, are carried out in a way that gives endangered plants the greatest possibility for long-term persistence and resilience and provides data to improve future decision making.

More Mitigation Choices Are Needed

At the same time, we must increase the choices for mitigating endangered plant impacts. Mitigation through translocation is too experimental and risky to stand alone. In cases where avoidance is not an option, we need to consider alternatives to the "no-net-loss" approach. In the long run, we may protect an endangered plant more effectively if we allow the loss of some small, degraded populations with little potential for long-term survival in return for permanent protection of larger, more pristine sites. Currently, we are losing some of the best sites through failed translocations without gaining any additional protection for the few good sites that remain.

One way to gain permanent protection for large important sites is to use mitigation banking to consolidate smaller mitigation "debts" toward the purchase and protection of existing high-quality sites. So far, mitigation banking in California has been used mainly in conjunction with wetland creation schemes. One project that seeks to go beyond this, protecting existing alkali wetlands and endangered species, has been delayed for several years, while agency reviewers grapple with the fact that current mitigation banking guidelines do not encompass projects of this type.

Selecting which sites to protect through mitigation banking or other mechanisms could be accomplished through regional habitat conservation planning. A Southern California pilot project of the CDFG's Natural Communities Conservation Program is using a regional evaluation process to prevent the listing of the California gnatcatcher and to protect coastal sage scrub sites and their endangered species (CDFG 1992b). In 1993 federal funding was obtained to prepare a regional conservation plan for the Santa Rosa Plain's vernal pool ecosystem. The plan will identify areas that must be protected and those that can be developed and will streamline the permit process for developers who comply with the goals of the plan.

Stronger Legal Protection Needed for Endangered Plants

Although current challenges to the Federal Endangered Species Act threaten to be the strongest put forth so far, we need to move in the direction of greater protection for endangered plants. Plants have had the reputation of being "second-class citizens" (Berg 1993) in the world of endangered species conservation since the state and federal ESAs were enacted. In California there is a particular need to eliminate exemptions for agriculture (including grazing) and to strengthen the protection plants receive under CEQA and CESA. (see Bean, Chapter Sixteen).

Effective State and Federal Guidelines Needed for Translocations

Improving the quality of mitigation-related translocations requires the implementation of effective state and federal guidelines that cover all aspects of the process. Established guidelines would put regulatory agencies in a stronger position, would reduce the ad hoc nature of current regulation, and would offer developers the security of knowing exactly what is expected of them. The CDFG's guidelines are a start, but to be genuinely effective, comprehensive guidelines should be adopted by all agencies that are involved with mitigation of endangered plants and should address broader questions (for example, as discussed by Falk and Olwell [1992] the need to ensure that mitigation efforts do not contribute to the degradation of valuable natural habitat). In addition, agency staffing levels must be increased if new guidelines are to have a chance of being implemented successfully.

Groups such as the Center for Plant Conservation, native plant societies, botanical gardens, research institutions and conservation groups (IUCN 1992) all have valuable expertise to contribute to the process of developing recognized standards. Part Five presents the guidelines that arose from workshops sponsored by the Center for Plant Conservation during the 1993 *Restoring Diversity* conference.

Recovery Plans Should Guide Process

In the final analysis, the role of mitigation-related translocations in the conservation of an endangered plant should be dictated by the goals of an agency-approved comprehensive recovery program for the species. However, in California only about twenty plant species have approved recovery plans, all of them prepared for federally listed plants. The CDFG is trying to address this lack of recovery planning with a new tool, the Species Management Data Base, a species-specific computerized database that will summarize the information base for the species, list both ongoing and recommended actions, and identify funding sources and experts who can help guide the recovery program. Intensive workshops are being used as a fast-track method to develop priorities and ideas for accomplishing recovery goals.

Recovery planning must develop realistic methods to reduce the level of threat to endangered species and their habitats. For some species, translocation may be the only feasible method for dealing with certain categories of threat and for recovery of species that have diminished appreciably in abundance and distribution within their natural recorded ranges. But the appropriateness of translocation should be determined as a part of an overall program of conservation developed through regional land use planning, not as a last-resort response to imminent destruction.

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REFERENCES

Bauder, E. T. 1986. *San Diego Vernal Pools: Recent and Projected Losses, Their Condition, and Threats to Their Existence, 1970–1990.* Final report to California Department of Fish and Game, Sacramento.

———. 1993. "Genetic Diversity: Esoteric or Essential?" In Proceedings of the Symposium *Interface Between Ecology and Land Development in California.* Edited by J. E. Keeley. Los Angeles: Southern California Academy of Sciences.

Benfell, C. "Wetlands Rule May Hike Cost of Housing." *Santa Rosa Press Democrat*, 19 March, 1993.

Berg, K. S. 1993. "Plants As Second-Class Citizens." In Proceedings of the Symposium *Interface Between Ecology and Land Development in California.* Edited by J. E. Keeley. Los Angeles: Southern California Academy of Sciences.

CDFG (California Department of Fish and Game). 1988. Agreement Between Cemtel and the Department of Fish and Game to Mitigate Impacts to *Holocarpha macradenia*. Public document.

———. 1992a. *1991 Annual Report on the Status of California State-Listed Threatened and Endangered Animals and Plants.* Sacramento: State of California, Resources Agency.

———. 1992b. *Southern California Coastal Sage Scrub Natural Community Conservation Planning Process Guidelines.* Unpublished report. Sacramento: State of California, Resources Agency.

———. 1993. California Endangered Species Act Memorandum of Understanding by and Between Pinole Redevelopment Agency and California Department of Fish and Game Regarding Pinole Vista IV Shopping Center Development. Unpublished Memorandum, reference No. 9310.

CNDDB (California Natural Diversity Data Base). 1990. Field survey forms for 1990 surveys of *Holocarpha macradenia* at Wildcat Canyon Regional Park, Contra Costa County, California Department of Fish and Game, Natural Heritage Division, Sacramento.

———. 1991. Field survey forms for 1991 surveys of *Holocarpha macradenia* at Wildcat Canyon Regional Park, Contra Costa County, California Department of Fish and Game, Natural Heritage Division, Sacramento.

———. 1992. Field survey forms for 1992 surveys of *Holocarpha macradenia* at Wildcat Canyon Regional Park, Contra Costa County, California Department of Fish and Game, Natural Heritage Division, Sacramento.

———. 1993a. Analysis of RareFind data base. Unpublished data. California Department of Fish and Game, Natural Heritage Division, Sacramento.

———. 1993b. RareFind records for *Blennosperma bakeri*, *Lasthenia burkei*, and *Limnanthes vinculans*. Unpublished records. California Department of Fish and Game, Natural Heritage Division, Sacramento.

———. 1993c. Field survey forms for 1993 surveys of *Holocarpha macradenia* at Wildcat Canyon Regional Park, Contra Costa County, California Department of Fish and Game, Natural Heritage Division, Sacramento.

Center for Natural Lands Management. 1993. "Statement of Qualifications." Unpublished document.

———. 1994. "Habitat Management Cost Analysis." Unpublished document. Prepared for Environmental Protection Agency, Sacramento.

CPC (Center for Plant Conservation). 1995. List of California Plants in Danger of Extinction Within the Next Ten Years. Unpublished document. Prepared by the California Task Force.

Dennis, N. B. 1994. "Does CEQA Protect Rare Plants?" *Fremontia* 22 (1): 3–13.

Dunn, J. 1993. "Endangered Builders." *Sonoma Business* 18 (6): 41–44.

Environmental Laboratory. 1987. "Corps of Engineers Wetlands Delineation Manual." Technical Report Y-87-1. Vicksburg, Miss.: U.S. Army Engineer Waterways Experiment Station.

Fahselt, D. 1988. "The Dangers of Transplantation As a Conservation Technique." *Natural Areas Journal* 8 (4): 238–244.

Falk, D. A., and P. Olwell. 1992. "Scientific and Policy Considerations in Restoration and Reintroduction of Endangered Species." *Rhodora* 94: 287–315.

Ferren, W. R., Jr., and D. A. Pritchett. 1988. "Enhancement, Restoration, and Creation of Vernal Pools at Del Sol Open Space and Pool Reserve, Santa Barbara County, California." The Herbarium. Department of Biological Sciences, University of California, Santa Barbara. Environmental Report No. 13.

———, and E. M. Gevirtz. 1990. "Restoration and Creation of Vernal Pools: Cookbook Recipes or Complex Science?" In *Vernal Pool Plants: Their Habitat and Biology*. Edited by D. H. Ikeda and R. A. Schlising. Studies from the Herbarium, California State University, Chico. No. 8.

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Fiedler, P. L. 1991. "Mitigation-Related Transplantation, Relocation and Reintroduction Projects Involving Endangered, Threatened and Rare Plant Species in California." Unpublished report. Sacramento: California Department of Fish and Game, Endangered Plant Program.

Hall, L. A. 1987. "Transplantation of Sensitive Plants As Mitigation for Environmental Impacts." In *Conservation and Management of Rare and Endangered Plants*. Edited by T. S. Elias. Sacramento: California Native Plant Society.

Havlik, N. A. 1987. "The 1986 Santa Cruz Tarweed Relocation Project." In *Conservation and Management of Rare and Endangered Plants*. Edited by T. S. Elias. Sacramento: California Native Plant Society.

———. 1989. "Final Report of the Santa Cruz Tarweed Local Preservation Project, Contra Costa and Alameda Counties, California." Unpublished report. Sacramento: California Department of Fish and Game, Endangered Plant Program.

Hickman, J. C., ed. 1993. *The Jepson Manual*. Berkeley: University of California Press.

Hoffman, M. S., ed. 1993. *The World Almanac and Book of Facts, 1993*. New York: Pharos Books.

Howald, A. M. 1993. "Finding Effective Approaches to Endangered Plant Mitigation." In Proceedings of the Symposium *Interface Between Ecology and Land Development in California*. Edited by J. E. Keeley. Los Angeles: Southern California Academy of Sciences.

Howald, A. M., and L. P. Wickenheiser. 1990. "Mitigation Plan Annotated Outline for Endangered Plants of California." Unpublished report. Sacramento: California Department of Fish and Game.

International Union for the Conservation of Nature and Natural Resources. 1992. "Draft Guidelines for Reintroductions." Species Survival Commission, Reintroduction Specialist Group. Royal Botanic Gardens, Kew, U.K.

Jones and Stokes Associates. 1987. *Sliding Towards Extinction: The State of California's Natural Heritage, 1987*. Unpublished report. San Francisco: The California Nature Conservancy.

Kentula, M. E., R. P. Brooks, S. E. Gwin, C. C. Holland, A. D. Sherman, and J. C. Sifneos. 1992. *An Approach to Improving Decision Making in Wetland Restoration and Creation*. Edited by A. J. Hairston. Corvallis, Ore.: U.S. Environmental Protection Agency, Environmental Research Laboratory.

LSA Associates. 1990. *Draft Mitigation Plan, Santa Cruz Tarplant Relocation, Pinole Vista IV*. Unpublished report.

Matthews, J. R. ed. 1990. *Official World Wildlife Fund Guide to Endangered Species of North America*. Vol. I. Washington, D.C.: Beacham.

Monk and Associates. 1993. "TMD-Brown Wetlands Monitoring Report, Waltzer Meadows Subdivision, Santa Rosa, CA." Unpublished report prepared for TMD-Brown Builders, Santa Rosa, Calif.

Patterson, C. A. 1989. Letter to Mr. Robert Becker, Sonoma County Airport, Calif., 25 February.

———. 1990a. "Vernal Pool Creation and Rare Plant Translocation, Sonoma County, California." Unpublished report.

———. 1990b. "Vernal Pool Creation and Sensitive Plant Translocation at the Montclair Park Development Site, Annual Monitoring Report, Year 1, Sonoma County, California." Unpublished report prepared for Christopherson Homes, Santa Rosa, California.

———. 1991a. "Vernal Wetland and Sensitive Plant Monitoring Report, Year 2, Alton Road Mitigation Site, Sonoma County, California." Unpublished report prepared for Cobblestone Development, Santa Rosa, California.

———. 1991b. "Mitigation Plan for Sebastopol Meadowfoam (*Limnanthes vinculans*), Northpoint Village, Sonoma County, California." Unpublished report prepared for Pine Creek Properties, Santa Rosa, California.

———. 1992a. "Mitigation Plan for Sebastopol Meadowfoam (*Limnanthes vinculans*) at the Santa Rosa Air Center and Madera Parcels, Sonoma County, California." Unpublished report prepared for Madera Avenue Land Associates and Santa Rosa Associates II, San Carlos, California.

———. 1992b. "Vernal Wetland and Sensitive Plant Monitoring Report, Year 3 - 1992, Alton Lane Mitigation Site, Sonoma County, California." Unpublished report prepared for Cobblestone Development, Santa Rosa, California.

———. 1992c. "Mitigation Plan for Burke's Goldfields (*Lasthenia burkei* at the Skylane Business Park (Graynor Property)." Unpublished report prepared for Mr. Rand Graynor, Petaluma, California.

———. 1993. Unpublished maps and tables documenting 1993 census of Alton Lane mitigation site. Prepared for California Department of Fish and Game, Yountville, California.

———. 1994. "Vernal Wetland and Sensitive Plant Monitoring Report, Year 4–1993, Alton Lane Mitigation Site, Sonoma County, California." Unpublished report prepared for Cobblestone Development, Santa Rosa, California.

Pavlik, B. M. 1990. "Reintroduction of *Amsinckia grandiflora* to Stewartville." Unpublished report. Sacramento: California Department of Fish and Game, Endangered Plant Program.

———. 1991a. "Management of Reintroduced and Natural Populations of *Amsinckia grandiflora*." Unpublished report. Sacramento: California Department of Fish and Game, Endangered Plant Program.

———. 1991b. "Reintroduction of *Amsinckia grandiflora* to Three Sites Across Its Historic Range." Unpublished report. Sacramento: California Department of Fish and Game, Endangered Plant Program.

———. 1992. "Inching Towards Recovery: Evaluating the Performance of *Amsinckia grandiflora* Populations Under Different Management Regimes." Unpublished report. Sacramento: California Department of Fish and Game, Endangered Plant Program.

Pavlik, B. M., and K. Heisler. 1988. "Habitat Characterization and Selection of Potential Sites for Establishment of New Populations of *Amsinckia grandiflora*." Unpublished report. Sacramento: California Department of Fish and Game, Endangered Plant Program.

Rael, S. P. 1981. "Efforts Made to Save Endangered Tar Plant." *Outdoor California* 42: 16.

Raven, P. H. 1977. "The California Flora." In *Terrestrial Vegetation of California*. Edited by M. C. Barbour and J. Major. New York: John Wiley and Sons.

Raven, P. H., and D. I. Axelrod. 1978. *Origin and Relationships of the California Flora*. University of California Publications in Botany, Vol. 72. Berkeley: University of California Press.

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Shevock, J. R., B. Ertter, and D. W. Taylor. 1993. "*Neviusia cliftonii* (Rosaceae: Kerieae), an Intriguing New Relict Species from California." *Novon* 2: 285–289.

Shevock, J. R., and D. W. Taylor. 1987. "Plant Exploration in California, the Frontier is Still Here." In *Conservation and Management of Rare and Endangered Plants*. Edited by T. S. Elias. Sacramento: California Native Plant Society.

Skinner, M. W., and B. Pavlik. 1993. *California Native Plant Society Inventory of Rare and Endangered Vascular Plants of California*. Fifth Edition. Sacramento: California Native Plant Society.

Snyder, G. "Hope for Survival of Rare Vernal Pools." *San Francisco Chronicle*, 17 July, 1993.

Stromberg, L. P. 1994. "Physical Site Conditions and Vernal Pool Compensation, Sun City, Roseville, Agency Field Workshop." Unpublished report.

Thorpe, R. W. 1990. "Vernal Pool Flowers and Host-Specific Bees." In *Vernal Pool Plants, Their Habitat and Biology*. Edited by D. H. Ikeda and R. A. Schlising. Studies from the Herbarium, No. 8. Chico: California State University.

FWS (U.S. Fish and Wildlife Service). 1993. Listing packages in progress, plant species. Unpublished list. Sacramento: Endangered Species Office.

Vivrette, N. 1993. "Low Seed Viability in Rare and Endangered Species: A Warning to Vegetation Managers." Paper presented at the Southern California Academy of Sciences symposium Interface Between Ecology and Land Development in California. Abstract only. Los Angeles, California. May 1–2 1992.

Waaland, M., J. Vilms, and R. Thompson. 1989. "Santa Rosa Plains Endangered Plant Protection Program Report." Unpublished report. Sonoma County Planning Department and California Department of Fish and Game.

Waaland, M., and C. Dixon. n.d. "Characteristics of Vernal Pools at Three Sites in the Santa Rosa Plains." Unpublished data.

Western Ecological Services. 1993. "Fourth Year Monitoring Report, County Service Area 31, Airport Wastewater Storage Pond, Wetland Mitigation Project." Unpublished report prepared for County of Sonoma, Santa Rosa, California.

Zedler, J. B. 1991. "The Challenge of Protecting Endangered Species Habitat Along the Southern California Coast." *Coastal Management* 19: 35–53.

Zedler, P. H. 1987. *The Ecology of Southern California Vernal Pools: A Community Profile*. U.S. Fish and Wildlife Service Biological Report 85(7.11).

Zedler, P. H., C. K. Frazier and C. Black. 1993. "Habitat Creation as a Strategy in Ecosystem Preservation: An Example from Vernal Pools in San Diego County." Proceedings of the symposium *Interface Between Ecology and Land Development in California*. Edited by J. E. Keeley. Los Angeles: Southern California Academy of Sciences.

PART V

Guidelines for Developing a Rare Plant Reintroduction Plan

The reintroduction of any species is inherently complex. For endangered species, the complexity is exacerbated by a shortage of sound policies, effective models, and strong scientific underpinnings.

As is clear from several chapters in this book, the science of reintroduction is in its infancy; so too is the development of a policy framework to guide the use of reintroduction as a conservation tool. This policy vacuum is most evident with regard to the relationship between introducing new populations and conserving existing ones—a relationship that remains poorly articulated. For example, the policy of the International Union for Conservation of Nature and Natural Resources (IUCN 1987) describes translocations as powerful tools that can materially advance the diversity and viability of populations and habitat but notes that "like other powerful tools they have the potential to cause enormous damage if misused." (p. 1). The potential damage referred to—and much of the overall concern about reintroduction—is that its use will in some way displace the imperative to conserve existing populations and communities. The challenge, therefore, is to unlock the creative potential of reintroduction while guarding against its possible misuse. As the chapter on compensatory mitigation illustrates clearly, the ecological "meaning" of reintroduction depends largely on whether the natural populations still exist, or if they are somehow lost in the course of a project.

This chapter is intended to assist biologists and managers considering the use of reintroduction as a conservation tool. We have prepared these guidelines in the belief that well-planned and well-executed reintroduction can contribute materially to the goals of biodiversity conservation. While no single book can answer all relevant questions, the chapters in *Restoring Diversity* provide an excellent basis for advancing the understanding of the issues.

Re-establishment of populations is too variable to be reduced to simple formulations; there is no cookbook of reintroduction recipes. We have instead developed a series of questions that practitioners of reintroduction are likely to encounter. To form the framework for a reintroduction plan, the organizers of any well-planned project should be able, at a minimum, to provide coherent and well-researched answers to the following questions:

Is reintroduction appropriate?

1. What guidance can be found in existing policies on rare species reintroduction?
2. What criteria can be used to determine whether a species should be reintroduced?

3. Is reintroduction occurring in a mitigation context involving the loss or alteration of a natural population or community?
4. What legal or regulatory considerations are connected with the reintroduction?

How will reintroduction be conducted?

5. What are the defined goals of this reintroduction, and how will the project be monitored and evaluated?
6. Has available ecological knowledge of the species and its community been reviewed? What additional knowledge is needed to conduct the project well?
7. Who owns the land where the reintroduction is to occur, and how will the land be managed in the long term?
8. Where should the reintroduction occur?
9. What is the genetic composition of the material to be reintroduced?
10. How will the founding population be structured to favor demographic persistence and stability?
11. Are essential ecological processes intact at the site? If not, how will they be established?

These questions and the discussions that follow can help the restorationist cope with the likely event that the operative environments more closely resemble the imperfect world of compromise than they do the ideal. Our intention is, if not to provide definitive answers, at least to provoke good questions complementing other policy discussions (Falk and Olwell 1992; BGCI 1994). The guidelines are intended to be a template for further critical thinking about reintroduction. We hope that these ideas will serve as a foundation for scientists, agencies, non-government organizations, and others to develop specific policies and handbooks relevant to their own work.

We have discussed, in length, the semantics associated with reintroduction, introduction, and augmentation in the Introduction to this book. Restorationists should consider these concepts when setting goals or selecting the site or the source material. Guidelines 5 and 8 discuss the distinction between reintroduction, introduction, and augmentation; therefore, we have not redefined them here.

The biophysical aspects of a rare plant species—that is, the ecological community, the ecological processes, and the environmental context into which the species will be placed—make up the core operational details of reintroduction planning. Each species is unique in its taxonomy, history, ecology, and biogeography; each reintroduction thus presents novel challenges. Several guidelines stress the importance of matching the ecological and physical characteristics (process and structure) of the rare plant in its native habitat with those in the reintroduction site. Some of these elements (such as site selection and selection of source material) are limited to certain phases of a reintroduction; others (such as genetics and ecological processes) are general aspects to consider during several phases of a project.

Is Reintroduction Appropriate?

1. What guidance can be found in existing policies on rare species reintroduction?

In an effort to assess the state of existing rare plant reintroduction policy, the editors and contributors surveyed a wide range of agencies, organizations, and corporations. We reviewed dozens of documents from international conservation organizations, U.S. federal agencies, state agencies, national conservation organizations, private corporations, native plant societies, and professional organizations. These policies, along with the chapters in this book and other published literature, served as the primary materials for development of the guidelines (Table 1).

Many policies were in draft form, reflecting the evolving state of the field. Some policies are broad formulations, while others (such as Gordon 1994) apply only to a single preserve system. United States federal agencies focused primarily on the legal aspects of reintroduction and the ways in which such activity relates to the Endangered Species Act.

In addition to commentary on various specific topics treated in the following sections, several "take-home" messages emerge in existing policies about reintroduction:

- *It is far better, where appropriate, to conserve existing populations and communities than to attempt the difficult and imperfect task of creating new ones.*
- *Reintroductions are fraught with uncertainty and difficulties and should be viewed as experiments.* As such, it is unwise to rely on "successful" outcomes, given the risks of failure are significant (as is often the case in compensatory mitigation).

- *Determining the outcome of reintroduction takes time.* It certainly takes years, and probably takes decades, depending on species and community characteristics. For instance, Birkenshaw (1991) describes a detailed four- to five-year process for initial preparation, outplanting, and preliminary monitoring alone. As Sutter (Chapter Ten) points out, this means that for all practical purposes, monitoring should continue for the foreseeable future in most reintroductions.
- *Learning opportunities exist throughout the reintroduction process.* To reintroduce confidently, we need extensive and detailed knowledge about the species, its community, and the larger ecosystem. For most rare species this knowledge base is minimal and unevenly distributed among species or communities. Most projects will thus have to proceed on the basis of incomplete knowledge and preferably incorporate learning into the project design.
- *Documentation of outcomes of every reintroduction effort is extremely important.* Many journals accept data from reintroduction projects in progress; practitioners and scientists alike should publish preliminary results or progress reports, including negative outcomes (it is every bit as important to learn which techniques failed as it is to learn which ones worked.) If a project is well-conceived and executed, any outcome will yield useful ecological information.
- *Planning and long-term commitment are of utmost importance to the success of a reintroduction project.* Nearly all policy discussions agree that reintroduction is best when it is part of a comprehensive conservation and recovery strategy for the species and its community. If such a plan is developed, then reintroduction can be better incorporated into the larger objectives.

2. What criteria can be used to determine whether a species should be reintroduced?

Practically speaking, reintroductions are nearly always experiments. Accordingly, before beginning a reintroduction, organizations considering such projects should examine critically the reasons for conducting them. Reintroduction may not be the most effective or successful means to

Table 1. Policies and guidelines reviewed.

Agency/ organization	Type of organization	Form of document	Date of document
American Society of Plant Taxonomists	Professional organization	Resolution	1989
Botanic Gardens Conservation International	International conservation organization	Draft handbook	1994
Botanic Gardens Conservation International	International conservation organization	1988 workshop report	1990
Center for Plant Conservation	National conservation organization	Journal article (Falk and Olwell 1992)	1992
Florida Nature Conservancy	State conservation organization	Journal article (Gordon 1994)	1994
Illinois Endangered Species Protection Board	State government agency	Policy	1992
IUCN (International Union for Conservation of Nature and Natural Resources)	International conservation organization	Draft guidelines	1987 1992
National Park Service	Federal government agency	Policy	1988
Nature Conservancy Council (U.K.)	National conservation organization	Guidelines (Birkenshaw 1991)	1991
New England Wild Flower Society	Regional conservation organization	Policy	1992
Native Plant Society of Oregon	State native plant society	Policy	1992
The Nature Conservancy	International conservation organization	Draft policy	1992
U.S. Army Corps of Engineers	Federal government agency	Policy guidance letter	1991
U.S. Bureau of Land Management	Federal government agency	Policy	1992
USDA Forest Service	Federal government agency	Policy	n.d.
U.S. Fish and Wildlife Service	Federal government agency	Draft policy	1992
Waste Management	Private industry	Guidelines	1992
Wisconsin Department of Natural Resources	State government agency	Draft policy	1991

advance the conservation of an endangered species. Careful thought should be given to the reintroduction's potential effects on the future of the species and its community (Reinartz 1995). The expense and effort of reintroducing rare plants and establishing new populations should be undertaken for specific, defensible reasons, and not simply for opportunistic reasons, such as the availability of plant material.

By what criteria, then, can populations and species be selected as promising candidates for reintroduction? The following characteristics may render a species or population a good candidate:

- A species or population is extinct (or nearly so) in the wild. This depends on whether appropriate genetic material is available and whether threats can be managed.
- It has unnaturally few, small, or severely declining populations. Many new tools are emerging that can improve the traditional classification schemes used to identify the most endangered species. Among the most promising are those that use population viability analysis (PVA) to make quantitative, probabilistic predictions about the likelihood of a species becoming extinct (Mace and Lande 1991). While these methods are not without theoretical and pragmatic difficulties (Taylor 1995), they represent a potentially more powerful way to identify species that may be deserving candidates for reintroduction provided that other conditions listed below can be met.
- It has poor protection of existing natural populations.
- It shows evidence of problems with dispersal and/or fragmented habitat. Reintroduction may be a valuable conservation tool for overcoming the inability of some rare plants to disperse effectively to appropriate habitat, especially in fragmented natural habitats.
- It is anticipated to be affected adversely by climate change. Rapid climate change may place new demands and constraints on conservation of rare plant species (Kutner and Morse, Chapter Two; Morse, Chapter One); reintroduction may be part of the solution to these conservation challenges.
- It has available high-quality source material. This material should be genetically diverse, disease free, and of an appropriate provenance.

- It can be successfully propagated and established in experimental trials.
- Its reintroduction is supported by a recovery team. The team agrees that reintroduction will contribute positively to the conservation of the species.

Conversely, certain characteristics may render a species inappropriate for reintroduction:

- Reintroduction or establishment of new populations will undermine the imperative to protect existing sites.
- Feasibility of growing and establishing new populations has not been demonstrated, if the project involves loss of a natural site.
- High-quality appropriate source material is not available.
- Existing threats to natural (or other reintroduced) populations have not been controlled.

3. Is reintroduction occurring in a mitigation context involving the loss or alteration of a natural population or community?

Reintroduction of threatened species is most controversial when practiced in a context of compensatory mitigation. Mitigation directly challenges the relationship of restoration to conservation, in that it requires us to judge the value of existing nature against an artificial substitute. Recognizing that every mitigation case is different, we discuss some of the issues that should be examined.

A broad consensus exists among conservation biologists and planners that it is better to protect existing native populations and communities than to create new ones. Most policies that address compensatory mitigation emphasize the importance of protecting existing diversity. The highest possible priority must be given to avoiding or minimizing impacts to natural populations, especially where rare species or communities are concerned.

However, it is manifestly impossible to fulfill the mandate to "always protect existing sites from development" (Birkenshaw 1991, p. 4). If this were the case, mitigation would not have to occur at all. Compensatory mitigation represents a strategic gamble that the net goals of biological conservation will be furthered if resources of land development and commodity extraction can be diverted to protect some species and some habitats. In addition, legal protection for rare plants often does not apply on privately held lands (Roan, Chapter Sixteen; Klatt and Niemann, Chapter Fifteen). While many

private and corporate landowners voluntarily attempt to avoid damaging rare plants, they are often under no requirement to do so except in the case of wetlands and certain government-permitted activities. In such circumstances there may be no legal way to prevent a development-related translocation.

These realities suggest difficult questions: What, if any, are the characteristics of a good mitigation? Under what circumstances should species or communities be off-limits to any form of tradeoff? Are there circumstances in which mitigation-related reintroduction involving the destruction of a naturally occurring population advances the cause of conservation? Planners should consider the following:

Species Rarity and Vulnerability

Somewhere along the continuum of increasing abundance, an implicit judgment is made that a species is not of conservation concern, and that not every population of a species needs to be protected. For very rare organisms, by contrast, every individual may warrant protection. Somewhere between these two extremes lie the many species for which the fate of an individual population has an uncertain relationship to the future of the species. It is this middle zone of species for which mitigation policy is most important.

Any mitigation policy needs to state clearly that certain species and populations are categorically off limits to destruction. In particular, this applies to extremely rare species—those with very few populations, a small number of individuals, or an extremely restricted geographic range. Unfortunately, terms such as *few*, *small*, and *restricted* lack dimension and can thus be interpreted in several ways. For example, minimum viable population (MVP) standards could conceivably be used to ascertain the sustainable size of a population. But MVP analyses result in probabilistic statements about extinction or persistence, not absolute values. Similarly, rarity is a multidimensional quantitative attribute, not a simple categorical state (Fiedler and Ahouse 1992). The uncomfortable fact is that the threshold for tolerance of a possible destruction event is often difficult to define in intermediate cases of species viability.

There is no standard of rarity, numerical or otherwise, that can be applied across taxonomic and ecological lines. The conservative approach is thus to set limits high: only populations of abundant or stable species should be subjected to mitigation tradeoff. This places the burden of proof squarely on the mitigation proponent, where arguably it should be. The biological rationale for every case must be worked out individually, but mitigation should proceed only when it can be demonstrated with acceptable certainty that there will be no irreparable harm to the species as a whole.

Community or Habitat Uniqueness

Unique habitats are as important to save as are populations of rare species. Certain communities represent an irreplaceable combination of ecological history and function. Many also harbor populations of rare or habitat-restricted species. Mitigation tradeoffs of rare community types should be avoided altogether, if for no other reason than to prevent more species from becoming endangered (See Gann and Gerson, Chapter Seventeen; Zedler, Chapter Fourteen).

Uncertainty and the Distribution Risk

The natural processes of colonization and establishment are often very low-probability affairs. While some aspects can be made more predictable in a deliberate outplanting, a great deal of uncertainty surrounds any newly established population. Reviews of existing literature (Hall 1987; Fiedler 1991) indicate that failures—low germination and establishment rates, losses due to droughts or floods, massive herbivory events, and other obstacles to successful colonization—are more common than success (Howald, Chapter Thirteen; Case Studies). These difficulties may be only the *visible* evidence of failure. Less obvious problems may lurk in reduced gene pools; absent pollinators, dispersal agents, or mycorrhizae; and compromised functional parity with undisturbed natural systems (Zedler, Chapter Fourteen).

The threshold of acceptable certainty must be set substantially higher any time a natural population is proposed for destruction. Where reintroduction is practiced "proactively" (*sensu* New England Wild Flower Society 1992) as a conservation measure to heal past harms, this uncertainty may be tolerated because existing populations are not being placed at additional risk. When the equation involves the destruction of natural populations, however, the balance potentially shifts to the negative. Mitigation often involves trading off existing, naturally occurring habitat for created systems of unknown ecological value and an uncertain future.

One of the central problems with mitigation is the unequal distribution of risk in various parts of the process. For example, when a population is to be destroyed by construction activity and replaced by a newly established population elsewhere, the destruction is certain and immediate; it *will* happen. The replacement, however, faces an uncertain future; its prognosis fifty or even five years in the future cannot be predicted. The brunt of uncertainty, therefore, falls primarily on the replacement population. This asymmetry of risk constitutes a major problem for many proposed mitigation projects.

The condition of the reintroduction site poses an additional difficulty. If, as is often the case, the outplanting site is itself in a degraded or altered condition, then the prospects for successful establishment are reduced further. Altered or degraded sites will rarely offer suitable conditions for trading against any naturally occurring population.

Because mitigation efforts are so uncertain, they should be viewed as a last recourse in dealing with development impacts. Draft U.S. Fish and Wildlife Service policy states that propagation and reintroduction should supplement, not replace, conservation of existing populations (McDonald, Chapter Four). Some corporate policies also recognize avoidance or minimization of impacts to naturally occurring, sensitive populations as preferable (Klatt and Niemann, Chapter Fifteen). Only when impacts to rare species are genuinely unavoidable, after a good-faith effort, should compensatory mitigation be considered as an acceptable alternative.

The Mitigation Time Scale

Transplants take a long time to become part of a functioning ecological community, if they ever do (Pavlik, Chapter Six; Zedler, Chapter Fourteen). There is little research on establishment times for new populations under natural circumstances, let alone artificial outplantings. Whatever insight exists comes largely from the literature on postdisturbance recovery and succession, which suggests that community-level relationships can take decades to equilibrate.

As with the allocation of risk, the relative time scales of destruction and replacement are asymmetrical. Once a project begins, destruction of an existing population or habitat is more or less instantaneous. The "creation" of a new population or habitat, by contrast, is a matter of many years or decades. In combination with the high degree of uncertainty, the long time frame can make the promises of mitigation-related tradeoffs difficult to evaluate (Berg, Chapter Twelve; Zedler, Chapter Fourteen).

Mitigating Impacts Across Biological Levels

One commonly used compensatory mitigation technique involves salvage or rescue of individual rare plants that are about to be destroyed. In some cases entire populations consisting of hundreds of individuals are dug up and relocated. Under the best of circumstances, plants are taken in blocks of soil, in the hope of exporting site-level symbionts to the new location (Johnson, Case Study Six). Most of the time, however, what is removed from the site consists primarily of individual plants to be transplanted elsewhere.

As a form of mitigating impact, this practice obscures the different levels of biological organization affected in both sites. A natural, complex ecological community is lost or destroyed, involving many species and their interactions with each other and with the abiotic environment. What are "saved" are a few individuals representing some fraction of a single population of a single species, with no supporting context. Even in the case of very rare species, this is not an acceptable exchange; if the species is of conservation concern, then so should be the habitat in which it exists.

Eliminating Causes of Decline or Threats

A replacement population can be established only if the original causes of decline have been eliminated. These threats can include invasion by exotic weeds or feral herbivores, disease, suppressed or altered fire regimes, flood suppression, elimination of native pollinators or dispersers, or more pervasive effects such as weather or climate changes (Ledig, Chapter Eleven; Case Studies 2 and 6, this volume). If factors that led to the species' decline remain present, then there may be little reason for confidence in a replacement site. (See Pavlik, Chapter Six; and Pavlik, Nickrent, and Howald 1993) As with reintroduction into physically altered or degraded sites, a mitigation-related outplanting is unlikely to succeed in the long term if the threatening processes have not been eliminated.

4. What legal or regulatory considerations are connected with the reintroduction?

Legal protection for plants is far more limited than legal protection for animals. The most important legislation dealing with the reintroduction of rare plants is the U.S. Endangered Species Act of 1973. The act provides protection for federally listed plants on federal lands and in situations where federal funds, permits, or other actions are involved. The act does not protect endangered plants on private lands.

Reintroduced populations of federally listed plants on federal lands are automatically protected under the act (U.S. Fish and Wildlife Service 1988), and reintroduced populations are protected exactly as the other populations of the listed species, unless the reintroduced populations are listed under the act as experimental. Experimental populations are designated as either *essential* or *nonessential*. An essential population is protected as a threatened species, and a nonessential population is treated as a proposed species under the act. However, the experimental population designation has yet to be used for plants. If a federal agency is worried about reintroducing a listed species onto its lands because the reintroduction would limit their management actions, then an experimental population designation may be useful. In most cases the federal agency considers all sites, puts the reintroduced

population in an area with less conflict, and avoids the use of experimental population designation. To date, no experimental population designation has been used for a plant reintroduction.

If the reintroduction involves federal agencies, then a Section 7 consultation with FWS may be necessary. Permits may be obtained from the U.S. Fish and Wildlife Service (FWS) to collect propagules from lands under federal jurisdiction or to reintroduce a federally listed species on federal lands.

As McDonald (Chapter Four) indicates, draft policy guidance for the U.S. Fish and Wildlife Service states that "propagation programs will not be employed in lieu of habitat conservation (USFWS 1992, p. 1)." Protection of the species and its existing habitat is the foremost objective of a recovery program, with reintroduction being a tool to assist in the recovery of the species.

The lack of federal protection for plants on private lands simplifies the reintroduction process and may increase the likelihood of finding a private property owner who would allow a reintroduction on their property. In the case of *Amsonia kearneyana*, an endangered plant in southern Arizona, it was the goodwill of the owners of a canyon just east of its only known canyon locality who volunteered their property as the site for the reintroduction (Reichenbacher 1990).

State laws regarding endangered plants differ, and not all U.S. states have such legislation. Individual state laws should be checked to see which plants are covered, what activities are allowed, and how the permit process works. (For information on states with rare plant laws or contacts at federal or state agencies see the 1995 *Plant Conservation Directory* [Center for Plant Conservation 1995].)

How Will the Reintroduction Be Conducted?

5. What are the defined goals of this reintroduction, and how will the project be monitored and evaluated?

Once it is determined that reintroduction can help conserve a species or community, the planners must determine what the objectives are and how outcomes will be evaluated. As Pavlik (Chapter Six) notes, however, there is little consensus on standards of success. Moreover, reintroduction projects are so diverse that a single evaluation standard cannot be offered here. Consequently, the evaluation of each project will be based on some combination of standard measures and ad hoc criteria. Further project activities can then be subject to adaptive management if the outcome does not meet those criteria.

Definitions of Success

Pavlik (Chapter Six) defines success at the population level as "meeting taxon-specific objectives that fulfill the goals of abundance, extent, resilience, and persistence." Pavlik is careful to distinguish between this definition of project success and biological success, which "only includes the performance of individuals, populations, and metapopulations of a targeted taxon."

Monitoring

Monitoring is essential for evaluating success in a reintroduction project. Sutter (Chapter Ten) observes that "Monitoring is the foundation of success . . . not a luxury." Sutter sets out four criteria for a reintroduction monitoring program: (1) monitoring data must have a known and acceptable level of precision; (2) data-collection techniques must be repeatable; (3) collection of data must be done over a long enough period of time to capture important natural processes and responses to management; and (4) the monitoring design must be efficient.

In addition, monitoring objectives must be specific and quantifiable and must define the framework for specific tasks. To evaluate outcomes, Sutter (Chapter Ten) suggests four elements of a reintroduced population that need to be monitored: (1) plants reintroduced to the site, (2) recruitment of new individuals, (3) condition and functioning of the community and ecosystem ,and (4) genetic variability of the population of reintroduced plants.

If we begin to think of all reintroductions as experiments, a vital step in any project will be to use the information from monitoring in managing the species or community. Such feedback is crucial because reintroduction should be an iterative process (Pavlik, Chapter Six). Agency plans must be flexible enough so that the original design can be modified to include information gleaned from the monitoring process (a process called adaptive management). However, those conducting reintroductions should not be too quick to change a monitoring or evaluation scheme simply because a project doesn't appear to be progressing as planned. The failure of a new population to establish provides important information about the biology of threatened and endangered plants and about the frequency of successful establishment in reintroduction programs (Pavlik 1994).

6. Has available ecological knowledge of the species and its community been reviewed? What additional knowledge is needed to conduct the project well?

Although most guidelines and policy formulations state that reintroduction should be based on a sound understanding of species and community ecology, there remains a general shortage of reliable information about many rare species. In such cases, should a project proceed or be delayed until an adequate (however defined) knowledge base exists? Moreover, it is commonly recommended that each reintroduction be treated as an experiment, in terms both of acknowledging uncertain outcomes and gleaning opportunities for learning. But designing an experiment to generate knowledge and designing an implementation project to maximize chances of short-term success may require different approaches. Can reintroduction be designed simultaneously as potential successes and as experiments?

Basic Knowledge of Rare Species Biology

The field is wide open for research initiatives into rare species biology, especially for work involving the ecology of reintroduction and restoration (Wildt and Seal 1988; Falk and Holsinger 1991; Bowles and Whelan 1994; Schemske et al. 1994). The published literature will rarely be sufficient to answer all relevant questions about the ecology of a rare plant species proposed for reintroduction. Since these ecological relationships are especially germane to the process of reintroduction, it is unlikely that the practitioner will have the desired scientific basis in hand. This leaves reintroduction planners in the position of making more or less educated guesses about the response of the species, and makes the practice of restoration generally one of informed speculation. This predicament is most troubling in circumstances in which "failure" has significant consequences, such as critically threatened species, those for which very limited source material is available, or any situation involving a destructive tradeoff with an existing natural population.

Translocations as Experiments

To some extent, simply documenting and publishing methods and outcomes will improve empirical understanding of reintroduction ecology. But if reintroductions are to serve as more refined investigations, they must conform to the criteria that would make them good experiments. This means including the basic elements of experimental design: controls, replication, a limited number of variables, and tests of statistical significance. These conditions are not automatically satisfied in applied restoration work, where the proximate objective may be to succeed according to the terms of a contract, rather than to learn. There is no standard formula for achieving the correct balance of immediate results and expanding knowledge, although the two should be recognized as complementary in the long run (Zedler, Chapter Fourteen).

Any reintroduction project can contribute to the empirical knowledge base by recording baseline conditions. This includes carefully recording the number and type of individuals outplanted, their genetic diversity (if known), outplanting protocols (spacing, depth), soil treatments, management measures, and a detailed description of the receptor site and locality, preferably in a Geographic Information System (GIS). At the very least, this information should be recorded in the archives of a public or private conservation agency; a better practice is to offer the data for publication. Without such information, the knowledge surrounding reintroduction projects may be as ephemeral as the memories of those who conducted them; with proper documentation, projects can serve as empirical tests to which restoration ecologists can return decades later to interpret long-term outcomes. This orientation to the long term is vital to understanding natural ranges of variation and performing trend analyses for ecological responses such as population size and genetic variation. It is also probably the only means by which long-term empirical studies of time scales in the reintroduction process will be carried out. The key to all this is to capture baseline data early.

Some of the best research opportunities are for study of the ecological processes that reintroduction mimics: founder events, small population dynamics, establishment-phase competition, dispersal and disturbance ecology, and patch dynamics. Studies can be directed at colonization of ephemeral or disturbed habitats and at the effects of succession on population persistence, resilience, and stability over time. Cohort studies of reintroduced populations can provide data on the natural range of variation in survival, mortality, and recruitment. Reintroducing plants along gradients of key habitat parameters (moisture, light, elevation) will allow examination of the influence of these and other measures of habitat specificity.

Designing a study for research purposes may require a different approach than for maximizing short-term "success," at least in some instances. Research studies typically focus on a limited number of variables, and provide a wide enough range of conditions in the chosen variables to permit hypothesis testing. This means that some translocated plants may "fail" by growing, reproducing, or surviving at a lower rate than plants exposed to

other conditions in the test matrix. In other words, an experiment may "succeed" in explaining different outcomes, but "fail" to result in the establishment of a permanently viable population. By contrast, if the primary objective is to establish a viable population, then outplanting may need to be restricted to (or at least centered on) conditions known to offer the best prospects for survival. Hybrid approaches are possible, in which a somewhat larger number of variables are tested across a more limited magnitude of values, without the full range of conditions or controls. Under these circumstances, outplanting may provide some usable scientific information and create a viable population.

While the outcome of any individual reintroduction project is unknown at the beginning, the complex interactions of many factors offer an exciting and important opportunity for learning. As reintroduction progresses from trial-and-error to an adaptive ecological management tool, its design can increasingly accommodate needs for both science and conservation practice (Pavlik 1994). Over time, careful experiments will improve both the base of knowledge and the prospects for success.

7. Who owns the land where the reintroduction is to occur, and how will the land be managed in the long term?

Long-term funding and land management are important elements of any reintroduction plan. Many reintroductions are conducted without adequate planning for land use, management, or financial support. Since a reintroduction may take years or even decades to stabilize, inadequate planning can seriously compromise the long-term prospects for success. A reintroduction project that needs two decades of monitoring may outlast the tenure of most agency personnel.

LANDOWNER COMMITMENT TO PERMANENT SITE PROTECTION

For rare plant reintroduction to be of permanent value to conservation, the habitat must be securely protected for the long term. Landowners and land managers of the sites must be brought into the dialogue early in the planning phase. The Knowlton cactus reintroduction project (Cully, *Pediocactus knowltonii* Case Study Two) began with considerable dialogue and commitment between seven federal and state agencies and one conservation organization. It is this continued dialogue and commitment that keep the project going ten years later. There are, unfortunately, many cases in which a rare plant was reintroduced onto a site and eventually forgotten because of personnel or priority changes. In some cases these "forgotten" sites were later used for other purposes—parking lots, building sites or, mowed roadsides—not compatible with the population's survival (Hall 1987). Texas snowbells (McDonald, Case Study Three) illustrates of public and private landowner cooperation in a political climate that would otherwise be unsupportive.

A useful litmus test is to determine if the reintroduction is basic or incidental to the owner's primary interest or the managing agency's mission. Commitment by the landowner or manager to the project in general, and the use of the reintroduction site specifically, needs to be secured prior to initiating the project. Without a long-term commitment to protecting and managing the site, reintroduction projects are exposed to elevated long-term risk. A reintroduction plan should outline the main elements of the long-term program. This plan may take various forms, such as a recovery plan or land use document. Private lands can be secured by an easement or, as in the case of *Amsonia kearneyana*, by voluntary agreement with the landowner (Reichenbacher 1990). Reintroduction plans should cover a period as long as required by the institutional, legal, biological, and monitoring requirements of each species reintroduced; this will rarely be less than five years.

FUNDING FOR LONG-TERM MANAGEMENT

Two reviews of the outcomes of rare plant reintroduction work in California (Hall 1987; Fiedler 1991) found follow-up to be lacking in many projects. The main reason was the shortage of funds allocated to monitoring and ongoing habitat management. To design a legitimate reintroduction project, planners must define the time frame associated with measuring those outcomes and then incorporate these costs associated with the full life of the project. Such planning will make many reintroduction projects more expensive, but two benefits are realized: first, the process provides a more realistic assessment of the real long-term costs. Second, once such costs are made explicit as part of the agency's commitment, it may be more difficult for them to be rescinded than if they were "invisible" in the organization's budget.

Even if costs can be estimated for the entire life of the project, it may be difficult to secure financial commitment for a long-term project. Funds are usually appropriated to federal and state agencies on an annual basis, although programmatic commitments extend into decades. Funding for reintroduction projects undertaken in a mitigation context and paid for by a developer is often subject to even more stringent funding constraints, unless longer management is required by law. Institutional commitment and involvement in the project may improve prospects of funding for the full life of the project. In the extreme cases, conservationists may find it necessary to

refuse to undertake an outplanting project without long-term commitment and funding. Such a position would send a strong message about what is required to reintroduce rare plants successfully.

Bean (Chapter Sixteen) and Klatt and Niemann (Chapter Fifteen) suggest various ways for securing a long-term commitment. These include dedicated trust funds, surety bonds, and other irrevocable financial guarantees to be used for ecosystem management. Many statutory and contractual models exist for such guarantees, which can be adapted from construction and performance bonding or siting hazardous waste facilities. Although financial assurances for endangered species projects are generally not required at present, such guarantees could be included by regulatory agencies as a permit condition. Such up-front financial commitment is preferable if it can be obtained, in part because of the security afforded for the future.

HABITAT MANAGEMENT

A reintroduction site must be managed as an ongoing ecological unit long after the initial outplanting. Processes that need to be addressed include controlling exotic plants and animals, restoring disturbance regimes such as fire and floods, and reducing new sources of anthropogenic impact (Huenneke and Thompson 1995).

The reintroduction plan should also consider the bioregional context of the project. Since all reintroduction projects should aim to become part of landscape-scale conservation efforts, knowledge of current and future land use is imperative. By focusing on landscape-level management one can better ensure that the reintroduction is nested in a larger context and not subject to short-sighted decisions and policy changes.

OTHER LAND-MANAGEMENT CONSIDERATIONS

Populations of some rare species (such as *Betula uber* and *Asclepias meadii* have experienced what appear to be intentional acts of vandalism. Reintroduction in controversial locations (such as range allotments on public lands) may be similarly vulnerable. Public ownership can offer strong protection, although private nature preserves may be superior if available. Potential future landscape configurations should be considered in selecting the best site. For example, will land settlement or land management practices around the site result in a biological island for the rare plant?

Availability of superior sites meeting all criteria (see Guideline 8) will almost always be the limiting factor; the best site may be prohibitively expensive to obtain or administratively or practically unavailable.

8. Where should the reintroduction occur?

Selection of a reintroduction site is a central decision in any project; perhaps no other single aspect influences the eventual outcome as strongly. Site selection involves important long-term considerations of security, management, and monitoring physical/geomorphic, biological, and spatial-temporal considerations. And yet, as Birkenshaw (1991, p. 6) notes, "[E]xcept in the case of re-establishment . . . the selection of a translocation site is, to some extent, a shot in the dark."

Once a decision has been made to proceed with reintroduction, a key step is selecting the receptor site on which the new population will be established. Ideally, it is best to match physical and ecological conditions of the species in its native range with the reintroduction site. In practice, however, outplanting may have to occur in areas with introduced exotics, communities that differ from the species' native habitat, and the unpredictable challenges of climate change.

CRITERIA FOR SUITABLE TRANSLOCATION SITES

The ideal receptor site is not difficult to define hypothetically: it matches the habitat characteristics of the target species (such as biotic community, ecosystem function, and spatial context), and especially of those native populations closest and most similar to the potential receptor site. In practice, however, these conditions are rarely satisfied, for several reasons. First, for only a very few species can we define optimal (or even typical) habitat. The distribution of many rare species has been fragmented or altered, and existing populations often occur in habitat that is far from ideal. Superficially suitable reintroduction sites may prove to be unsuitable because of a cryptic ecological factor in soil chemistry, microhabitat or microclimate relations, absent pollinators, or mycorrhizae (Allen 1993). Second, even where appropriate conditions can be defined with some accuracy, available receptor sites that match these characteristics often do not exist. Available suitable sites may be too small or may lie on unprotected land, while land under reasonably secure management may not offer the appropriate biotic or abiotic environment. And third, sites that are ecologically suitable and protected may nonetheless fall outside of the species' known range. Or they may fall within its overall range but with no evidence that the species occurred at a particular location.

Site selection thus represents a series of tactical compromises. The process begins by determining areas encompassing tolerable variation in key biotic and abiotic parameters, which define suitable potential habitat (figure 1). These include commonly used physical site indices (soil, available moisture, temperature regime, topographic position) as well as various characteristics of the biotic community. This envelope of feasibility may be compared to an envelope of security, areas that meet the administrative and management criteria discussed previously. Among areas meeting these criteria, the restorationist can then select sites of known or suspected historical occurrence within a specified time frame. In this manner, potential receptor sites may be evaluated in terms of ecological, administrative, and historical suitability. Note that Figure 1 is a conceptual set diagram, not a "map" of a physical area; actual sites meeting the criteria may be patchy and dispersed across the landscape.

Three groups of sites emerge as possible reintroduction locations. Preferred sites are those that meet all three criteria. A second tier meets habitat and protection criteria but may fail (or not be demonstrated to meet) the criterion of historical occurrence. Ecologically and historically suitable sites on unprotected land would also fall into this category. Third-tier sites meet only the criterion of feasibility. Beyond this envelope, sites are neither biologically

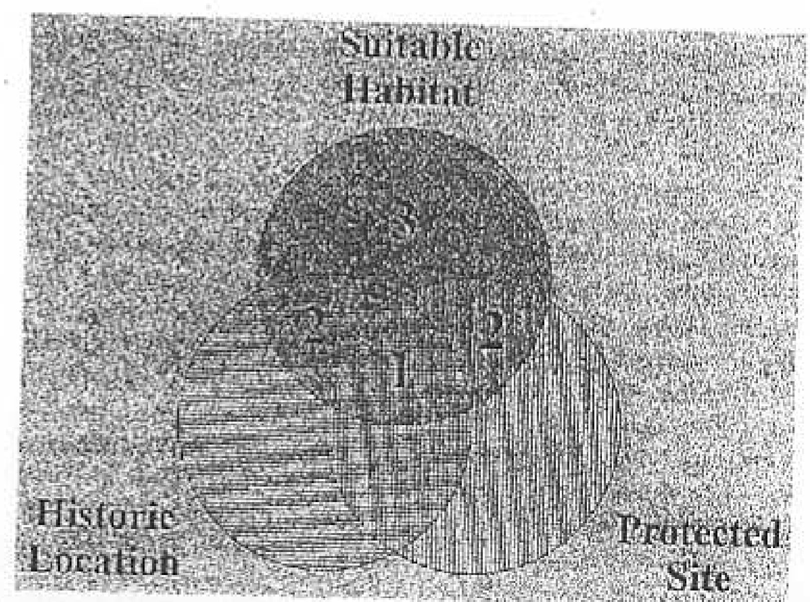

FIGURE 1. Set diagram for evaluating potential reintroduction sites. Sites may be evaluated for the degree to which they meet primary criteria for habitat suitability, protection, and historic locality. Preferred sites (1) meet all three criteria to a high degree; secondary sites (2) meet two criteria, one of which must be ecological suitability. Tertiary sites (3) pass only the test of habitat suitability. All other sites are presumed to be nonviable for both ecological and conservation purposes.

nor administratively viable for the species in question. Any proposed reintroduction site may be classified according to these criteria.

The Historical Range Issue

Existing policies vary in their approach to site selection and historical range. The U.S. Bureau of Land Management (1992, p. 11) permits release outside of historical range "for those threatened and endangered species for which remaining historical habitat has been destroyed or otherwise rendered unsuitable." The Botanical Society for the British Isles (Birkenshaw 1991) categorically restricts reintroductions to sites within 1 kilometer of a documented locality and considers all other outplantings to be introductions. The Illinois Endangered Species Protection Board (1992, p. 1) states unequivocally that outplantings "should not extend the historic ranges of distribution, the range of habitats in which a plant species is known to have occurred, nor exceed the pre-settlement [sic] abundance of a species in a community or in the state." While such policies are a good start, they beg the essential questions of defining spatial and temporal scales at which species distributions are to be determined, and with what fineness of grain individual sites will be defined.

In the approach described previously, more weight may be assigned to feasibility and security considerations than to documentation of historical locations, provided that reintroduction is reasonably occurring within the species' overall range. The overall historical range and individual locations of most rare species remain unknown for more than a few decades in the past. Moreover, the ranges of most species have changed over ecological and evolutionary history; even current distributions may not reflect a species' potential ecological amplitude. Giant Sequoia (*Sequoiadendron giganteum*), for example, is narrowly distributed at present, but the species is planted successfully throughout California's Sierra Nevada and in Europe, New Zealand, and elsewhere in a wide range of habitats. Giant Sequoia's tertiary and quaternary distribution were widespread in North America; its present range probably represents only a portion of its potential range. The species seems to have retained genetic potential for many habitats. Finally, even when overall range is known, individual past localities within that range may be difficult to reconstruct (unless the species has a very strong association with a habitat or community type that is itself limited in distribution).

Even more problematic are species with only one or two extant populations. In such cases, historical range becomes an almost irrelevant notion, and the emphasis must shift to search to sites that are ecologically and administratively feasible (Linder 1995).

In the face of such ambiguity, it may be difficult to apply criteria of historical range and documented localities in real-world practice. As discussed in the Introduction, we recommend instead an approach based on evaluating natural variation in range, distribution, and density of populations over time,

as more realistically reflecting the continually changing "history" of any species.

Defining potential habitat is itself difficult, because even naturally occurring populations may not reflect habitat and distributional optima. As the landscape becomes increasingly modified by human actions, populations of rare species are increasingly fragmented and pushed into ecological corners that may represent the fringes, rather than the center, of their historical distribution and niche space. Consequently, a search image based on current populations may reflect poorly the optimal conditions for their reintroduction. In southern Arizona, for example, Lemon lily (*Lilium parryi*) occurs in upper-elevation stream systems with moderate stream energy and periodically high flows. California populations are genetically similar but occur mostly in lower-elevation, low-energy cienegas and wetlands—habitat that has been largely destroyed in southern Arizona. A related rare species, *L. occidentale*, occurs in Northern California and southern Oregon on a handful of sites, virtually all of which appear to have been substantially altered by decades of fire suppression (E. Guerrant, personal communication, May 1995). In the midwestern United States, many formerly widespread prairie species (such as the royal catchfly [*Silene regia*]) now persist in only a few marginal sites, which may be wetter or drier (or of different soil composition or community type) than previous mean values.

Ecological Criteria

At the level of community structure and process, the receptor site should provide resources and opportunities for key life history requirements: dispersal, pollination, germination and establishment, mycorrhizal associations, and other mutualisms. The site should also be similar to the rare plant's native habitat in floristic and faunal composition and structure, successional stage, functional parameters, and disturbance regime (Primack, Chapter Nine). If possible, avoid sites where disruptive exotics (including pathogens) persist, even if other conditions are appropriate. For instance, Rejmanek (1989) has demonstrated that some highly modified communities are no longer invasible by rare plants (Loope and Medeiros 1994; also Pavlik, Chapter Six). Although careful matching of native habitat and receptor site ecology is preferable, in many cases this approach will be difficult to implement (Schemske 1994). Given the paucity of information about many rare species, a directly experimental approach will often be necessary, using outplanted populations on an array of sites to evaluate outcomes over time.

The Spatial Context

Landscape or spatial context is also important in the selection of the receptor site. White (Chapter Three) describes the importance of selecting sites that contribute to re-establishment of natural patterns of heterogeneity at the landscape level. This may include the mosaic of successional habitats and the disturbance regime that will exist on the site.

The act of establishing a population creates a new source of propagules for the surrounding landscape. Depending on the dispersal ecology of the species, the amount of material translocated, and the characteristics of the surrounding vegetation matrix, each site-level introduction has the potential to influence the vegetation of surrounding areas.

Species characterized by metapopulation ecology require a careful definition of "site." For such species, the functional ecological unit may be a cluster of sites along a riparian corridor or among canopy gaps or edaphic islands. Each individual act of reintroduction should be intended to establish one component of this larger entity, in some cases simply filling in a gap within an existing metapopulation (Primack, Chapter Nine; Bowles and McBride, Case Study Five). Since gene flow is presumably higher among metapopulation sites than among differentiated populations, the genetic makeup of such subpopulations may be of special concern (see Guideline 9).

As with so many other aspects of biology and conservation, islands illustrate questions of spatial context intensively. The definition of a suitable landscape-scale area may be entirely bounded by a single island, even when potential habitat exists nearby. Rates of interisland migration are often unknown, and it may be difficult to ascertain if observed differences among island populations reflect significant ecotypic variation or simply chance events of dispersal, colonization, and survival. The most conservative policy is to restrict normal outplantings to the island that provided the source material (HRPRG 1992).

Whenever possible, reintroduction projects should account both for among-site or contextual factors, and for within-site criteria. Spatial and landscape characteristics of the receptor site should be compared with the species' native habitat, especially populations closest to potential reintroduction sites. Various characteristics of the landscape matrix can be evaluated, including corridors, patch configuration, buffer zones, fragmentation patterns, and watershed position (Naveh 1994).

CLIMATE CHANGE CONSIDERATIONS

Introducing some species outside of their known historical range may be a strategic hedge (or perhaps a response) to potential climate change (Kutner and Morse, Chapter Two). As vegetation zones shift, many rare species are predicted to be excluded from their current range and may face formidable dispersal barriers of both natural and anthropogenic origin. Intentional introduction outside of the envelope of known historical range could be part of the

conservation response to the effects of a change in climate (Peters 1985; Peters and Lovejoy 1992).

No species can be introduced, however, outside of its current envelope of ecological feasibility, no matter how urgent the need. Over the next fifty years, changing climates may just begin to affect many plant populations, primarily populations at the ecological margins of species distributions. Uncertainties about the local manifestation of climate change may hinder our ability to predict impacts. Because the actual physical and biological limits for rare plants are often unknown, predicting the movement of their suitable habitat is necessarily a highly speculative venture. For proposed receptor sites close to known localities, it is probably safe to assume some variation in the perimeter of distribution and perhaps even the occurrence of some disjunct or relictual populations over the species' natural history. In the published literature, we find few cases where the movement of a species just beyond its currently documented distribution can be proven to violate the area of previous colonization. Examples where this may be possible would be habitats (such as high alpine areas, riparian zones, or islands) that are by nature persistently patchy and isolated for ecologically significant periods of time. However, such habitats are often also closely defined by gradients in soil, temperature, or precipitation that correspond to the envelope of potential habitat.

Following the approach recommended throughout this book, we define the reasonable test discriminating a outplanting from a biologically new event to be whether the act of reintroduction exceeds the natural range of likely dispersal events over a specified period of time. Crossing a near-absolute dispersal barrier (2,000 miles of ocean, for instance, for most terrestrial species) would in nearly all cases constitute an introduction, while crossing a low range of hills with continuity in vegetation and climate might not. Because of the uncertainty of both future climate and species niche breadth, perhaps the best way to hedge bets on survival is to plan for buffering, resilience, and migration of communities over space and time, including many experimental outplantings that will offer a cushion against attrition.

9. What is the genetic composition of the material to be reintroduced?

Genetic composition and genetic processes at different phases of population growth influence short- and long-term population viability (Kress et al. 1994; Godt et al. 1995). The most important times to consider genetic aspects, however, are when (1) selecting the site, (2) developing and outplanting source material for initial planting and for supplementing the reintroduced population (such as replanting to replace initial mortality), (3) ensuring reproductive and dispersal adequacy of the new population, and (4) designing a monitoring program (Guerrant, Chapter Eight). For excellent overviews, see Fenster and Dudash (1994) and Schemske et al. (1994).

SITE SELECTION

When considering candidate sites, match known or inferred genetic elements with those in nearby healthy populations (Fiedler and Laven, Chapter Seven). Ideally, sites should be avoided if they are surrounded by (that is, within significant gene flow distance of) populations of nonlocal genotypes or races capable of contaminating the reintroduced population. Sites should also be avoided if populations are surrounded by widespread congeners capable of swamping the reintroduced gene pool via interspecific hybridization. Conversely, if the species naturally occurs in a scattered metapopulation structure, matching or creating this structure may be important both for genetic and demographic reasons (Primack, Chapter Nine). Choosing a site that is large enough to accommodate a healthy native population may favor maintenance of genetic diversity by maintaining large effective population sizes.

SOURCE MATERIAL AND DESIGN FOR INITIAL REINTRODUCTION AND SUPPLEMENTAL PLANTINGS

The objective in selecting and developing appropriate germplasm is to establish resilient, self-sustaining populations that retain the genetic resources necessary to undergo adaptive evolutionary change (Guerrant, Chapter Eight). One effective strategy to achieve this objective might be to do whatever possible to maximize initial population growth and to minimize short- and long-term extinction probability. Two aspects are most important: (1) the genetic source of founders (and supplements) and (2) the diversity and number of genetically effective individuals (that is, effective population size). Regarding the source of founders, match germplasm to the reintroduction site by choosing native donor populations that are geographically close and ecologically similar to the reintroduction site. However, the dimensions and characteristics that define "local" are unique for each species—no direct rule applies. "Local" is ultimately determined by the size of the genetic neighborhoods of native populations, the environmental factors that condition selection gradients of genetic change over space, and the historical elements that influenced the evolution of the population's genetic structure (DeMauro 1994). The conservative guide is to choose donors from closest neighboring population(s) if those populations are relatively large, viable, uncontaminated (by nonlocal genotypes of the same species or interspecific hybridization), and healthy. In addition, conditions of the donor site should match the ecological conditions of the reintroduction site. If neither of these conditions applies, choose donors from more distant native populations, following the best ecological knowledge to match donor populations with similar conditions to the reintroduction site and ensuring that collection does not harm donor populations (Lesica and Allendorf 1995). Only exceptional and urgent conditions would justify using germplasm of unknown origin. Even local germplasm grown for several generations in a nursery or botanical garden may be genetically different from native local gene pools (Kitzmiller 1990; Pavlik, Nickrent, and Howald 1993; Lippett et al. 1994).

Although few valid generalities exist regarding the optimal number of donor populations to use, the conservative guide is to use one if the population is healthy as described previously. Conditions other than these might favor using a mix of several native populations as donors. (See Guerrant, Chapter Eight, for discussion.) The guiding factor is to establish a population with appropriate genetic diversity to provide raw material for adaptation to the site.

In collecting propagules from natural or cultivated populations, the goal is to maintain high effective population sizes throughout the propagation process. This is achieved by maximizing the number of distinct founding genotypes (by collecting propagules systematically throughout the donor population), maintaining equal numbers of propagules from each founder through nursery stages to outplanting, and encouraging rapid early population growth (Lippett et al. 1994). Experience is insufficient to prescribe in general how large the founding population should be. Within obvious practical considerations, the default rule is "bigger is better" (Guerrant, Chapter Eight; Center for Plant Conservation 1991).

GENETIC CONSIDERATIONS FOR REPRODUCTION AND DISPERSAL

The general guideline for safeguarding genetic diversity during this phase of the reintroduction is to mimic the natural life-history characteristics of the rare species, including its pattern of dispersal (Primack, Chapter Nine). This minimizing inbreeding (except for inbreeders) and favoring natural-dispersal patterns (numbers of propagules, dispersal distance, vectors). By so doing, genetic diversity is most likely to be maintained, and natural genetic structure will evolve in the new population. There are two ways to minimize inbreeding: (1) plant diverse genotypes scattered systematically over the planting site (that is, don't plant in groups of clones or close relatives such as selfed individuals, full sibs, or inbred propagules), and (2) plant with high stocking density to promote abundant cross-fertilization.

MONITORING GENETIC VARIATION

Genetic monitoring is a research field in itself and not straightforward in design, standards, or interpretation. The conceptual standard for genetic monitoring is that genetic diversity be adequate to maintain population viability (demographic stability and growth) and sustainability (long-term adaptability and resilience to change). In practice, determining how much genetic diversity is enough to meet these goals is nearly impossible, even for species that are well understood genetically. Further, teasing apart genetic diversity from other factors that affect demographic stability and population viability is, with present knowledge and techniques, extremely difficult. The best practical guideline to ensure genetic integrity during the monitoring period is to begin with a good baseline genetic profile of the material to be introduced to the site and then over time to monitor levels and trends in overall genetic diversity. Other proxy data (such as demographic attributes and life-history parameters of population growth and viability) can be used to help interpret genetic status. If results from monitoring these traits indicate a population decline or a significant drop in viability, and genetic diversity similarly has dropped precipitously, then genetic factors may be contributing to the decline. Conversely, if overall levels of genetic diversity are maintained or increase gradually, and the population is viable and healthy, it can be assumed cautiously that genetic diversity is adequate. Abrupt changes in allelic frequencies (that is, the appearance of unique alleles) may indicate gene contamination or interspecific hybridization and should be followed by careful inspection of neighboring populations.

The choice of genetic traits to monitor is debatable. *Marker traits* (allozymes, DNA), although expensive, are relatively quick to measure and indicate actual levels of genetic diversity. They are, however, almost always ambiguously and indirectly related to genetic loci controlling adaptive traits, which are usually the traits of interest in monitoring population viability. If used only to measure overall genetic diversity, and used in conjunction with other proxies, markers are probably best. *Quantitative traits* (such as plant height, fruit size, or seed weight) are of more direct interest. The role of genetic diversity in adaptive fitness requires either that the reintroduced population be originally designed as a common-garden test (rarely desirable for other reasons) or that common-garden experiments be undertaken periodically on propagules from the reintroduced population. An appropriate sampling design for monitoring genetic diversity should be followed regardless of genetic traits monitored (Center for Plant Conservation 1991).

10. How will the founding population be structured to favor demographic persistence and stability?

An immediate goal for reintroduction is to establish robust, self-sufficient, and reproductively effective populations. Attention must be paid to the early phases of a reintroduction, especially the demographic consequences of the outplanting materials chosen and the dynamics of early establishment and growth (Guerrant, Chapter Eight; Primack, Chapter Nine). Two important demographic goals are to maximize population growth and to avoid local extinction. Both stage-class (seed, seedling, juvenile, and so on) and age-class of founders affect subsequent population growth and extinction probabilities. How they specifically affect these values depends on the life history of the species. On average, simulations and empirical evidence show that populations experience lower extinctions when mature plants are outplanted, rather than seeds or very small seedlings. Although larger plants appear to decrease extinction probabilities, the greatest gain in avoiding extinction is between seeds or seedlings and small plants. Therefore, when the goal is not mere persistence but rapid population growth, using the largest outplants appears to be best, since population growth rate generally increases continuously as plant size increases (Guerrant, Chapter Eight). These guidelines are based on simulation results and only tentatively offered practically, since there are some potential downsides of outplanting mature plants: selection under garden conditions; the time required to find out if the seed-to-seedling hurdle can be passed at a given site (McDonald, Case Study Three), and the lack of experimental or quantitative analysis of a significant demographic event (seed to seedling). Putting out seeds, mixed with whole plants, may circumvent these difficulties, especially if large numbers of seed are available (Guerrant, Chapter Eight).

There is no simple, standard answer to the question of how many plants are enough to constitute a viable founder population. Unfortunately, the actual critical values—minimum viable population size, founder population size to avoid an early extinction event, or even the age structure of a normal population—are unknown and probably nearly unknowable because of our uncertainty about future environments (see Pavlik, Chapter Six). The practitioner/researcher will have to explore the literature on the target species or congeners and make a series of best guesses based on the size and design of natural populations that appear ecologically comparable (Ruggiero et al. 1994; Schemske et al. 1994). We offer guidance here on some of the key questions that such exploration should attempt to address.

FOUNDER POPULATION SIZE

Reintroduction practitioners should become familiar with the literature applying analysis of minimum viable populations, population viability and vulnerability, founder events, and demographic stochasticity to problems in conservation biology (Pavlik, Chapter Six; Guerrant, Chapter Eight; Shaffer 1981; Gilpin and Soulé 1986; Soulé 1987; Menges 1991a, 1992). This work confirms both theoretically and empirically that, other things being equal, small populations are at greater risk of local extirpation due to demographic fluctuations than are large populations. However, the actual details about numbers are almost entirely a matter of speculation for most species, especially rare ones. Mathematically, predicted persistence time appears to be a function of the power of founding population size, but it is influenced as well by predicted growth rates and many other factors (Menges 1990). Persistence over time is also a function of the effective population size, with regard to the maintenance of genetic variability and reproductive processes (Guerrant, Chapter Eight; Lande and Barrowclough 1987; Menges 1991b; Ryman and Laikre 1991).

Moreover, the true effects of demographic oscillations are only evident over many generations. Most demographic extinctions have been simulated in ecological models of populations over tens or hundreds of generations down the line. Chance extinction models based on birth-and-death processes (Goodman 1987) permit population size and growth rates to be correlated probabilistically with time (or number of generations) to extinction. Alternatively, the same parameters can be used to estimate the probability of population persistence.

Since minimum viable population values for individual species may be correlated with various life-history attributes, some insight may be gained by comparing the target species to others with similar characteristics (Pavlik, Chapter Six).

Population Growth, Recruitment, and Survivorship

Although rapid population growth is theoretically favored; management techniques to achieve it (such as fertilization or intensive culture) may not promote population sustainability. Most models suggest that population-level persistence can be enhanced by very large population sizes, high survivorship, or high growth rates; persistence probability can be expressed mathematically as a function of these and other factors. Ideally, the values for growth, recruitment, and survivorship will come from studies of natural populations or closely comparable congeners. In the absence of such baseline data in natural populations, the restorationist must estimate projected growth and survivorship and then monitor the outcomes closely.

Such trials may provide the best information over the long term if the project includes a series of successive outplantings over a period of years. In only a few cases will an initial outplanting be successful, in the sense of establishing a viable, self-reproducing population on the first try. The probability of extinction is very high in any given trial, especially those at the beginning of a reintroduction program. As such, the best strategy for achieving a stable population may be to treat the first attempts as ministudies that will provide qualitative information about survivorship, recruitment, growth rates, competitive interactions, pollination success, and other parameters.

If mature plants are placed on the site, every individual should be marked and mapped to allow survivorship, recruitment, and growth to be tracked accurately in subsequent years. If seed are used, a planting record and map

should indicate the amount of material released and its location. Over a period of several years, these methods will reveal a site-specific pattern of establishment and growth for the species. Survivorship studies must be continued for a long enough period to include the natural range of variation in weather and ideally some variation in related environmental factors (such as stream flow for riparian endemics). Laboratory-derived seed germination rates can provide a yardstick for evaluating response on the outplanting site, taking into account that germination rates can be an order of magnitude lower in the field due to suboptimal germination conditions, seed predation, and competition.

Size and Stage Structure of the Reintroduced Population

By itself, stage structure does not tell us all we need to know about a population's health. Species and populations may have a characteristic age structure reflecting multiple demographic, reproductive, and life-history factors, although many species are highly variable. For perennial species, the stage and size structure of comparable natural populations should be observed closely in designing the reintroduction program. Should the reintroduction program attempt to replicate this age structure, or should the population be permitted to establish its own demographic equilibrium over a period of years? In evaluating model simulations, Guerrant (Chapter Eight) argues that decisions about inital stage structure should include considerations of survivorship, cost, effort, and other variables beyond "pure" demogragraphy.

The simulations show that stage structure of the founding population can influence long-term extinction risk significantly, although the outcome depends on growth form (long-lived trees versus herbaceous perennials, and so on). The introduction of some plants of larger size classes (even relatively small or juvenile plants but one stage class only) dramatically reduced extinction risk compared to introductions using seeds. These simulation results suggest that using the largest founders practical may theoretically be the best, although using a diversity of stage classes as founders and multiple introductions may be safest practically. To the extent possible, reintroduction would treat these factors experimentally and track success by size class.

The multiyear outplanting approach recommended here will introduce a rudimentary degree of age structure diversity to the population. However, the resulting structure may not approximate the age-class distribution found in existing populations. In some cases, it may be possible to introduce literally a multiple age-class population by outplanting a combination of seeds, young rooted cuttings, and mature individuals of various sizes. Such an approach may be limited by the availability of material or time constraints for project completion, but if resources permit it may be worth considering (very little empirical work with this approach has been conducted to date). Guerrant (Chapter Eight) discusses in detail the relative merits of outplanting various ages and types of plant material (see also Primack, Chapter Nine).

11. Are essential ecological processes intact at the site?
If not, how will they be established?

Since an ultimate goal of reintroduction is not simply recovery of the rare plant but restoration of the ecological community, attention should be paid over time to ecosystem processes (White, Chapter Three; Sutter, Chapter Ten). In preceding sections, we have touched on several ecological processes important for successful reintroduction: interactions with ecological associates, symbionts, and mutualists such as mycorrhizae and pollinators; flower and fruit production; seed dispersal; gene-flow (within and among populations); disturbance processes (fire, flooding); and restoration of habitat relationships (Johnson, Case Study Six). Management actions for the reintroduced population should be adapted to promote key ecosystem processes such as nutrient cycling, disturbance and hydrologic regimes, watershed protection, wildlife corridors, and so on (Thomas 1994).

POLLINATION

Beyond the first outplanted generation of seeds or growing plants successful reproduction is vital to long-term success (Bond 1995; Weller 1994; Sipes and Tepedino 1995). Despite the obvious and fundamental importance of successful reproduction to persistence of the population, remarkably few reintroduction projects include any conscious effort to ensure that pollination can occur. For the many species that require animal vectors for pollen, the project will be short lived or will require hand-pollination, as does *Brighamia rockii* on Molokai, Hawaii (U.S. Fish and Wildlife Service 1995). If at all possible, the assistance of experts in pollination ecology for the taxon (or congeners) should be enlisted.

DISPERSAL

As with pollination, many plants rely on external agents to disperse propagules. In fact, there is evidence that dispersal failure accounts for at least some instances of recent decrease in range or population numbers of rare species (Primack, Chapter Nine; Primack and Miao 1992). The tendency toward ecological niche specificity in rare species amplifies the importance of dispersal. Moreover, many animal dispersal vectors (such as birds, mammals, ants, and bats) also prepare chemically for germination and may actually initiate the germination process.

In a real sense, reintroduction is an act of dispersal, at least for the first generation (Primack, Chapter Nine). Successful dispersal involves not only get-

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ting seeds (or other material) to a suitable macrosite and community but also securing a variety of microsite factors: proper planting or sowing depth, litter cover, sun/shade position, soil moisture, and other parameters. Careful attention should be given to microsite characteristics and microclimatic variation as they may affect the early establishment phase.

MYCORRHIZAL ASSOCIATIONS AND
OTHER SOIL MICROORGANISMS

The incidence and importance of root mycorrhizal symbiosis and other microorganismal interactions in rare plants are generally unknown. Allen (1993) has reviewed the role of mycorrhizae in ecological restoration efforts and concluded that their importance has probably been underestimated for long-term vigor and growth of established plants (Allen 1991; Weinbaum, Allen, and Allen in press). If reference natural populations or published literature do not provide data for the target species, the restorationist may have to look to congeners for clues. As an empirical alternative, some reintroduction projects bring soil from an existing population to inoculate the reintroduction site. While this practice may be effective, it may also introduce disease organisms or other undesirable elements into a new ecosystem; for this reason, one should be cautious about moving large amounts of soil.

DISTURBANCE

Few questions in ecology are as complex and controversial as the influence of disturbance on the distribution of species and communities. Many of these decisions will be delimited by the site itself, either because of its biological characteristics or land management regime (White, Chapter Three; Fiedler and Laven, Chapter Seven; Guideline 8).

A guiding philosophy must be to understand and work with the dynamic nature of natural processes (Primack, Chapter Nine). Reintroduction should accommodate the reality of short- to medium-term (successional) changes, episodic processes (such as disturbance events), and long-term trajectories (climate change) and accept the stochastic nature of these dynamics (Falk 1990). Changes in landscape patterns due to human settlement and management (such as fragmentation) may have important implications for natural processes within the reintroduced population. In some cases, managers may have to intercede (by artificial pollination or dispersal, by clearing, or by prescribed burns) to promote important processes that are blocked due to highly altered landscape conditions.

Disturbance dynamics at a very fine spatial scale affect many of the more intimate aspects of population-level reintroduction. Many species have seeds that germinate only after fire scarification or contact with damp soil. Post-disturbance processes can directly affect germination and growth rates and can alter profoundly the competitive interactions with other species on the site. Reintroduction is not simply a matter of bringing plant material to a site and then walking away; the disturbance regime is an important determinant of the pattern of distribution of species and communities on the landscape and on the long-term viability of the reintroduced population (Pavlovic 1994).

Recruitment and establishment of new individuals are critical measures of success for a reintroduced population (Pavlik, Chapter Six; Primack, Chapter Nine; Sutter, Chapter Ten). Mimicking known or inferred natural processes for the individual species is again the best guide: yearly recruitment is vital for annuals, while recruitment in long-lived perennials is often more sporadic. Since recruitment depends not only on adequate numbers of sound seeds but safe sites for germination and establishment, it is important to ensure that the reintroduction area can sustain disturbances that provide safe sites (Sutter, Chapter Ten).

Natural disturbances, such as fire, floods, windfalls, and insect and disease outbreaks often create gaps or areas of preferred habitat and should be permitted on the reintroduction site. Suppression of these processes, or introduction of artificial disturbance processes, may detrimentally affect creation of safe seed and seedling sites and thus inhibit recruitment and establishment. This illustrates the importance of ongoing habitat management (Guideline 7) even for single-species reintroductions (Gordon, Case Study Four).

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REFERENCES

Allen, M.F. 1991. *The Ecology of Mycorrhizae.* Cambridge Study in Ecology Series, Cambridge University Press.

Allen, M.F. 1993. Microbial and Phosphate dynamics in a Restored Shrub Steppe in Southwestern Wyoming. *Restoration Ecology* 1(3): 196–205.

American Society of Plant Taxonomists. 1989. "A Resolution on Transplantation." Adopted at August 1989 annual meeting, University of Toronto, Canada.

Birkenshaw, C. R. 1991. *Guidance Notes for Translocating Plants as Part of Recovery Plans.* Cambridge, England: Nature Conservancy Council Report Number 1225.

Bond, W. J. 1995. "Assessing the Risk of Plant Extinction Due to Pollinator and Disperser Failure." In *Extinction Rates.* Edited by J. H. Lawton and R. M. May. Oxford, England: Oxford University Press.

BGCI (Botanic Gardens Conservation International). 1994. *A Handbook for Botanic Gardens on the Reintroduction of Plants to the Wild.* Richmond, Surrey, England: Botanic Garden Conservation International/IUCN Species Survival Commission.

BGCI (Botanic Gardens Conservation International). 1990. *Techniques for Germplasm Conservation of Wild Species by Botanic Gardens.* Report of a workshop, December 1988, in Maspalomas, Gran Canaria, Spain.

Bowles, M. L., and C. J. Whelan, eds. 1994. *Restoration of Endangered Species: Conceptual Issues, Planning and Implementation.* Cambridge, England: Cambridge University Press.

Center for Plant Conservation. 1991. "Genetic Sampling Guidelines for Conservation Collections of Rare Plants." In *Genetics and Conservation of Rare Plants.* Edited by D. A. Falk and K. E. Holsinger. New York: Oxford University Press.

Center for Plant Conservation. 1995. *1995 Plant Conservation Directory.* St. Louis, Mo.: Center for Plant Conservation.

DeMauro, M. M. 1994. "Development and Implementation of a Recovery Program for the Federal Threatened Lakeside Daisy (*Hymenoxys acaulis var. glabra*)." In *Restoration of Endangered Species: Conceptual Issues, Planning and Implementation.* Edited by M. L. Bowles, and C. J Whelan. Cambridge, England: Cambridge University Press.

Falk, D. A. 1990. "Discovering the Past, Restoring the Future." *Restoration and Management Notes* 8 (2): 71.

Falk, D. A., and K. E. Holsinger, eds. 1991. *Genetics and Conservation of Rare Plants.* New York: Oxford University Press.

Falk, D. A., and P. Olwell. 1992. "Scientific and Policy Considerations in Restoration and Reintroduction of Endangered Species." *Rhodora* 94 (879): 287–315.

Fenster, C. B. and M. R. Dudash. 1994. Genetic considerations for plant population restoration and conservation. Pp. 34–62 in Bowles *et al., op. cit.*

Fiedler, P. L. 1991. *Mitigation Related Transplantation, Relocation and Reintroduction Projects Involving Endangered and Threatened, and Rare Plant Species in California.* Final report to California Department of Fish and Game. Sacramento: Endangered Plant Program.

Fiedler, P. L., and J. J. Ahouse. 1992. "Hierarchies of Cause: Toward an Understanding of Rarity in Vascular Plant Species." In *Conservation Biology: The Theory and Practice of Nature Conservation, Preservation, and Management.* Edited by P. L. Fiedler and S. K. Jain. New York: Chapman and Hall.

Gilpin, M. E., and M. E. Soulé. 1986. "Minimum Viable Populations: The Processes of Species Extinctions." In *Conservation Biology: The Science of Scarcity and Diversity.* Edited by M. E. Soulé. Sunderland, Mass.: Sinauer Associates.

Godt, M. J. W., J. L. Hamrick, and S. Bratton. 1995. "Genetic Diversity in a Threatened Wetland Species, *Helonias bullata* (Liliaceae)." *Conservation Biology* 9 (3): 596–604.

Goodman, D. 1987. "The Demography of Chance Extinction." In *Viable Populations for Conservation.* Edited by M. E. Soulé. Cambridge, England: Cambridge University Press.

Gordon, D. R. 1994. "Translocation of Species into Conservation Areas: A Key for Natural Resource Managers." *Natural Areas Journal* 14 (1): 31–37.

Hall, L. A. 1987. "Transplantation of Sensitive Plants As Mitigation for Environmental

Impacts." In *Conservation and Management of Rare and Endangered Plants*. Edited by T. Elias and J. R. Nelson. Sacramento: California Native Plant Society.

HRPRG (Hawaii Rare Plant Restoration Group). 1992. *A System of Supplemental Outplanting and Propagation Facilities to Enhance the Conservation of Hawaiian Plants.* Honolulu, Hawaii: Center for Plant Conservation and Bernice P. Bishop Museum.

Heschel, M. S., and K. N. Page. 1995. "Inbreeding Depression, Environmental Stress, and Population Size Variation in Scarlet Gilia (*Ipomopsis aggregata*)." *Conservation Biology* 9 (1): 126–133.

Huenneke, L. F., and J. K. Thompson. 1995. "Potential Interference Between a Threatened Endemic Thistle and an Invasive Nonnative Plant." *Conservation Biology* 9 (2): 416–425.

Illinois Endangered Species Protection Board. 1992. "Establishing New Populations of Native Plants." Springfield, Ill.: Illinois Department of Conservation.

IUCN (International Union for the Conservation of Nature and Natural Resources). 1987. "The IUCN Position Statement on Translocation of Living Organisms: Introductions, Reintroduction and Restocking." Gland, Switzerland: IUCN.

International Union for the Conservation of Nature and Natural Resources/SSC Reintroduction Specialists Group—Plants. 1992. "Draft Guidelines for Reintroduction." *Reintroduction News* 4 (May). London: Species Survival Commission.

Kitzmiller, S. M. 1990. "Managing Genetic Diversity in a Tree Improvement Program." *Forest Ecology and Management* 35 (1,2): 131–150.

Kress, W. J., G. D. Maddox, and C. S. Roesel. 1994. "Genetic Variation and Protection Priorities in *Ptilimnium nodosum* (Apiaceae), an Endangered Plant of the Eastern United States." *Conservation Biology* 8 (1): 271–276.

Lande, R., and G. F Barrowclough. 1987. "Effective Population Size, Genetic Variation, and Their Use in Population Management." In *Viable Populations for Conservation*. Edited by M. E. Soulé. Cambridge, England: Cambridge University Press.

Lesica, P. and F. W. Allendorf. 1995. "When are Peripheral Populations valuable for Conservation?" *Conservation Biology* 9 (4) 753–760.

Linder, H. P. 1995. "Setting Conservation Priorities: the Importance of Endemism and Phylogeny in the Southern African Orchid Genus *Herschelia*." *Conservation Biology* 9 (3): 585–595.

Lippett, L., M. Fidelibus, and D. A. Bainbridge. 1994. "Native Seed Collection, Processing, and Storage for Revegetation Projects in the Western United States." *Restoration Ecology* 2 (2): 120–131.

Loope, L. L. and A. C. Medeiros. 1994. "Impacts of Biological Invasions on the Management and Recovery of Rare Plants in Haleakala National Park, Maui, Hawaii." Pp. 143–158 in Bowles *et al., op. cit.*

Mace, G. M. and R. Lande. 1991. "Assessing Extinction Threats: Toward Re-Evaluation of IUCN Threatened Species Categories." *Conservation Biology* 5: 148–157.

Menges, E. S. 1990. "Population Viability Analysis for an Endangered Plant. *Conservation Biology* 4 (1): 62–62.

Menges, E. S. 1991a. "The Application of Minimum Viable Population Theory to Plants." In *Genetics and Conservation of Rare Plants*. Edited by D. A. Falk and K. E. Holsinger. New York: Oxford University Press.

Menges, E. S. 1991b. "Seed Germination Percentage Increases with Population Size in a Fragmented Prairie Species." *Conservation Biology* 5 (2): 158–164.

Menges, E. S. 1992. "Stochastic Modelling of Extinction in Plant Populations." In *Conservation Biology: The Theory and Practice of Nature Conservation, Preservation, and Management*. Edited by P. L. Fiedler and S. K. Jain. New York: Chapman and Hall.

National Park Service, Wildlife and Vegetation Division. 1991. "Endangered, Threatened, and Rare Species Management." *Natural Resources Management Guideline*, 77.

Native Plant Society of Oregon. 1992. "Policy Statement on Reintroduction of Extirpated or Rare Plant Species." *NPSO Bulletin*, January.

The Nature Conservancy Stewardship Program. 1992. "Draft Proposed Policy and Criteria for Species Translocations to Preserves." Arlington, Virginia.

Naveh, A. 1994. "From Biodiversity to Ecodiversity: A Landscape-Ecology Approach to Conservation and Restoration." *Restoration Ecology* 2 (3): 180–189.

New England Wild Flower Society. 1992. "New England Plant Conservation Program." *Wild Flower Notes* 7 (1): 40–78.

Pavlik, B. M. 1994. "Demographic Monitoring and the Recovery of Endangered Plants." In *Restoration of Endangered Species: Conceptual Issues, Planning, and Implementation*. Edited by M. L. Bowles and C. J. Whelan. Cambridge, England: Cambridge University Press.

Pavlik, B. M., Nickrent, D. L. and Howald, A. M. 1993. "The Recovery of an Endangered Plant. I. Creating a New Population of *Amsinkia grandiflora*." *Conservation Biology* 7: 510–526.

Pavlovic, N. B. 1994. "Disturbance-Dependent Persistence of Rare Plants: Anthropogenic Impacts and Restoration Implications." Pp. 159–193 in Bowles, *et al., op. cit.*

Peters, R. L. 1985. "Global Climate Change: A Challenge for Restoration Ecology." *Restoration and Management Notes* 3 (2): 62–67.

Peters, R. L., and T. E. Lovejoy. 1992. *Global Warming and Biological Diversity*. New Haven, Connecticut: Yale University Press.

Primack, R., and S. L. Miao. 1992. "Dispersal Can Limit Local Plant Distribution." *Conservation Biology* 6: 513–519.

Reichenbacher, F. W. 1990. "Reintroduction Brings Kearney's Blue Star from Extinction's Edge." *Plant Conservation* 5: 3.

Reinartz, J. A. 1995. "Planting State-Listed Endangered and Threatened Plants." *Conservation Biology* 9 (4): 771–781.

Rejmanek, M. 1989. "Invasibility of Plant Communities." In *Ecology of Biological Invasions: A Global Perspective*. Edited by J. A. Drake, H. A. Mooney, F. diCastri, R. H. Groves, F. J. Kruger, M. Rejmanek, and M. Williamson. Chichester, England: Wiley and Sons.

Ryman, N., and L. Laikre. 1991. "Effects of Supportive Breeding on the Genetically Effective Population Size." *Conservation Biology* 5 (3): 325–329.

Ruggiero, L. F., G. D. Hayward, and J. R. Squires. 1994. "Viability Analysis in Biological Evaluations: Concepts of Population Viability Analysis, Biological Population, and Ecological Scale." *Conservation Biology* 8 (2): 364–372.

Schemske, D.W., B. C. Husband, C. Goodwillie, I. M. Parker, and J. G. Bishop. 1994. "Evaluating Approaches to the Conservation of Rare and Endangered Plants." *Ecology* 75 (3): 584–606.

Shaffer, M. L. 1981. "Minimum Population Sizes for Species Conservation." *BioScience* 31: 131–134.

Sipes, S. D. and V. J. Tepedino. 1995. "Reproductive Biology of the Rare Orchid, *Spiranthes diluvialis*: Breeding System, Pollination and Implications for Conservation." *Conservation Biology* 9 (4): 929–938.

Soulé, M. E., ed. 1987. *Viable Populations for Conservation*. Cambridge, England: Cambridge University Press.

Taylor, B. L. 1995. "The Reliability of Using Population Viability Analysis for Risk Classification of Species." *Conservation Biology* 9: 551–558.

Thomas, C. D. 1994. "Extinction, Colonization, and Metapopulations: Environmental Tracking by Rare Species." *Conservation Biology* 8 (2): 373–378.

U.S. Army Corps of Engineers. 1991. "Restoration of Fish and Wildlife Habitat Resources." Policy guidance letter number 24, March 7, Washington, DC: Department of the Army.

U.S. Fish and Wildlife Service. 1988. "Endangered Species Act of 1973 As Amended through the 100th Congress." Washington, D.C.: Department of the Interior.

U.S. Fish and Wildlife Service. 1992. "Policy and Guidelines for Planning and Coordinating Recovery of Endangered and Threatened Species." Washington, D.C.: Department of the Interior.

U. S. Fish and Wildlife Service. 1995. "Technical/Agency Draft Molokai Plant Cluster Recovery Plan." U.S. Fish and Wildlife Service, Portland, OR.

Waste Management, Inc. 1992. "Guidelines for Biological Diversity Conservation." Oak Brook, Ill.: Waste Management, Inc.

Weinbaum, B. S., M. F. Allen, and E. B. Allen. "Survival of Arbuscular Mycorrhizal Fungi Following Reciprocal Transplanting Across the Great Basin, USA." *Ecological Applications*, in press.

Weller, S. G. 1994. "The Relationship of Rarity to Plant Reproductive Biology. Pp. 90–117 in Bowles *et al., op. cit.*

Wildt, D. E., and U. S. Seal. 1988. "Research Priorities for Single-Species Conservation Biology." Proceedings of a workshop sponsored by the National Science Foundation and the National Zoological Park, November 1988, Washington, D.C.

Wisconsin Department of Natural Resources. 1991. "Draft Rare Plant Propagation and Distribution Policy." Madison, Wis.: Bureau of Natural Resources.

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