Monitoring and Adaptive Management Program

7.1 Introduction

This chapter describes the HCP/NCCP monitoring and adaptive management program. The purpose of this program is to assess the status of species and natural communities within the Preserve System and to provide for their ongoing conservation and recovery. The adaptive management component of the program will guide how information is collected by the Implementing Entity and how it will be evaluated and used to improve conservation actions in the Preserve System. Collecting and analyzing data through monitoring and focused management are essential components of adaptive management. The monitoring component of the program will track the success of the management activities, including restoration and creation, in conserving and recovering species and natural communities within the Preserve System. Management activities and monitoring efforts will change adaptively to improve conservation and to increase the efficacy of the monitoring data.

7.2 Process Overview

Designing a biological monitoring and adaptive management program that is logistically feasible and scientifically sound is a complicated task that will take many years. This chapter provides a framework, guidelines, and specific suggestions that will help the Implementing Entity develop a detailed monitoring program during the initial years of implementation. It is beyond the scope of this HCP to develop a comprehensive monitoring program. Rather, the goal of this plan is to provide sufficient guidance such that the monitoring program meets the standards outlined herein. As much as possible, this Plan has sought to incorporate recommendations for monitoring and adaptive management based on recent guidelines provided by the U.S. Geological Survey Biological Resources Division (USGS), CDFG, and USFWS (Atkinson et al. 2004). The following is an overview of the monitoring and adaptive management framework based on the steps recommended in that document.

Purpose. The purpose of the monitoring and adaptive management program is to inform and improve conservation actions in the Preserve System and to ensure that the Plan achieves its biological goals and objectives.

Scope. The scope of the monitoring and adaptive management program is limited to the assembly of the Preserve System, the restoration and creation of habitat within the Preserve System, and the management and monitoring of the Preserve System.

The scope of the monitoring and adaptive management program is limited by the assurances provided by USFWS and CDFG to the Permittees and described in Chapter 10. These assurances include the commitment by USFWS and CDFG that if unforeseen circumstances arise (as defined in Section 10.2.2), the Permittees will not be required to provide additional land, water, or financial compensation. Therefore, the scope of the monitoring and adaptive management program is limited to the budget for this program identified in Tables 9-1 and 9-2 and Appendix G. Funding can be shifted within the Plan at the discretion of the Implementing Entity to respond to the changing needs of the monitoring and adaptive management program, but additional funding is not required beyond that committed to in the Plan.

The geographic scope of the monitoring and adaptive management program will be determined by the lands acquired for the Preserve System. Because lands for the Preserve System will be assembled over the course of the 30-year permit, the exact configuration of the Preserve System is unknown. However, the general location of acquisition priorities has been defined (see Figures 5-2 and 5-3). As the Preserve System grows, on-the-ground monitoring will grow.

Like the conservation measures described in Chapter 5, the monitoring and adaptive management program will function at multiple scales—landscape, natural community, and species.

Data Compilation. The conservation strategy described in Chapter 5 and the adaptive management and monitoring program described herein were based on relevant biological information from a variety of sources. These include programmatic documents such as recovery plans; USFWS biological opinions; reserve management plans; spatial data integrated into GIS; and technical information, including relevant articles in the scientific literature, consultant reports, and expert opinion, including from the Science Advisors for this Plan. Species-habitat models were generated for 20 of the 28 covered species and will form an important component of the adaptive management and monitoring program. In concert with management-based conceptual models, these will help identify areas where additional information is needed and act as an evolving repository of our understanding of species and natural communities. As new data become available, they will be used to improve management and monitoring operations through adaptive management.

Divide the System and Set Priorities. The monitoring and adaptive management program, like the Plan as a whole, is based upon a multi-species, habitat-focused approach. This holistic approach focuses on preserving and creating functional natural communities that provide habitat for numerous native species. To that end, adaptive management and monitoring will be centered on the six broad natural communities addressed in this Plan: wetland, grassland, oak

woodland, chaparral/scrub, and streams and riparian woodland/scrub. The functional integrity of these natural community types will be reviewed as the adaptive management and monitoring program is developed to determine if the community types described herein best capture the ecological processes in the inventory area and are efficacious for supporting species-level conservation objectives. For the purposes of this document, these community types help provide a geographic and biological framework for the program.

The monitoring and adaptive management program will address three primary areas to meet ESA and NCCPA requirements and to ensure the success of the Plan:

1. effects of the management of the Preserve System on landscapes, communities, and species;

2. ecosystem function; and

3. status of covered species.

Develop Conceptual Models. Conceptual ecological models will be a cornerstone of the monitoring-program document and will be created during the initial years of implementation. These models will inform the monitoring program by identifying data gaps, by establishing metrics by which to evaluate ecosystem function, and by identifying relationships between system components. As the monitoring program collects additional data, these "living" models will serve as a framework for management and will function as reference points for the Implementing Entity's understanding of the ecosystems within the Preserve System.

Determine What to Monitor. Using the management-oriented conceptual models (see description below), the Implementing Entity will select the appropriate attributes to be monitored for each natural community type (see section on Indicators). For covered species, habitat variables or surrogates may be selected. Objectives for monitoring will be stated. Also based on the management-oriented conceptual models, critical uncertainties (e.g., role of fire in natural communities, effects of grazing alone or in combination with other techniques, control of invasive species) will be identified and targeted for monitoring.

Determine a Strategy for Monitoring. Based on USGS, CDFG, and USFWS guidelines on regional monitoring, the following steps should be implemented to guide the monitoring and adaptive management program:

- develop a work plan,

- coordinate with existing programs,

- develop good monitoring protocols, and

- avoid statistical pitfalls in developing sampling design.

Further guidance on these items can be found in Atkinson et al. (2004), in published literature and white papers, and below in the subsections of this chapter.

Develop Data and Reporting Strategies. The importance of analyzing data in a timely and accessible way and in using results to influence management is paramount to the success of the monitoring and adaptive management program. Initial reporting and analysis strategies are described throughout this chapter and, specifically, in the *Reporting* section below.

7.2.1   Regulatory Requirements

An NCCP must incorporate an integrated adaptive management strategy that is periodically reviewed and modified on the basis of the results of monitoring efforts and other sources of new information (California Fish and Game Code Section 2820(a)(2)). Accordingly, an NCCP must also have a monitoring program, including surveys to determine the status of biological resources, periodic accountings and assessments of take, and a schedule for conducting monitoring activities.

An HCP must incorporate monitoring of conservation measures and species responses to these measures (50 CFR 17.22(b)(1)(iii) and 50 CFR 222.22(b)(5)(iii)). The Five-Point Policy (65 FR 35241-35257), which guides the development of adaptive management in HCPs, describes adaptive management as an integrated method for addressing uncertainty in natural resource management. In order to be successfully implemented, adaptive management must be linked to measurable biological goals and monitoring. Effectiveness monitoring, therefore, must be designed to provide the information necessary to verify progress toward the Plan's biological goals.

According to USFWS, a successful adaptive management strategy should (1) identify the uncertainty in question, (2) develop alternative strategies for management, (3) integrate monitoring to assess the strategy, and (4) incorporate feedback loops that link implementation to monitoring.

7.2.2   Monitoring and Adaptive Management Goals

The monitoring and adaptive management program will incorporate important principles of "learning by doing" into the operations of the Preserve System. The goals of the monitoring and adaptive management program are as follows:

■   provide an organizational framework and decision-making process for evaluating monitoring, research, and other data to adjust management actions;

■   establish the baseline condition of biological resources in the Preserve System using existing geographic information, species models, and the results of pre-acquisition surveys;

■   develop conceptual models that can be used as the basis for collecting information, verifying hypotheses, and changing management practices;

■   incorporate hypothesis testing and experimental management, including pilot projects and directed research, into Plan implementation to address questions of uncertainty;

■   develop and implement scientifically valid monitoring protocols at multiple scales to ensure that data collected will inform management and integrate with other monitoring efforts;

■   collect the data necessary to refine and implement effective management within the Preserve System; and

■   ensure that monitoring data are collected, analyzed, stored, and organized so the data are accessible to the Implementing Entity, local jurisdictions, local land managers, regulatory agencies, scientists, and, as appropriate, to the public.

7.2.3   Integration of Monitoring and Adaptive Management

The integration of adaptive management and monitoring is critical to the successful implementation of the conservation strategy. Monitoring is the foundation of an adaptive approach, and adaptive management actions are borne, in part, from the results of monitoring. In this Plan, the two components are integrated into a single program.

The monitoring and adaptive management program will inform reserve managers and other decision makers of the status of covered species, natural communities, and essential ecological processes such that management actions can be revised to meet the biological goals of the plan. The effectiveness of conservation efforts will be evaluated following the model outlined in Figure 7-1: *Flowchart of Adaptive Management Process.* This figure illustrates how indicators and performance standards will be developed and how monitoring will be used to ensure the effectiveness of the plan. Using monitoring to provide information for adaptive management actions will require a framework for measuring responses (Figure 7-2 *Continuum of Experimental Management*). At the simplest level, monitoring post-management will inform future efforts. However, as the figure illustrates, management actions must be developed in concert with monitoring objectives such that increased certainty regarding the significance of the results can be obtained. In general, management actions will be treated as experiments, and monitoring will be used to evaluate each action. This will allow management to proceed without complete knowledge of the needs of the species or ecological processes.

7.2.4   Organizational Structure

The organizational structure of the monitoring and adaptive management decision-making process is described in detail in Chapter 8 and is depicted in Figure 8-1. In general, the Implementing Entity oversees the adaptive management and monitoring program. Science Advisors, the Resource Agencies, and an Independent Assessment Team will provide input and help guide the program, but the Implementing Entity has ultimate responsibility for implementing the program and instituting changes through adaptive management. Additional responsibilities of the Implementing Entity include prioritizing actions of NCCP components, disseminating information, developing annual and long-term work plans, and facilitating input from the public and outside scientists. As described in Chapter 8, the Executive Director of the Implementing Entity will work with senior scientists and managers in the Implementing Entity to implement the adaptive management and monitoring program. Preserve managers, who will be in charge of day-to-day activities within the preserves, will also contribute to annual work plans and formulate adaptive management recommendations for the plan as a whole.

A pool of Science Advisors will provide outside input regarding implementation of the monitoring and adaptive management program. Input will be provided regularly as needed to help guide monitoring protocols and experimental design, to interpret results and generate hypotheses, and to comment on the overall success of the monitoring and adaptive management program in achieving the biological goals of the plan. Upon implementation, the Science Advisors will meet formally at least once a year to review the progress of the Plan   Formal reviews will occur less frequently as the Plan progresses.

The Resource Agencies (CDFG, USFWS) will provide feedback on the implementation of the adaptive management and monitoring program described in the annual work plans. Individuals within the Resource Agencies with particular expertise in management may also participate as Science Advisors. All forms of input will be collected by the Implementing Entity and incorporated into management and monitoring practices, as appropriate (see Chapter 8, *Implementation*, for more details).

An Independent Conservation Assessment Team, distinct from the Science Advisors, will provide conservation "audits" every five years. The role of the Independent Conservation Assessment Team is described in detail in Chapter 8, *Implementation*.

A Local Land Managers Forum made up of both private and public landholders (e.g., park managers, local landowners) may be established to solicit feedback regarding the effects of preserve management on adjacent lands, to make recommendations for changing specific aspects of the HCP/NCCP, and to facilitate communication between local landowners and the Implementing Entity. For more details see Chapter 8, *Implementation.*

7.3 Implementation Schedule for the Monitoring and Adaptive Management Program

Development of a comprehensive monitoring strategy will begin once the plan is approved. The essential elements of Monitoring and Adaptive Management have been segregated into three main phases and are described below.

The initial "monitoring design phase" of monitoring occurs following permit approval and within the first five years of plan implementation and will lay the foundation of the overarching monitoring program. Because the Preserve System will take years to assemble, the monitoring design phase will focus on the development of management-oriented conceptual ecological models, prioritization and implementation of projects, the identification of focal species or groups of species for intensive monitoring, and the selection of biotic and abiotic indicators for ecosystem condition. The framework developed during the monitoring design phase will be a part of the comprehensive monitoring strategy and will be documented.

While the monitoring design phase focuses on the development of a comprehensive framework for monitoring, the inventory phase focuses on the collection of basic information as the preserve system is assembled. The "inventory phase" can take place in conjunction with the development of the above-described framework as long as standardized criteria for the inventory processes have been established. The Implementing Entity will inventory and assess landscapes, natural communities, and species, as appropriate, within the Preserve System. This information will build largely on the information collected during pre-acquisition surveys and will be supplemented by post-acquisition monitoring. Activities within this phase will begin when the first lands are incorporated into the Preserve System. The amount of activity within this phase will be proportional to the amount of land in the Preserve System.

Both the monitoring design phase and the inventory phase will be followed by long-term monitoring to determine the status and trends of landscapes, natural communities and species and the effectiveness of the management of the Preserve System in achieving the biological goals of the HCP/NCCP (Figure 7-3). The long-term monitoring phase will occur as soon as a comprehensive strategy has been developed (monitoring design phase) and baseline studies are complete (inventory phase), or before then, if appropriate. Long-term monitoring will use the framework developed during the planning and inventory phases to carry out effectiveness monitoring and to implement adaptive management.

Key tasks in each phase are described below. In general, activities in the monitoring design phase will occur during the first five years of Plan implementation (see Chapter 8 for the overall schedule of Plan implementation). Activities in the inventory phase will be initiated for each parcel as it is acquired. For an individual site, the inventory phase will begin immediately after land acquisition. Activities in the long-term monitoring phase will begin on each site after the activities in the inventory phase are complete. Because the Preserve

System is being created over a 30-year span, there will likely be extensive overlap between activities in each phase during the first 10 to 20 years of Plan implementation (Figures 7-3).

7.3.1   Monitoring Design Phase (First 5 Years of Plan Implementation)

The monitoring design phase comprises the following tasks.

■   Compile information from the HCP/NCCP and other sources (e.g., existing species models [Appendix D], GIS data layers, aerial photos, maps, plans and data from adjacent regional parks, USFWS recovery plans, critical-habitat designations, technical reports, monitoring methods) that will inform the development of a comprehensive monitoring strategy. These will be reviewed periodically (see Long-term Monitoring Phase).

■   Develop conceptual ecological models for the natural community types in the inventory area. The relevance of these conceptual models is described in the section on Conceptual Models below.

■   Determine monitoring priorities within each natural community by identifying key threats to covered species, covered species that may be declining, or changes to key ecological processes.

■   Identify focal species or groups of species such that monitoring of covered species can be carried out efficiently and cost-effectively.

■   Identify the indicators (or variables) for natural community function and, if appropriate, for covered species and develop performance indicators for the conservation measures.

■   Develop preliminary strategies for monitoring species and natural communities (protocols, schedules, time intervals for monitoring, multi-species approaches) and landscape-level processes.

■   Use aerial photos or satellite imagery to update land cover mapping in inventory area to track condition of natural communities.

7.3.2   Inventory Phase (Immediately after Land Acquisition)

The inventory phase consists of the following tasks.

■   Inventory resources as the Preserve System is assembled. The results of the surveys for land acquisition (i.e., pre-acquisition surveys) will be the first source of baseline data.

■   Use pre-acquisition surveys to validate and refine species models as lands are surveyed and acquired (note that data collected during pre-acquisition

surveys on lands not acquired by the Implementing Entity will be kept confidential to the extent allowable by law).

■ Use aerial photos and ground surveys, as needed, to assess quality and location of habitat linkages between unprotected natural areas and adjacent protected lands.

■ Refine conceptual ecological models at all scales and species-habitat models based on inventory data and other new information.

■ Begin pre-treatment monitoring of sites considered for enhancement, restoration or creation. Develop criteria for measuring success. Prioritize and begin enhancement, restoration, and creation efforts.

■ Prioritize, design, and initiate pilot projects to test management and monitoring methods.

■ Conduct post-acquisition biological inventories. Additional surveys may be needed to provide more resolution and detail than gathered in pre-acquisition surveys.

■ Initiate management actions and management planning (e.g., Preserve System Recreation Plan, Preserve System Exotic Species Plan, Preserve Management Plans, or updates to these plans, as needed) described in Conservation Strategy.

7.3.3   Long-Term Monitoring Phase

The long-term monitoring phase includes the following tasks.

■ Update GIS layer of land cover at intervals that will detect substantive changes in land use (i.e., every five years) through aerial photos or satellite imagery. Assess status and trends at the landscape and natural community levels.

■ Monitor species (covered species or indicator species) response to enhancement, restoration, and habitat creation.

■ Monitor restoration sites for success; remediate sites if initial success criteria are not being met.

■ Conduct pilot projects and directed research and assess results.

■ Refine conceptual species-habitat models and management-oriented ecosystem models as more information becomes available.

■ Monitor focal covered species using methodologies developed in monitoring design phase. Assess status and trends of covered species by monitoring covered species populations, groups, or guilds of species or indicators over time.

■ Continue to evaluate and modify monitoring protocols as necessary.

■ When restoration projects are complete and meet final success criteria, scale back monitoring effort to be consistent with the rest of the Preserve System.

■ Work with other individuals and organizations (e.g., EBRPD, local universities) to facilitate research on the Preserve System that will improve management.

7.4 Monitoring and Adaptive Management Program

The Implementing Entity is responsible for monitoring the status of covered species, ecosystem function, and the effectiveness of the conservation strategy. The monitoring and adaptive management program will evaluate the following:

■ success of management measures in achieving preferred habitat conditions and other biological goals and objectives.

■ species response to desired habitat condition.

■ status and trends at the landscape, natural community, and species levels.

Additionally, the monitoring and adaptive management program will seek to identify and develop the following:

■ Preserve management actions in response to unanticipated changes and threats, and

■ Preserve management actions to address changed circumstances (see Chapter 10 for a description of changed circumstances and the remedial measures that will be applied if they occur).

The framework and guidelines for the monitoring and adaptive management program is described below.

7.4.1 Adaptive Approach

Based on the best scientific information currently available, it is expected that the Plan's conservation measures will effectively achieve the biological goals and objectives. However, there is uncertainty associated with the management techniques, and the conditions within the inventory area, regional habitat conditions, and the status of covered species and natural communities may change in unexpected ways during Plan implementation. It is possible that additional and different management measures not identified in the Plan will be identified and proven to be more effective in achieving biological goals and objectives than those currently implemented. Results of effectiveness monitoring may also indicate that some management measures are less effective than anticipated. To address these uncertainties, the monitoring and adaptive management program will:

- gauge, in cooperation with USFWS and CDFG, the effectiveness of conservation measures and techniques to implement them; and

- propose alternative or modified management measures within the Preserve System as the need arises consistent with existing funding.

The cornerstone of the monitoring and adaptive management program is an experimental approach—monitoring will be established to yield results that inform management decisions (Figures 7-2 and 7-4). Information collected through monitoring and other experiments will be used to manage preserve lands and protect covered species habitat and natural communities. The adaptive management process will be administered by the Implementing Entity. Through the local land-managers forum (described in detail in Chapter 8), the Implementing Entity will also coordinate and share monitoring and other experimental results, as appropriate, with other regional restoration and management programs. A well-coordinated and scaleable monitoring program design will enable the Implementing Entity and others to measure and evaluate change in resources and threats in individual preserves, across the entire Plan area, and within the ecoregion. Such coordination requires standardization of protocols, sampling design, and training of personnel, as well as integrative data analyses. Programs and organizations with which the Implementing Entity should coordinate include those listed below.

- Los Vaqueros Watershed Management and Habitat Restoration (CCWD).

- Management of East Bay Regional Park District units in the inventory area (EBRPD; see Table 2-4).

- Management of Mt. Diablo and Cowell Ranch State Parks (CDPR).

- Management of Byron Airport Habitat Management Lands by Contra Costa County.

- Restoration Program for Dutch Slough (California Coastal Conservancy, Natural Heritage Institute, and California Department of Water Resources).

- Marsh Creek Habitat Enhancement (City of Brentwood, City of Oakley, Natural Heritage Institute, Contra Costa County Flood Control and Water Conservation District).

- Marsh Creek Reservoir Expansion Project (Contra Costa County Flood Control and Water Conservation District).

- Mitchell Canyon Creek Restoration Project (Mt. Diablo State Park, Save Mount Diablo).

- Kirker Creek Watershed Management Plan (Contra Costa Resource Conservation District).

The Science Advisors will evaluate the effectiveness of existing or proposed preserve management measures. The Implementing Entity will incorporate recommendations provided by these reviews, where appropriate, into Plan implementation. It is also intended that the adaptive management program will provide the basis for budget and funding decisions throughout the term of the

Plan. Figure 7-4 conceptually illustrates the adaptive management process that will be used in this plan. The adaptive management process, using data from monitoring and management experiments, will provide the Implementing Entity with a process to effectively address uncertainties.

7.4.2   Definitions

The Plan primarily utilizes a habitat-based approach for ensuring that covered species and natural communities are conserved in the Plan area. However, our knowledge of the covered species, their habitats, and the ecological systems that support them are generally poor. This lack of data introduces uncertainty into the effectiveness of Plan management measures within the Preserve System. Uncertainty is also an inherent component of ecological systems because of natural variation (e.g., rainfall, climate, and species behavior and responses). Land use changes outside the influence of this Plan (e.g., development in Antioch and other non-covered activities) also introduce uncertainty. Ecosystems are inherently complex, which makes predicting species and habitat responses to management actions difficult. To address such uncertainties, the monitoring and adaptive management program is based on the principles of adaptive management, which allow preserve management measures to be adjusted over time based on results of monitoring and other experiments. This approach provides greater certainty that Plan goals and objectives for covered species and natural communities will be achieved.

According to Kershner (1997):

> Adaptive management is the process whereby management is initiated, evaluated, and refined (Holling 1978, Walters 1986). It differs from traditional management by recognizing and preparing for the uncertainty that underlies resource management decisions. Adaptive management is typically incremental in that it uses information from monitoring and research to continually evaluate and modify management practices. It promotes long-term objectives for ecosystem management and recognizes that the ability to predict results is limited by knowledge of the system. Adaptive management uses information gained from past management experiences to evaluate both success and failure, and to explore new management options.

USFWS's Five-Point Policy for HCPs (65 FR 106, June 1, 2000) defines adaptive management as

> a method for examining alternative strategies for meeting measurable biological goals and objectives, and then if necessary, adjusting future conservation management actions according to what is learned.

The California NCCPA of 2003 (California Fish and Game Code 2805(a)) defines adaptive management as follows:

us[ing] the results of new information gathered through the monitoring program of the plan and from other sources to adjust management strategies and practices to assist in providing for the conservation of covered species.

The HCP/NCCP adaptive management process described in this section is designed to be consistent with these definitions. The Plan's adaptive management program incorporates the four elements USFWS recommends for adaptive management strategies in HCPs (65 FR 35252):

- Identify uncertainties and the questions that need to be addressed to resolve the uncertainties .

- Develop alternative strategies and determine which experimental strategies to implement.

- Integrate a monitoring program that is able to detect the necessary information for strategy evaluation.

- Incorporate feedback loops that link implementation and monitoring to a decision-making process.

The Plan incorporates the concepts of passive and active adaptive management advocated and defined by USFWS for implementing HCPs (65 FR 35250–35257). Through passive adaptive management, the Implementing Entity will learn how to ensure better attainment of the Plan's biological goals and objectives based on the measured success of various approaches to implementing the Plan (as indicated by effectiveness monitoring results). The Implementing Entity will also take an active adaptive management approach, including directed research, to resolve uncertainties related to the best approaches for achieving specific Plan objectives. Under this concept, the Implementing Entity would design and implement experimental pilot projects to test the relative efficacy of several approaches for attaining an objective and to evaluate different monitoring techniques.

7.4.3   Scientific Principles

Because the biological outcome of many management actions is uncertain, the monitoring and adaptive management program is based on scientific principles that guide continual refinement of conservation efforts in order to achieve the biological goals of the plan. The adaptive management program will develop alternative management strategies and test the effectiveness of these strategies in the Preserve System. To that end, there is a continuum of management actions that incorporate scientific principles of adaptive management to varying degrees (Figure 7-2). The most basic monitoring involves simply monitoring effects once a management action has been taken, without any replication, controls, or comparison of management treatments. At the other end of the spectrum is directed research that tests a hypothesis in a manner that can be validated through statistical inference. Even simple experimental methods will yield important

results to help guide and improve management. The following scientific principles will guide the adaptive management program:

- Management actions, especially early in Plan implementation, should incorporate scientific principles of replication, control, and pre- and post-treatment monitoring, where feasible.

- Management actions should be linked to hypotheses about species' ecological relationships and responses to management actions, when possible.

- When feasible, adaptive management or directed research should include an experimental design with appropriate significance levels (alpha level) as well as sufficient power to detect effects (beta level).

Adaptive management, and the design of experimental research, should be driven by hypotheses about key factors in the natural community in which the management is applied. For example, if the goal of management is to increase populations of small mammals to serve as a prey base for covered species, land managers must develop hypotheses about what controls small mammal abundance and distribution. Management actions and monitoring should be directed towards confirming or disproving those hypotheses. For key management questions, directed research should be tested on a small scale using an experimental design that will yield statistically valid results.

In addition to the scientific guidelines described above, the following steps will precede experimental design:

1. **Define the question.** Monitoring strategies should be designed to address specific hypotheses. Conceptual, statistical, or spatially explicit models will define those hypotheses. Conceptual models are described below.

2. **Determine what to measure.** Establish the attributes or variables that the monitoring will measure to answer the question defined above.

3. **Develop monitoring protocols.** Questions to be answered by the monitoring program can be at the species, natural community or landscape level. Monitoring protocols will vary with scale and with the target of the monitoring. Monitoring protocols should be developed in accordance with the guidelines provided in the section on Monitoring Protocols below.

4. **Use indicator species, if appropriate.** In some cases groups of species or indicator species will streamline monitoring. Indicators are selected because they are easy to survey and provide usable information on the species or system in question. Guidelines for selecting and using indicators are described in detail below.

5. **Consider sampling design.** Sampling design needs to be a consideration prior to initiating the experiment. The experimental-management approach of the HCP/NCCP requires that questions of site selection, pseudo-replication, power, and significance be incorporated, as much as possible,

into the monitoring and adaptive management program. Sampling design is described in detail below.

Management-Oriented Conceptual Models

Conceptual models describe our current understanding of a functioning ecosystem. They provide a framework for learning about a system and help formulate hypotheses about cause-and-effect relationships. Conceptual models are useful for management because they can help to identify which factors may be important in a system, which of these factors may be influenced by management, and hence which attribute (component or condition) of the system should be monitored. Conceptual models can inform the monitoring program in several important ways: by providing a basis from which to test assumptions about the relative importance of certain processes, by helping to identify threats or stressors that require monitoring, by identifying species or other attributes that function as indicators, and by serving as a repository of our changing understanding of the system as more data become available. Conceptual models can also be used to communicate understanding of the system to other scientists and the public and to facilitate review by outside experts.

For a multi-species, habitat-based conservation plan, models such as this will provide a useful framework for understanding how individual species react to the same management actions. Therefore, models must be sufficiently complex as to capture the relationships that drive the system and translate these relationships to covered species but streamlined enough to be useful as management and monitoring tools.

Models are only as good as the information used to develop them. At first, models can be developed that show hypothesized relationships among species and processes (i.e., based on little or no data). These early models will help identify key data gaps that should be filled through directed research or other exploratory studies. As data improve, the confidence in model parameters will also improve.

Models can be either narrative or diagrammatic. In most cases, diagrams show the hypothesized relationships that characterize the ecosystem and are supplemented by written materials. Several types of models can be used including stress-response models and habitat models. In the stress-response model (shown in Figure 7-5), stressors and threats are aligned along the left tier of the model; the central tier displays habitat responses, and the right tier shows hypothesized responses of covered species. A more complex stress-response model is seen in Figure 7-6. This model incorporates the following concepts:

- **Drivers/sources:** natural or anthropogenic forces having large-scale influence on natural systems.

- ■ **Stressors/pressures:** physical or chemical changes to the system brought about by the drivers that cause subsequent changes to the relationships or components of the natural system.

- ■ **Ecological effects:** the biological response caused by the stressor.

- ■ **Attributes:** a streamlined set of key biological elements that best represent the overall ecological elements of the system. These items should function as indicators of the hypothesized effects of the stressors and are useful to identify for the purposes of monitoring. Covered species may also serve as attributes such that the effect of stressors on these species may be evaluated.

- ■ **Indicators (Performance measures):** the specific features of each attribute to be measured.

Species-habitat models are also useful tools that make explicit our assumptions about the relationship between species and land cover. These can also be considered conceptual models. Species-habitat models were developed for most covered species using GIS to hypothesize a relationship between land cover type and other habitat associations and the distribution of covered species. These models (Appendix D) have served as the basis for estimating impacts and prioritizing land acquisition. Information from the pre-acquisition surveys and the planning surveys for covered activities will further refine these models such that they can be used to predict distribution, occupancy, and assess population trends.

In the monitoring design phase, the Implementing Entity will develop stress-response models for each natural community type. Additionally, species-habitat models will be improved or stress-response models created for each of the covered species. A critical task in the development of these models is the identification of uncertainties and threats or pressures. The identification of uncertainties provides a springboard for additional targeted studies. The following steps are recommended to develop conceptual ecological models (Atkinson et al. 2004):

1. Complete conceptual models for each covered species (existing species models and species profiles can be used).

2. Identify critical uncertainties for covered species requiring additional study.

3. Identify pressures on natural community types including species-specific, local, and regional or global pressures.

4. Develop conceptual models for natural community types and include relationships to covered species.

5. Select monitoring variables for ecosystem function and for covered species based on conceptual models. Species groups or indicators may be monitored when applicable.

6. Refine landscape and natural community level studies described in section *Adaptive Management and Monitoring by Natural Community Type* below based on conceptual models.

7. Develop landscape-level model across multiple natural community types including interactions with processes and pressures. Identify regional pressures such as fragmentation, catastrophic fire, etc.

These models will inform the selection of indicators and guide the monitoring that is to take place. The section *Adaptive Management and Monitoring by Natural Community Type* provides background on each natural community type and broadly describes the threats, disturbance regimes, etc., that may be incorporated as components of the models.

Monitoring Protocols

When possible, accepted monitoring protocols will be adopted to facilitate data comparison with other studies. Monitoring protocols should be appropriate to the task, accurate, and as cost-effective as possible. Monitoring protocols should be standardized across the entire Preserve System and should be incorporated into all preserve management plans. To be successful, the monitoring protocols must be applied consistently by different observers and across monitoring cycles. Ongoing training will be necessary by Implementing Entity staff or their contractors to ensure this consistency. The National Park Service's Inventory and Monitoring Program guidelines for monitoring protocols (Oakley et al. 2003) or the Bureau of Land Management's guidelines (Elzinga et al. 1998), in addition to other sources, can be used as references for developing monitoring protocols.

Monitoring protocols will vary by covered species. For a species that is difficult to detect, such as Alameda whipsnake or silvery legless lizard, monitoring may be limited to determining whether the species persists from sample period to sample period, what features define its habitat, and what threats it faces. Monitoring for a less rare (or more detectable) species such as California tiger salamander may detect whether its range is increasing or decreasing. For a species that is sufficiently detectable to obtain estimations of population size or probability of detection such as western burrowing owl or many covered plants, monitoring a randomly selected subset of the population in order to make statistical inference to the whole population can be achieved through adherence to the following principles:

- Develop and state the assumptions in the hypotheses and models *before* collecting monitoring data or conducting manipulations such as experiments and adaptive management.

- When designing an experiment or using adaptive management, select the number and location of sampling units so as to apply sufficient scientific rigor for evaluating the hypothesis being advanced.

- Replicate in space and time the number of the sites surveyed for population estimates and/or those receiving a management action. Use controls when appropriate.

- Adjust the sensitivity of the data to reflect true changes in the resource being sampled. When appropriate, adjust counts, measures of species richness and patch occupancy (i.e., presence/absence) with an estimate of detection probability as described by Lancia and others (1994), Yoccoz and others (2001), and Pollock and others (2002).

Indicators

Indicators can be used in many ways: to predict species richness (MacNally and Fleishman 2004), to estimate biodiversity (Kati et al. 2004), to assess levels of disturbance, or to provide targeted information on a system or species (Caro and O'Doherty 1999, Carignan and Villard 2004). Landres and others (1988) define an indicator species as

> an organism whose characteristics are used as an index of attributes too difficult, inconvenient, or expensive to measure of other species or environmental conditions of interest.

In this plan indicators will be used, when appropriate, to provide information on covered species and other components that are difficult to survey and to provide information on natural community or ecosystem function. For the purposes of this plan, indicators are abiotic and biotic variables that are selected to facilitate monitoring of systems or species that are otherwise difficult to examine.

In cases where an indicator species is being used to monitor covered species (population indicator species) (Caro and O'Doherty 1999), we assume that impacts to the species being monitored are the same as impacts to the target species. In cases where an indicator is being used to monitor an ecosystem or natural community (health indicator species), the conceptual models will be used to help identify an appropriate indicator species or variable. Draft performance indicators for natural community enhancement, restoration, and creation measures are presented in Table 7-1. Indicators, in general, are easy to monitor and will demonstrate a change or trend that is quantifiable. Indicators need not be species, but may be ecological variables or structure-based indicators such as diameter and age-class of trees, interpatch distances between habitat, or key structural features of certain habitat types (e.g., snags or downed logs in forests, woody debris in rivers) (Noss 1999, Lindenmayer et al. 2000). Effective indicators (or variables) have some or all of the following characteristics (Carignan and Villard 2002, Atkinson et al. 2004).

- They are relevant to program goals and objectives and can assess the program performance at the appropriate spatial and temporal scales.

- They are sensitive to changes in the ecosystem providing early warning of response to environmental (or management) impacts.

- They indicate the cause of change, not just the existence of change.

- They give a continuum of responses to a range of stresses such that the indicator will not bottom out or stabilize at certain thresholds.

- They have known statistical properties, with baseline data, references, or benchmarks available.

- They are technically feasible, easily understood, and cost-effective to measure by all personnel involved in the monitoring.

If possible, the indicators or variables should also be coordinated with existing programs and data sets. Prior to adopting any indicator, field verification and fine-tuning in the system of interest is required (Atkinson et al. 2004). Once monitoring variables have been selected, the following descriptions should be made (Atkinson et al. 2004 as adapted from Gibbs et al. 1999 and National Research Council 2000).

- "what" will be monitored,

- "why" the monitoring is useful (i.e., the specific question the variable is designed to address),

- the conceptual ecological model underlying the selection of the monitoring variable,

- the geographical area where it will be monitored,

- the specific variable that will be measured and the protocol that will be used,

- the range of values the monitoring can produce and what these would mean,

- the expected response (as in response to management or outside pressures) and the magnitude of change expected, and

- the time frame and spatial scale over which change is expected to be demonstrated.

Finally, it is important to consider how the results will be interpreted and how they can be used to create change, if necessary.

Sampling Design

Sampling design will vary with the goals and phases of monitoring. During the Inventory Phase, baseline inventories may require a less rigorous sampling design, relying, for example, on visual surveys for detecting presence/absence/not detected. "Rapid Assessment" techniques may also be used. As the on-the-ground monitoring progresses, site selection and replication merit increased attention based on the goals of the monitoring at that time.

An important goal in sampling and experimental design is to minimize variance in the measured values of indicators or variables. Selection of variables should be guided by a thorough knowledge of the ecological relationships that drive natural communities. Sampling intensity and probability of detection should be

considered, as much as possible, to ensure that rare species are adequately inventoried and monitored. The way the data will be analyzed should be established prior to designing a study and a statistician or biologist with sufficient statistical expertise should be consulted. Issues to consider include (Scheiner and Gurevitch 1993):

- availability of sites on which treatments can be applied,

- the site-selection process (is it random?),

- systematic versus opportunistic sampling,

- detection probability of the protocol,

- replication versus pseudo-replication (Hurlbert 1984),

- the clarity of hypotheses, and

- sufficient power $(1-\beta)$ or significance level (α).

Pilot Projects

Pilot projects provide an opportunity to test methodologies for monitoring (monitoring protocols and sampling design) and to refine hypotheses on a small scale prior to initiating large-scale management actions or experiments. Pilot projects should be used extensively in this Plan to ascertain which management actions may ultimately yield the desired conservation gains prior to initiating a large-scale project. Pilot projects are also a cost-effective way to test management actions.

A brief implementation plan will be developed by the Implementing Entity for each pilot project. This plan will describe the study design, the hypotheses and variables being tested, and the monitoring and analytical methods that will be employed to assess the success of the pilot project. Results of these pilot projects will provide the information necessary to inform the Implementing Entity on how to proceed with full implementation of the conservation measures. Pilot projects are an important component of directed research (described below). Table 7-2 provides example pilot projects and directed research for several key conservation measures.

Directed Research

Directed research is the most rigorous form of "monitoring" on the spectrum described by Figure 7.2. Consequently, it is the most time-consuming and costly form of experimental management. Directed research employs an experimental approach that includes pre- and post-treatment monitoring, replication in time and space, and controls (Figure 7-2). Ideally, directed research can detect both false negatives and false positives, yielding statistically valid results. The Implementing Entity may undertake directed research to provide targeted

information necessary to adaptively implement the Plan. This research should answer specific management-related questions that arise based on results of monitoring and to address data gaps to provide information necessary to successfully implement management measures within the Preserve System (see Table 7-2). The Implementing Entity may undertake research to reduce the levels of uncertainty related to achieving biological goals and objectives. These uncertainties are generally related to the following:

■   the efficacy of natural community enhancement/creation/restoration techniques,

■   the ecological requirements of covered species, and

■   the likely response of covered species and natural communities to implementation of management measures within the Preserve System.

Results of research conducted under the Plan will inform management and ensure attainment of the biological goals and objectives.

It is expected that most or all directed research will be conducted by or in partnership with outside scientists from academic institutions, consulting firms, and non-profit organizations. It is anticipated that funding provided by the Implementing Entity for directed research could be matched or supplemented by other entities to increase the level of research and to achieve results that integrate with broader issues in the research community. The amount of directed research will be limited by funding available to the Implementing Entity (see Chapter 9). In addition to directed research undertaken by the Implementing Entity, it is also expected that scientists within the Implementing Entity (Executive Director, biological staff) will develop partnerships with academic institutions (undergraduate student projects, Masters theses, Ph.D. dissertations) to help direct research within the Preserve System that will inform and improve management and monitoring techniques. Funding for this and other programs is described in more detail in Chapter 9 *Funding*.

7.4.4   Monitoring at Multiple Scales

Because the conservation strategy addresses the conservation of species and natural communities at multiple scales, the monitoring program must evaluate success at the species, natural community, and landscape levels. The subsequent description details the framework for a three-tiered approach involving landscape-, natural community–, and species-level monitoring.

Landscape-level monitoring is designed to detect large-scale changes, including changes in ecosystem processes, shifts in natural community distribution, and the integrity of habitat connectivity. Community-level monitoring is designed to detect changes in the composition of natural communities, populations of key predator or prey populations, invasive species, and other important habitat factors for covered species. Species-level monitoring measures the impacts of covered

activities on selected covered species and tracks the abundance, distribution, and other variables of covered species in the Preserve System and the inventory area.

Specific monitoring tasks are described in the section below on *Adaptive Management and Monitoring by Natural Community Type*. In some cases the landscape-level monitoring could also be considered natural community–level monitoring, or the natural community monitoring could be considered species monitoring. As with all questions of scale, the distinction between levels is, in some way, subjective. As much as possible we have sought to adhere to the definitions of scale described in this document, acknowledging that the division between scales is not always clear-cut.

Landscape-Level Monitoring

Landscape-level monitoring is directed at geographically large areas that maintain essential ecological processes. Functioning landscapes encompass multiple ecosystems and natural communities and the movement of nutrients or materials between those units. Landscape-level monitoring addresses the following issues relevant to the HCP/NCCP:

- the amount and distribution of land cover types in the Preserve System and their relationship to each other (e.g., succession or conversion from one community type to another, transitions zones between communities),

- the status and trends of land cover types, natural communities, and other landscape features,

- the quality of habitat linkages and their potential role as dispersal and movement corridors,

- the delineation and function of watersheds, and

- regional weather patterns and groundwater levels that affect natural communities.

The purpose of monitoring changes in the extent of land cover types within the planning area is to track long-term, landscape-level changes and, by inference, changes to the habitats and natural communities contained therein. Long-term changes can indicate local, regional, or global problems such as unanticipated impacts of covered activities, influence of invasive species, and effects of climate change. Monitoring long-term changes will also track the contribution of the HCP/NCCP toward maintaining or improving the extent, distribution, and continuity of natural land cover types. Changes in land cover type should result from landscape-level management actions (e.g., conversion of unvegetated streams to riparian woodland/forest; see Chapter 5). If landscape-level changes differ from the expected outcomes due to management actions, the Implementing Entity will attempt to identify reasons for the changes and address them through the adaptive management program, if needed.

Some possible approaches to landscape-level monitoring are discussed below.

Planning and Pre-acquisition Surveys

Information on landscape features will be collected through planning and pre-acquisition surveys that provide information on the amount and distributions of land cover types in the Preserve System. These data will be used to refine currently existing species-habitat models (see section *Management-oriented Conceptual Models* above). Additionally, this information will be combined with other landscape-scale information being collected by others in the region to provide resource managers, including the Implementing Entity, with an understanding of how critical biological resources are generally trending under the influence of Plan implementation as well as under the influence of other human activities and other environmental factors (e.g., fire, drought, disease).

Remote Sensing

At the landscape level, the Implementing Entity will monitor, using aerial photos or satellite imagery, the extent and distribution of HCP/NCCP land cover types within the inventory area every 5 years. Land cover mapping should be verified in the field at sites where air photo interpretation is difficult. Current species models (Appendix D) reflect the landscape-level data available at the time of the writing of this plan (2001 aerial photos with field and other updates to 2004 conditions). Species models will be improved as new data become available.

Additionally, landscape-scale information generated through pre-acquisition and planning surveys will be cross-checked against periodic updates to the land cover map from aerial photos or satellite imagery. The Implementing Entity will coordinate landscape-level monitoring with ongoing or future efforts that may be conducted by others within the Plan Area (e.g., EBRPD).

Natural Community–Level Monitoring

The Implementing Entity will conduct monitoring to assess ecosystem and natural community function and to determine the response of natural communities to management. Natural community–level monitoring focuses on local threats to communities and habitats (such as specific invasive species) and the habitat attributes that may affect the status of covered species. Natural community monitoring includes, but is not limited to, the following issues relevant to the HCP/NCCP:

■ the extent and quality of natural communities and the relationships between their constituent elements;

■ the ability of natural communities to withstand natural and anthropogenic stressors/threats;

■ the effectiveness of the conservation measures in enhancing, creating, or restoring natural communities and their associated features (ponds, riparian

areas, etc.) and the ability of these areas to provide their intended ecological functions and values;

- the response of keystone species (i.e., species such as ground squirrels that affect the community in greater proportion than their relative abundance) to management actions;

- community dynamics such as grassland burrow systems; and

- the presence/absence and abundance of nonnative invasive species.

Monitoring Enhanced, Created, and Restored Habitat

Natural community monitoring will inform enhancement/creation/restoration techniques through the adaptive-management program. Specifically, monitoring will be established using an experimental approach (described under *Principles of Monitoring* above) such that results can be evaluated and future management actions improved. Monitoring of enhanced, created, or restored habitat will focus on the community or habitat response and, when applicable, the species response. This monitoring will ensure that the restored natural communities are functioning as habitat for a particular covered species or suite of species associated with the subject communities. Table 7-1 lists examples of standards and objectives that may be the basis for assessing success of natural community enhancement, creation, and restoration conservation measures.

Conceptual Models. Ecological models will be used as a planning/design tool for monitoring ecosystem and natural community function, and, to some extent, the success of the conservation strategy in creating, enhancing, and restoring habitat. See section on Conceptual Models above for more details.

Mapping invasive plants. Within the Preserve System, the Implementing Entity will delineate occurrences of invasive, nonnative plants as they are identified (by planning and other surveys) and periodically monitor these occurrences. The frequency of monitoring will depend on the threat that species pose to native biological diversity. For example, nonnative plants that occur within the preserves and have the ability to spread rapidly will be monitored more frequently (e.g., several times per year). Species that spread slowly will be monitored less frequently (e.g., every 3–5 years). Additionally, Implementing Entity field staff will look for occurrences of new invasive plants that require immediate eradication or control actions within the HCP/NCCP preserves. Department of Fish and Game maintains a list of invasive plants that can be used for reference purposes.

Monitoring protocols for invasive plants will be coordinated with those of other local entities (e.g., EBRPD, CDPR, CCWD, Contra Costa County Department of Agriculture, Weights and Measures) to ensure consistency with these programs and facilitate the sharing of monitoring results. This monitoring information will be used to determine the need for management actions to control the spread of existing invasive plants and future, potential invasions. The effectiveness of

control methods will also be reviewed. This monitoring information will be shared with the Alameda–Contra Costa Weed Management Area, EBRPD, CDPR, CCWD, and other state and local land-management agencies charged with the control of invasive plants as well as with managers of adjacent public lands.

Natural Community Inventory Protocols. In addition to the surveys for land acquisition, once the parcels have been acquired a vegetation and wildlife community inventory will be conducted. This inventory and mapping will draw as much as possible from accepted protocols for typing vegetation communities and wildlife habitats. These typing protocols include the California Native Plant Society "Vegetation Rapid Assessment Protocol" (California Native Plant Society 2002) and "Releve Protocol" (California Native Plant Society 2003) for plants. Vegetation associations and alliances will be classified and mapped in more detail than the regional land cover classification used in this Plan.

Similarly, acquired parcels will be surveyed for wildlife communities including covered species, invasive species, and other potential disturbances. These protocols will be developed by the Implementing Entity during the initial phase of implementation. Additional specific protocols that may be used for wildlife include live trapping, vocalizations/recordings, mist netting, observation scans, search transects/plots, infrared camera stations, and identification of tracks and scat.

Along with the existing species models, the California Wildlife Habitat Relationships (CWHR) classification will be used, to the extent possible, to understand the relationship between natural communities, their habitat, and wildlife species. Information from CWHR, the results of protocol surveys, and any other relevant, new information will be incorporated into species and community models throughout the lifetime of the plan. When feasible, the Implementing Entity will seek to develop protocols that use a multi-species or habitat-based approach.

Species-Level Monitoring

The Implementing Entity will conduct monitoring to assess the status of covered species and to determine the extent to which the biological goals and objectives for species are being met. Species monitoring will address the following issues relevant to the HCP/NCCP:

- the response of covered species to HCP/NCCP conservation measures and adaptive management,

- status and trends of covered species and other relevant species within preserve lands, and

- trends in abundance for selected wildlife indicator species over the term of the Plan.

Take Authorization during Monitoring. Certain activities associated with monitoring may result in take of covered species (e.g., trapping, handling, enhancement or propagation, use of recorded vocalizations, marking). Take of covered species is authorized providing that

- the take occurs during activities described in the conservation strategy, monitoring chapter, or monitoring plan to be written for the Preserve System;

- the take occurs during activities conducted by the agents or employees of the CDFG, USFWS, the Implementing Entity, or any person acting under the direct guidance or authority of these entities;

- the person(s) undertaking such activities is qualified to do so and can carry out their duties in conformance with the protocols and procedures specified in the monitoring chapter and in the subsequent monitoring plan(s); and

- the activity is consistent with the monitoring and adaptive management program.

In order to meet USFWS requirements, the amount and extent of take must be reported in accordance with 10(a)(1)(a) guidelines, and the annual workplan that describes the monitoring must be submitted for review and approval by the USFWS and CDFG.

These provisions are consistent with the USFWS policy described in the HCP Handbook (USFWS 1996).

Indicator Species. When appropriate, species can be used as indicators of ecosystem function and as surrogates for covered species that are difficult to monitor.

Species monitoring will provide data for use by USFWS, CDFG, universities, and wildlife conservation organizations to assess the overall status of species populations; to identify species conservation needs; and to direct future conservation efforts. This information may also be used to redirect, HCP/NCCP conservation efforts in future years (e.g., preserve management prescriptions) to improve conditions on preserve lands for declining species. (Any redirection of HCP/NCCP funds in response to monitoring must be done within the terms and conditions of the IA and permits, including the No Surprises assurances.)

Focal Covered Species. The status of all covered species will be monitored during the 30-year permit term. To facilitate the monitoring of covered species, a multi-species approach will be used, to the extent possible, for long-term monitoring. Focal covered species or species groups will be monitored routinely to provide the data most likely to influence the conservation strategy and to manage costs effectively. In some cases, indicator species may be used when/if information on some species is highly correlated with other species, and intensively monitoring all species provides little additional information. Indicator species could also be used when monitoring covered species would have unacceptable adverse effects.

When appropriate, covered species may be used as indicators of overall ecosystem function within the Preserve System. Where feasible, species will be grouped into categories (e.g., raptors, vernal-pool species) for ease in collecting data per individual species. If appropriate, sampling stations may be used to collect information on multiple species.

Monitoring Habitat to Assess Species. Selecting the best attributes by which to measure status and trends increases the effectiveness of monitoring. Monitoring adult abundance and distribution of Covered Species is often the most appropriate, direct measure of status. However, in many cases monitoring protocols for certain species yield variable and imprecise results or require a prohibitively expensive amount of sampling effort. In these cases key habitat variables may be used—in conjunction with other information—to evaluate species status. This method requires pilot projects to verify the relationship between the habitat attribute and the species status and should be periodically re-tested to ensure that the relationship between the indirect indicator and the condition of the species does not change. See section on *Indicators* above for additional information on selection of biotic and abiotic variables. An effective monitoring program balances efficiency and cost-effectiveness with the reliability of the information obtained.

Species-habitat Models. Parameters for the existing species habitat models (Appendix D) will be refined and revised as more information becomes available. If possible, species models will be developed for the eight species for which models were not developed for this Plan (Townsend's big-eared bat, four vernal pool invertebrates, brittlescale, showy madia, and adobe navarretia).

Protocols. The Implementing Entity will be assembling the Preserve System throughout the 30 years of the permit term. Upon implementation of the Plan, the Implementing Entity will establish baseline conditions along with survey methods and monitoring schedules based on the scientific principles described above. Survey protocols and schedules will be established in the initial phase of implementation (years 1-5). These protocols and schedules will provide the overarching framework that will be implemented in each management unit. Where feasible, the Implementing Entity will draw from relevant and established protocols (i.e., CDFG and USFWS survey protocols) and will adapt them as more information becomes available.

7.5 Monitoring and Adaptive Management by Natural Community Type

The following sections describe an integrated approach to monitoring and adaptive management for each natural community type. Under this framework, covered species will be affiliated with one or more of the five natural community assemblages: wetlands (and other aquatic), grassland, chaparral/scrub, oak woodland, streams and riparian woodland/scrub. Within each of these habitat associations, monitoring and adaptive-management protocols are described at the

landscape, natural community, and species level. Species can be associated with one or more natural community types. In such cases, species-specific management and monitoring measures are described in the community type with which the species is most strongly associated (shown in brackets following the species name in discussions of habitats with secondary associations). If equally associated with more than one community type, the measures are described in the first natural community type in the document with which the species is associated. Each section below presents ecological information and recommended monitoring and adaptive management actions. The natural community types and their associated species mirror those of the biological goals and objectives (see Table 5-1).

Additional information on natural communities is found in Chapter 3; additional information on species ecology is found in Appendix D.

7.5.1   Wetlands (and other Aquatic)

Associated Land Cover Type:

- Permanent wetlands
- Seasonal wetlands
- Alkali wetlands
- Reservoir
- Ponds
- Slough/channel

Associated Covered Species:

- Tricolored blackbird
- California red-legged frog
- California tiger salamander
- Giant garter snake
- Western pond turtle
- Vernal pool fairy shrimp
- Vernal pool tadpole shrimp
- Longhorn fairy shrimp
- Midvalley fairy shrimp
- Brittlescale [Grassland[1]]

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[1] Natural communities in brackets indicate other communities with which the species is strongly associated.

■ Adobe navarretia

Ecology

Wetlands are dominated by herbaceous species that grow in wet or flooded soils. Within the inventory area, wetlands can be classified as permanent (characterized by a year-round water source), seasonal (ponded during winter and spring and dry through the summer and fall), and alkali (distinguished by alkali substrate). Vernal pools could not be mapped in the Plan but are included in the seasonal wetland land cover type. Vernal pools pond water for extended durations during winter and spring and dry completely during late spring and summer; they support numerous specialized plant and animal species, including endangered species such as longhorn fairy shrimp.

Other aquatic land cover types include open water or aquatic habitats such as lakes, reservoirs, water treatment ponds, sloughs, channels, streams, and ponds (including stock ponds) that do not support emergent vegetation. Sloughs and channels are features with perennial water and artificial banks (e.g., levees) constructed of natural soil materials with little or no in-channel vegetation. Streams that have been channelized and leveed were mapped as sloughs/channels. Ponds are small perennial or seasonal water bodies that either lack vegetation or have submerged or floating vegetation. Ponds with submerged or emergent vegetation can provide important habitat for amphibians. Ponds can either be natural features or have been created by ranchers as watering sites. The inventory area also includes four reservoirs—Los Vaqueros, Contra Loma, Antioch, and Marsh Creek Reservoirs.

Threats

Threats to wetlands include urban development, clearing or filling for agricultural, and altered subsurface and surface hydrology due to changes in land use. Perennial wetlands are also threatened by invasion of exotic plants and wildlife.

Wetlands: Landscape

Landscape-level monitoring and adaptive-management relevant to wetlands and other aquatic features include the following actions.

Inventory Phase

■ Map the distribution of ponds, wetlands, and sloughs in and adjacent to the Preserve System and assess connectivity between the aquatic habitat types and between aquatic habitat and associated upland habitat types.

- Assess connectivity between the wetlands, including vernal pools and evaluate connectivity to upland areas.

Long-Term Monitoring Phase

- Quantify changes in habitat that result from wetland and pond enhancement and restoration.

- Determine and quantify changes in habitat that result from management activities (wetland restoration) and quantify other changes that may affect covered species.

Wetlands: Natural Community

Natural-community-level monitoring and adaptive-management relevant to wetlands and other aquatic habitat types include the following actions.

Monitoring Design Phase

- Develop conceptual ecological model for wetlands. Separate models for vernal pools or other aquatic features may be necessary.

- Identify indicators for evaluating condition of wetlands.

- Develop criteria for evaluating success of wetland and pond enhancement, restoration, and creation. These criteria should evaluate whether restored habitat increased hydro-geomorphic and ecologic functions, improved habitat value, and enhanced the habitats' ability to support existing and new populations of covered species.

Inventory Phase

- Survey wetlands within preserves to determine the native wetland vegetation and monitor to ensure that levels are maintained or increased as implementation progresses.

- Survey wetland and pond capacity and water duration and monitor to ensure that the ecological and hydro-geomorphic functions related to these parameters are maintained or increased.

- Prioritize wetlands and ponds for restoration and enhancement efforts. Potential restoration sites will be identified and selected on the basis of their physical processes and hydrologic, geomorphic, and soil conditions to ensure that successful restoration can occur and be self-sustaining.

■ Use experimental-management techniques to test different creation/restoration methods (i.e., use pre- and post-treatment monitoring, replication, controls).

Long-Term Monitoring Phase

■ Determine the effectiveness of small checkdams in arresting stream-channel erosion in seasonal alkali wetlands.

■ Monitor restored wetlands using scientific principles described above (*Scientific Principles for Monitoring*).

■ Monitor and record populations and incursions of nonnative predators (e.g., dogs, cats, red foxes).

■ Assess exotic invasive plants, including maps and descriptions of their distribution and abundance; their known or potential effects on ecosystem function, native biological diversity, sensitive natural communities, and covered species; and the means and risk of their spread to other areas within and outside the preserves.

■ Determine the effects of different livestock grazing regimes (including exclosures) on wetlands and other aquatic features.

■ Assess impacts from recreation use on wetland resources and manage adaptively to reduce or eliminate impacts.

■ Evaluate the use of wetland-upland complexes by covered species.

■ Monitor predation on tricolored blackbird nesting colonies by black-crowned night heron.

Wetlands: Species

Species-level monitoring and adaptive management relevant to wetlands include the following actions.

Monitoring Design Phase

■ Develop specific monitoring protocols for giant garter snake.

■ Identify monitoring strategies for covered species.

Inventory Phase

■ Conduct surveys for vernal pool invertebrates in preserves to refine our understanding of suitable habitat for these species in the inventory area.

Long-Term Monitoring Phase

■ Determine species response of tricolored blackbird, California red-legged frog, western pond turtle, and vernal pool invertebrates to wetland and pond restoration.

■ Evaluate restored vernal pools to determine if covered vernal-pool crustaceans are present at frequencies similar to those in natural vernal-pool complexes. If not, the Implementing Entity will assess the feasibility of transplanting inoculant species samples from occupied pools to restored pools to establish new populations.

■ Survey populations of wetlands-covered species to ensure that populations are stable or increasing.

■ Survey populations of adobe navarretia to refine our understanding of suitable microhabitats for these species and determine attributes of habitat. Monitor populations to determine responses to management.

■ Further refine species-habitat models and develop models, if feasible, for vernal pool invertebrates and adobe navarretia.

■ Conduct pilot project to determine the relative benefit to California red-legged frog, California tiger salamander, and western pond turtle of different pond treatments such as access/exclusion by livestock, vegetated/unvegetated banks, and pond depth and duration.

■ Determine species response of tricolored blackbird, California red-legged frog, and western pond turtle to pond creation.

7.5.2   Grassland

Associated Land Cover Type

■ Annual grassland

■ Native grassland

■ Alkali grassland

■ Ruderal

Associated Covered Species

■ San Joaquin kit fox

■ Townsend's big-eared bat

■ Western burrowing owl

■ Swainson's hawk [streams & riparian woodland/scrub]

- Tricolored blackbird [wetlands]

- Golden eagle

- Silvery legless lizard

- Alameda whipsnake [chaparral/scrub]

- Western pond turtle [wetlands]

- California tiger salamander [wetlands]

- California red-legged frog [wetlands]

- Big tarplant

- San Joaquin spearscale

- Brittlescale

- Recurved larkspur

- Round-leaved filaree

- Showy madia [oak woodland]

- Mount Diablo fairy lantern [chaparral/scrub]

- Brewer's dwarf flax [chaparral/scrub]

Ecology

Grasslands found in the inventory area are dominated by grasses and forbs. The key processes creating and maintaining these grasslands are fire and grazing. Most of the grassland in the inventory area is currently grazed by cattle. Some areas have also been disked to improve foraging conditions for livestock. Native grasslands are very rare within the inventory area, and most native grassland species have been replaced by exotic grasses. The invasion of native grasslands by exotic grasses was facilitated in the past by drought conditions and improper grazing management. Currently, native grasslands occur either as pockets within the larger annual grasslands or as subdominant components.

Threats

The key threats facing grasslands include alteration of the disturbance regime (i.e., fire); improper grazing management (degradation of native grasses and continued replacement by nonnative species, compaction and loss of cover leading to erosion, disking); conversion to urban development; or conversion to cultivated agriculture, primarily vineyards.

Current Monitoring

Biologists at EBRPD, in cooperation with Drs. James Bartolome and Reginald Barrett of the University of California, Berkeley, are currently experimenting with monitoring methods in grasslands in the inventory area for wildlife and plant communities. Their grassland monitoring project began in 2002 on eight EBRPD units, including two in the inventory area: Vasco Caves and Morgan Territory Regional Preserves. The goals of the project are to establish baseline conditions in grassland species composition and to determine the response of these species to management. The project is expected to run for at least 10 years. Permanent plots have been established at each preserve to measure plant composition and density, soil chemistry, slope, aspect, bird species and abundance, and small mammal species occurrence. Other variables and plots may be added in the future. The methods and analyses developed for this long-term monitoring study can serve as a model for the Implementing Entity to use in establishing its own baseline conditions and monitoring the response of the grassland natural community to management actions.

Grassland: Landscape

Landscape-level monitoring and adaptive management relevant to grasslands include the following actions.

Inventory Phase

- Map all stands of grassland with at least 25% relative cover of native species (grasses or forbs) within the Preserve System to identify areas for enhancement practices and monitor to ensure that relative cover of native grasses and forbs is increased.

- Quantitatively classify each grassland stand in the Preserve System to the alliance level according to the CNDDB vegetation classification scheme (California Department of Fish and Game 2002) to aid in cataloguing habitat diversity and in tracking habitat responses to management.

Long-Term Monitoring Phase

- Develop a pilot project to determine the feasibility of enhancement activities on a large scale. The pilot project will investigate the effect of management actions, including grazing and burning regimes, on native grassland species.

- Assess grassland landscape connectivity between preserves.

- Record the frequency, location, and ignition source of all wildland fires within this community to develop a long-term fire record.

Grassland: Natural Community

Natural-community-level monitoring and adaptive management relevant to grasslands include the following actions.

Monitoring Design Phase

■ Develop a management-oriented conceptual model for grasslands that includes important factors such as the effects of rainfall, temperature, fire, herbivory (i.e., grazing) and succession to woody communities such as chaparral/scrub or oak woodland.

Inventory Phase

■ Develop a pilot project to evaluate management methods to increase prey for covered grassland species. Consider using methods already developed and applied to the Los Vaqueros Watershed to monitor ground squirrel population density as an indicator of habitat quality for San Joaquin kit fox (Jones & Stokes Associates 1998c; Jones & Stokes 2000).

Long-Term Monitoring Phase

■ Assess and monitor exotic invasive plants, including developing maps and descriptions of their distribution and abundance; their known or potential effects on ecosystem function, native biological diversity, sensitive natural communities, and covered species; and the means and risk of their spread to other areas within and outside the preserves.

■ Develop projects that test the effect of different grazing practices (e.g., grazing intensity, duration, season, type of livestock) on the maintenance and regeneration of native grasses and forbs. If possible, combine grazing treatments with other management techniques such as prescribed burns and hand seeding to detect interactions among management treatments.

■ After the pilot project described in the Inventory Phase above has established the preferred management methods for increasing prey, monitor ground squirrel and other small-mammal populations to determine the abundance of prey and burrows for several covered species (e.g., western burrowing owl, golden eagle, California red-legged frog, California tiger salamander) and many common species).

Grassland: Species

Species-level monitoring and adaptive management relevant to grasslands include the actions listed below.

Monitoring Design Phase

- Estimate relevant demographic parameters such as adult survivorship and age structure of some covered species (e.g., San Joaquin kit fox, western burrowing owl) to help estimate population trends. (Construction of complete demographic models will not be feasible for most species.)

- Identify monitoring strategies for covered species.

Inventory Phase

- Using a bat detector, inventory Townsend's big-eared bat in acquired lands with potential habitat features (rocky outcrops, caves, mines, old structures).

- Develop a pilot project to evaluate the suitability of artificial hibernacula for use by Townsend's big-eared bat.

- Map all locations of active golden eagle and tricolored blackbird nests in and adjacent to the inventory area to determine the most likely foraging habitat for these species. The Contra Costa Water District monitors the location of all active golden eagles nests on their land in the Los Vaqueros Watershed. Monitoring data collected by the Implementing Entity should incorporate CCWD data on golden eagles.

- Determine the most effective artificial-burrow designs and placement strategies for attracting burrowing owls and ensuring reproductive success of owls that use artificial burrows.

- Determine the effectiveness of artificial perch sites in attracting use by burrowing owls and the most effective perch designs and placement strategies (e.g., height above ground level, location relative to available burrows).

- Conduct soil sampling to determine soil associations in the inventory area for San Joaquin spearscale, brittlescale, recurved larkspur, big tarplant, and round-leaved filaree. Identify and map any occurrences of these species.

- Verify suitability of modeled habitat for silvery legless lizard with field data, as much as possible. Assess habitat suitability and identify occupied habitat prior to acquisition of preserve lands. Results of these surveys will be used to guide acquisition of occupied or suitable habitat to the maximum extent practicable. Record any occurrences of silvery legless lizard.

Long-Term Monitoring Phase

- Determine if populations of covered species are being maintained and enhanced.

- Monitor populations of grassland-dependent covered plants to ensure that populations are being maintained or restored.

- Conduct monitoring for Swainson's hawk within low-elevation grassland in the inventory area within the range of the species to refine the estimate of the species' range. This will aid with preserve assembly and in riparian-restoration efforts to create breeding sites for the species.

- Assess movement to and use of breeding sites by California red-legged frog, California tiger salamanders, and western pond turtles to determine upland movement through grassland. This will verify the key assumption in the habitat models regarding movement habitat and inform preserve assembly. Use recent literature to guide study design (incl. Petranka et al. 2004).

- Evaluate use of artificial burrows and artificial perches by western burrowing owl. Use results from other studies, if appropriate.

- Consider research to determine the circumstances in which Alameda whipsnake forages or breeds in grassland.

- Further refine species-habitat models in this Plan and develop species-habitat models, if feasible, for brittlescale.

7.5.3 Chaparral/Scrub

Associated Land Cover Type

- Chaparral

- Coastal sage scrub

- Black sage scrub

Associated Covered Species

- Alameda whipsnake

- Mount Diablo manzanita

- Mount Diablo fairy lantern

- Diablo helianthella

- Brewer's dwarf flax

Ecology

Chaparral and scrub consists of woody vegetation dominated by shrubs. Within the inventory area, this natural community type is generally found on south-facing slopes and ridges. Dominant shrub species include chamise (*Adenostoma fasciculatum*), manzanita (*Arctostaphylos* spp.), and buckbrush (*Ceanothus* spp.). Within the study area, chaparral is uncommon (2% of land cover) and primarily occurs in scattered mid-elevation patches near Mt. Diablo. In addition to shrubs,

scattered trees and small stands of trees, such as foothill pine (*Pinus sabiniana*) and oaks (*Quercus* spp.) are present, but they are not the dominant species.

Chaparral shrubs form a nearly continuous stand and, thus, herbaceous vegetation is rare except immediately following fire. Fire is an important determinant of chaparral communities, and fire frequency helps delimit the distribution of chaparral vegetation: areas with more frequent fires may tend toward grassland while areas with less frequent fires may tend toward oak woodland.

Threats

Threats to this natural community type may include fire suppression, conversion to grasslands through grazing, and urban or rural development. The natural fire interval for chaparral/scrub in the inventory area is not known. The increased frequency of severe weather conditions due to climate change (e.g., low humidity, high winds, high temperature, and drought) and the number of people with access to stands (providing an ignition source) may have increased fire frequency relative to historic conditions. Ecosystem modeling and review of historic conditions will attempt to identify stressors (i.e., changes to fire regime) to this system and provide an understanding of cause-and-effect relationship between community function and these and other pressures/stressors.

Chaparral/Scrub: Landscape

Landscape-level monitoring and adaptive-management relevant to chaparral/scrub include the following actions.

Monitoring Design Phase

■ Use planning and pre-acquisition surveys and other ground truthing to establish the distribution and abundance of small stands of chapparal/scrub (< 10 acres) not mapped for this Plan that may be important in increasing connectivity between larger stands.

■ Assess the historic extent, conditions, and fire frequency of chaparral and coastal sage scrub stands within the inventory area using aerial photographs and historic records of fire in the area. This information will be used to determine whether active management is required to maintain these stands in their current extent and condition.

■ If prescribed burns are necessary to protect human safety and/or ecosystem function, prepare Burn Plans that describe pre- and post-burn monitoring to determine effects.

Inventory Phase

■ Assess connectivity between patches of chaparral/scrub within and outside preserves (e.g., mapping, ground-truthing, threat analysis).

Long-Term Monitoring Phase

■ Monitor chaparral and coastal sage scrub stands within preserves through vegetation sampling and periodic interpretation of aerial photographs to ensure that the overall extent of these stands is not declining.

■ Monitor the frequency, location, and ignition source of all wildland fires within this community to develop a long-term fire record.

Chaparral/Scrub: Natural Community

Natural-community-level monitoring and adaptive-management relevant to chaparral/scrub include the following actions.

Monitoring Design Phase

■ Develop conceptual ecological model for grassland/shrub community type.

Inventory Phase

■ Quantitatively classify each major chaparral stand in the Preserve System to the alliance level according to the CNDDB vegetation classification scheme (California Department of Fish and Game 2002) to aid in cataloguing habitat diversity and in tracking habitat responses to management.

■ Estimate the age of chaparral stands; map and monitor the successional stage of chaparral to ensure an adequate diversity of stand ages and an adequate distribution of canopy gaps to sustain chaparral herbs.

Long-Term Monitoring Phase

■ Determine the habitat function of chaparral/scrub for Alameda whipsnake and the need for active management measures to maintain or enhance this species.

■ Assess exotic invasive plants, including maps and descriptions of their distribution and abundance; their known or potential effects on ecosystem function, native biological diversity, sensitive natural communities, and

covered species; and the means and risk of their spread to other areas within and outside the preserves.

■ Document any signs of disturbance within the Preserve System from recreational uses, and assess annually.

Chaparral/Scrub: Species

Species-level monitoring and adaptive management relevant to chaparral/scrub include the actions listed below.

Monitoring Design Phase

■ Identify monitoring strategies for covered species.

Inventory Phase

■ Map and monitor stands of Mount Diablo manzanita in the Preserve System; determine the age structure of stands to ensure adequate structural diversity and assess their ability to reproduce without fire.

■ Map and monitor populations of Mount Diablo fairy lantern, Diablo helianthella, and Brewer's dwarf flax in the Preserve System and develop pilot projects to determine each species' response to management actions such as burning.

Long-Term Monitoring Phase

■ Monitor response of Alameda whipsnake population to prescribed burn and wildfires. Consider new research results on the effects of prescribed burning on Alameda whipsnake within its range (K. Swaim, due in 2005).

■ Further refine species-habitat models.

7.5.4   Oak Woodland

Associated Land Cover Type

■ Oak woodland

■ Oak savanna

■ Mixed evergreen woodland

Associated Covered Species

- San Joaquin kit fox [grassland]

- Golden eagle [grassland]

- Silvery legless lizard [grassland]

- Western pond turtle [wetlands]

- California tiger salamander [grassland]

- California red-legged frog [wetlands]

- Mount Diablo fairy lantern [chaparral/scrub]

- Diablo helianthella [chaparral/scrub]

- Brewer's dwarf flax [chaparral/scrub]

- Showy madia

- Round-leaved filaree [grassland]

Ecology

Oak woodland is common in the inventory area (17%) and is primarily found in the mid- to high-elevation zones in the southwestern portion. Common species include blue oak, interior live oak, valley oak, and coast live oak. Oak woodland grades into mixed evergreen forest at higher elevations in which codominant species in the oak woodland, such as California bay, California buckeye, and foothill pine, become more prevalent. Oak woodland can also occur along ephemeral and intermittent drainages with coast live oak occurring alongside riparian woodland trees, including California buckeye, big-leaf maple, and California bay.

Many factors may influence the population dynamics of oaks (Pavlik et al. 1991). Accordingly, a site-specific assessment is required to determine the factors most important in stands within preserves. Based on an assessment of oaks in the Kellogg Creek watershed (Jones & Stokes Associates 1995), the health of this natural community in the inventory area may be limited by a lack of oak regeneration due to a high density of invasive weeds and nonnative plants in the understory. Some studies have found browsing by deer and livestock as well as grazing by small mammals to impair recruitment (Bartolome et al. 2002, Tyler et al. 2002, Borchert et al. 1989). Fire may have negative or no effect on oak recruitment, depending on the timing, frequency, and intensity of the fire (Griffin 1977; Bartolome et al. 2002).

Threats

Wild pigs may be a serious threat to oak regeneration in the inventory area. A recent study of the effects of wild pigs in California showed that they can disturb

up to 35–65% of the ground annually where they occur in high densities and that they significantly reduce acorn survival (Sweitzer and Van Vuren 2002).

Sudden oak death (SOD), caused by the pathogen *Phytophthora ramorum*, is a serious threat to oak woodlands and mixed evergreen forests in northern California. Several dominant and important trees in the inventory area have been identified as hosts to this pathogen: coast live oak, California black oak, California bay laurel, madrone, California buckeye, and big-leaf maple (Davidson et al. 2003).

Oak Woodland: Landscape

Landscape-level monitoring and adaptive-management relevant to oak woodland include the following actions.

Inventory Phase

- Using recent aerial photographs, document the range of percent canopy coverage within the Preserve System to estimate structural habitat diversity. Also, separate mapping of oak woodland stands from stands of mixed evergreen forest, which could not be done for this Plan.

- Determine the status of tree recruitment using historical aerial photographs, if available. Determine whether the current canopy coverage of oaks are increasing, decreasing, or stable within the Preserve System. Oak stands in preserves will be evaluated in accordance with the decision-making process adopted by the California Department of Forestry and Fire Protection (Jones & Stokes Associates 1988) and used for management of oak stands in the Los Vaqueros Watershed (Brady and Associates 1997).

Long-Term Monitoring Phase

- At least every 5 years, oak savannas and woodlands within preserves will be reevaluated using aerial photographs and the oak decision-making process (Figure 5-12). This time interval will allow the Implementing Entity to capture any large-scale changes and adjust management priorities if necessary. More intensive management actions will be conducted if a decline in oak woodland or oak savanna stands is observed.

Oak Woodland: Natural Community

Natural-community-level monitoring and adaptive-management relevant to oak woodland include the following actions.

Monitoring Design Phase

■   Develop conceptual ecological model for oak woodland community type.

Inventory Phase

■   Assess oak stands (e.g., canopy coverage, tree condition, seedling and sapling abundance and survival, population age structure, acorn production) within the preserve within 2 years of acquisition to identify factors that may be limiting ecological functions. If canopy coverage is declining and/or tree recruitment is insufficient, adaptive management actions will be implemented to improve recruitment. These actions will be site specific and may include modifying livestock practices, replanting; fencing saplings; reducing competing herbaceous vegetation; and controlling wild pigs.

■   Use planning and pre-acquisition surveys and other ground truthing to establish the distribution and abundance of each species of oak within the Preserve System.

■   Test alternative methods of oak plantings, irrigation, and herbivory protection to maximize sapling survival.

Long-Term Monitoring Phase

■   Assess exotic invasive plants, including maps and descriptions of their distribution and abundance; their known or potential effects on ecosystem function, native biological diversity, sensitive natural communities, and covered species; and the means and risk of their spread to other areas within and outside the preserves.

■   Monitor impacts from recreation use on biological resources and manage adaptively to reduce or eliminate impacts.

■   Monitor oak stands for Sudden Oak Death.

Oak Woodland: Species

Species-level monitoring and adaptive management relevant to oak woodland include the actions listed below.

Monitoring Design Phase

■   Identify monitoring strategies for covered species.

Long-Term Monitoring Phase

- Monitor wild pig populations to track the success of control techniques and to determine their effects on oak woodlands and oak regeneration, in particular.

- Determine if populations of showy madia are being sustained and, if possible, enhanced.

- Further refine species-habitat models and develop model for showy madia, if feasible.

7.5.5 Streams and Riparian Woodland/Scrub

Associated Land Cover Type

- Riparian woodland

- Riparian scrub

- Stream

Associated Covered Species

- Swainson's hawk

- Western pond turtle [wetlands]

- California red-legged frog [wetlands]

- Foothill yellow-legged frog

Ecology

Riparian woodland is dominated by phreatophytic trees and is associated with streams and permanent and intermittent water sources. Riparian scrub is an early successional stage of riparian woodland and, thus, is dominated by young trees and shrubs. Riparian scrub may also occur in areas too dry or with groundwater too deep to support riparian trees. Generally, riparian areas occur as narrow corridors along streams representing less than 1% of the inventory area.

Due to its dependence on stream channels, riparian vegetation is adapted to a particular disturbance regime. The common riparian species of cottonwood and willow generally require bare mineral soil and high light for germination. Floods can provide these conditions through the processes of erosion and deposition.

Threats

Threats to riparian vegetation include uncontrolled livestock access to riparian areas. Livestock adversely affect existing habitats through the trampling of native vegetation, inducing bank erosion, introducing nonnative vegetation, and reducing the natural recruitment and establishment of native riparian vegetation through grazing. Moreover, introduction of animal waste can have adverse effects on water quality.

Invasive, nonnative plant species can outcompete native plant species for limited water, nutrients, light, and space. This competition results in a decrease in the overall species diversity and, consequently, in the quality of habitat. Additional threats include channelization and levee construction, hardscape construction (e.g., riprap, concrete channel lining), and clearing for agriculture or urban development.

Streams and Riparian Woodland/Scrub: Landscape

Landscape-level monitoring and adaptive management relevant to streams and riparian woodland/scrub include the following actions.

Inventory Phase

- Inventory riparian corridors within the preserves to identify stream segments suitable for enhancement or restoration.

- Use data from USGS gauging stations and/or weather stations to collect information on flood processes and their effect on other hydro-geomorphic processes and riparian communities.

- Assess connectivity of riparian corridors.

Long-Term Monitoring Phase

- Investigate and document historical natural-disturbance regimes in streams, and document hydrologic changes that may be affecting riparian systems.

Streams and Riparian Woodland/Scrub: Natural Community

Natural-community-level monitoring and adaptive management relevant to streams and riparian woodland/scrub include the following actions.

Monitoring Design Phase

- Develop conceptual ecological model for streams and riparian woodland/scrub natural community.

- Initiate a pilot project to develop restoration measures for individual sites or stream reaches based on specific geomorphic, hydraulic, and hydrologic conditions; extent and quality of existing habitats (e.g., percent native vegetation and presence/absence of exotic wildlife such as bullfrogs or cowbirds); existing wildlife use; and the potential for adverse effects (e.g., disturbance and/or removal of existing wetland habitat). These measures will include descriptions of plant material requirements (e.g., collected and propagated from local sources); planting and construction methods; and adaptive management and monitoring requirements including indicators and success criteria.

- Determine indicator species for monitoring restoration and develop criteria

Long-Term Monitoring Phase

- Monitor effects of livestock access and livestock exclusion on community composition and recruitment of dominant trees and shrubs.

- Assess exotic invasive plants, including maps and descriptions of their distribution and abundance; their known or potential effects on ecosystem and hydro-geomorphic functions, native biological diversity, sensitive natural communities, and covered species; and the means and risk of their spread to other areas within and outside the preserves.

- Monitor success of restored areas in recreating native cover and natural hydro-geomorphic and ecological processes.

- Monitor impacts from recreation use on biological resources and manage adaptively to reduce or eliminate impacts.

- Monitor restored riparian areas for presence of bullfrogs and other nonnative species including fish that have the potential to prey on native amphibians.

Streams and Riparian Woodland/Scrub: Species

Species-level monitoring and adaptive management relevant to streams and riparian woodland/scrub include the actions listed below.

Monitoring Design Phase

- Identify monitoring strategies for covered species.

Inventory Phase

■ More precisely map stream reaches with perennial water to improve the species-habitat models for foothill yellow-legged frog and western pond turtle.

Long-Term Monitoring Phase

■ Determine if populations of covered species are being restored and/or sustained.

■ Monitor active nests of Swainson's hawk to determine use patterns and specific habitat needs for breeding sites.

■ Monitor use of riparian forest as a movement corridor by native mammals.

■ Further refine species-habitat models.

7.6 Database Development and Reporting

Proper data management, analysis, and reporting is critical to the success of the adaptive management program. Data on monitoring methods, results, and analysis must be managed, stored, and made available to Implementing Entity staff, decision-makers, scientific advisors, and other appropriate persons. A database and clear reporting procedure is also required for permit compliance. The requirements for database development, maintenance, and data reporting are described in Chapter 8 to synthesize these overlapping needs.

7.7 Budget

The Implementing Entity will prepare annual budgets for monitoring, adaptive management, and directed-research costs (see Chapter 9 for a complete discussion of Plan costs). Monitoring and adaptive-management costs include the cost of planning, conducting, analyzing, and reporting on implementation of monitoring and adaptive management (compliance monitoring, pre-acquisition surveys, planning surveys for covered activities within preserves, preconstruction surveys within preserves, construction monitoring within preserves, and effectiveness monitoring). Monitoring costs also include the funding of pilot projects and limited directed research.

Monitoring costs are perhaps the most uncertain element of the HCP/NCCP because of the wide range of monitoring options available (location, frequency, intensity, number of variables, number of monitoring staff, analysis complexity, etc.). Upon initiation of implementation, a comprehensive monitoring strategy will be written that draws on the guidelines developed above. This strategy will be developed within the funding parameters established for monitoring in

Chapter 9. These parameters were derived from ongoing NCCP, HCP, and other monitoring efforts and represent an estimate for these costs based on currently functioning programs. It is critical that the Implementing Entity establish clear monitoring goals that are linked to the available budget. Monitoring priorities should be reassessed frequently to ensure that all monitoring goals can be met.

Conservation Measure	Performance Period[1]	Example Performance Indicators[2]	
		Example Minimum Value[3]	Example Target Value[4]
2.2 Manage Wetlands and Ponds: native wetlands	___ years following acquisition of native wetlands	*% relative native plant cover:* • Demonstrate an upward trend in % native plant cover relative to existing conditions	*% relative native plant cover:* • Increase % native plant cover by __% from existing conditions
2.2 Manage Wetlands and Ponds: stock ponds and permanent wetlands	__ years following acquisition of stock ponds and permanent wetlands	*Nonnative predators:* • Maintain __% of all stock ponds and permanent wetlands free of nonnative fish (except mosquitofish) and bullfrogs in any given year *Emergent vegetation cover-margins:* • Maintain native emergent vegetation along at least __% of pond and wetland edges *Emergent vegetation cover-pond surface:* • For ponds designed to support tricolored blackbird breeding: Maintain native emergent vegetation over at least __% of pond surface area	*Nonnative predators:* • Maintain all stock ponds and permanent wetlands free of nonnative fish (except mosquitofish) and bullfrogs annually *Emergent vegetation cover-margins:* • Maintain native emergent vegetation along at least __% of pond and wetland edges *Emergent vegetation cover-pond surface:* • For ponds designed to support tricolored blackbird breeding: Maintain native emergent vegetation over at least __% of pond surface area
2.2 Manage Wetlands and Ponds: alkali wetland	__ years following wetland restoration	*Extent restored:* • 15 acres[5] *Relative native alkali wetland plant cover:* • __% *Native plant diversity* • __% of species in reference alkali wetlands	*Extent restored:* • 15 acres[5] *Relative native alkali wetland plant cover:* • __% *Native plant diversity* • __% of species in reference alkali wetlands

Table 7-1. Continued

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Conservation Measure	Performance Period[1]	Example Performance Indicators[2]	
		Example Minimum Value[3]	Example Target Value[4]
2.2 Manage Wetlands and Ponds: seasonal wetland	__ years following wetland restoration	*Extent restored:* • 45 acres[5] *Relative native seasonal wetland plant cover:* • __% *Native plant diversity* • __% of species in reference seasonal wetlands	*Extent restored:* • 45 acres[5] *Relative native seasonal wetland plant cover:* • __% *Native plant diversity* • __% of species in reference seasonal wetlands
2.2 Manage Wetlands and Ponds: Ponds	__ years following pond creation	*Extent created:* • 13 acres[5] *Emergent vegetation cover:* • __% of ponds will support native emergent vegetation > 5 feet tall (e.g., cattail or tules) over at least 35% of surface area (for Tricolored Blackbird) • __% of ponds will support emergent vegetation over at least __% but no more than __% of the surface area (for California red-legged frog) *% emergent vegetation cover-margins:* • Maintain native emergent vegetation along at least __% of each pond margin *Nonnative predators:* • Maintain __% of all ponds of free of nonnative fish (except mosquitofish) and bullfrogs in any given year	*Extent created:* • 13 acres[5] *Emergent vegetation cover:* • __% of ponds will support native emergent vegetation > 5 feet tall (e.g., cattail or tules) over at least 50% of surface area (for Tricolored Blackbird) • __% of ponds will support emergent vegetation over at least 30% but no more than __% of the surface area (for California red-legged frog) *% emergent vegetation cover-margins:* • Maintain native emergent vegetation along at least __% of each pond margin *Nonnative predators:* • Maintain all ponds free of nonnative fish (except mosquitofish) and bullfrogs annually

Table 7-1. Continued

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Conservation Measure	Performance Period[1]	Example Performance Indicators[2]	
		Example Minimum Value[3]	Example Target Value[4]
		Hydrology: • Maintain ponded surface water until October 1 in normal rainfall years[6]	*Hydrology:* • Maintain ponded surface water until October 1 in dry rainfall years[6]
2.2 Manage Wetlands and Ponds: perennial wetlands	__ years following perennial wetland restoration	*Extent created/restored:* • 32 acres[5] *Emergent vegetation cover:* • __% of perennial wetland acreage will support native emergent vegetation > 5 feet tall (e.g., cattail or tules) over at least __% of surface area (for tricolored blackbird) *% emergent vegetation cover:* • Maintain native emergent vegetation along at least __% of each wetland *Nonnative predators:* • Maintain __% of all wetlands free of nonnative fish (except mosquitofish) and bullfrogs in any given year *Hydrology:* • Maintain wetlands year-round in normal rainfall years[6]	*Extent created/restored:* • 32 acres[5] *Emergent vegetation cover:* • __% of perennial wetland acreage will support native emergent vegetation > 5 feet tall (e.g., cattail or tules) over at least __% of surface area (for tricolored blackbird) *% emergent vegetation cover:* • Maintain native emergent vegetation along at least __% of each wetland *Nonnative predators:* • Maintain __% of all wetlands free of nonnative fish (except mosquitofish) and bullfrogs in any given year *Hydrology:* • Maintain wetlands year-round in dry rainfall years[6]

Table 7-1. Continued

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Conservation Measure	Performance Period[1]	Example Performance Indicators[2]	
		Example Minimum Value[3]	Example Target Value[4]
2.4 Manage Grassland	__ years following implementation of preserve-wide management of grasslands (and after pilot study complete)	*% native forb cover:* • Demonstrate an upward trend in % native forb cover relative to existing conditions *% native grass cover:* • Demonstrate an upward trend in % native grass cover (annual or perennial) relative to existing condition *Native plant diversity:* • Demonstrate an upward trend in native plant diversity	*% native forb cover:* • Increase native forb cover by __% relative to existing conditions *% native grass cover:* • Increase native grass cover by __% relative to existing conditions *Native plant diversity:* • Demonstrate an upward trend in native plant diversity
2.5 Manage Natural Burrow Availability and Prey Base in Grasslands	__ years following implementation of measure	*Abundance of burrows:* • Demonstrate and upward trend in burrow density within the preserve	*Abundance of burrows:* • Increase the density of burrows within preserves by __%
2.6 Manage Oak Woodland and Oak Savanna	Implement measures to increase oak tree establishment and densities within __ years of detecting a decline in canopy cover	*Absolute oak tree canopy cover:* • Maintain the existing % absolute oak tree canopy cover in oak savanna and woodlands on preserves	*Absolute oak tree canopy cover:* • Maintain the existing % absolute oak tree canopy cover in oak savanna and woodlands on preserves

Table 7-1. Continued

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Conservation Measure	Performance Period[1]	Example Performance Indicators[2]	
		Example Minimum Value[3]	Example Target Value[4]
2.7 Compensate for Loss of Oak Savanna	__ years following initial plantings of oak trees	*Extent restored:* • 36 acres[5] *% oak-tree canopy cover:* • % tree canopy cover equal to or up to __% greater than the percent canopy cover in oak savanna stands removed by covered activities	*Extent restored:* • 36 acres[5] *% oak- tree canopy cover:* • % tree canopy cover equal to or up to __% greater than the percent canopy cover in oak savanna stands removed by covered activities
	__ years following initial plantings of oak trees	*Understory native plant cover:* • Develop an understory with native plant cover within __% of existing conditions *Understory native plant diversity:* • Develop an understory with native plant diversity at least __% of existing conditions	*Understory native plant cover:* • Develop an understory with native plant cover equal to or greater than that of existing conditions *Understory native plant diversity:* • Develop an understory with native plant diversity equal to or greater than existing conditions
2.9 Manage Streams and Riparian Woodland/Scrub	__ years following initial treatments	*Relative native tree canopy cover:* • Increase the existing relative native tree canopy cover by at least __% *Relative native shrub canopy cover:* • Increase the existing relative native shrub canopy cover by at least __%	*Relative native tree canopy cover:* • Increase the existing relative native tree canopy cover by at least __% *Relative native shrub canopy cover:* • Increase the existing relative native shrub canopy cover by at least __%

Table 7-1. Continued

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Conservation Measure	Performance Period[1]	Example Performance Indicators[2]	
		Example Minimum Value[3]	Example Target Value[4]
2.10 Restore Streams and Riparian Woodland/Scrub to Compensate for Habitat Loss and to Increase Biodiversity	__ years following restoration planting	*Extent restored:* 1 acre[5] *Relative native tree canopy cover:* • Establish a relative native tree canopy cover by of at least __% *Relative native shrub canopy cover:* • Establish a relative native shrub canopy cover of at least __%	*Extent restored:* 1 acre[5] *Relative native tree canopy cover:* • Establish a relative native tree canopy cover by of at least __% *Relative native shrub canopy cover:* • Establish a relative native shrub canopy cover of at least __%
3.6 Compensate for Loss of Giant Garter Snake Habitat: created habitat[7,8]	To be established by USFWS[7]	To be developed in coordination with USFWS[7]	Not applicable.
3.8 Compensate for Loss of Occupied Covered Shrimp Habitat: seasonal wetland or vernal pool creation[8]	__ years following completion of seasonal wetland or vernal pool construction	*Extent created:* • 2 acres of created seasonal wetland for every affected acre of same *Hydrology:* • Maintain pooled surface water in normal rainfall years[6] similar in duration to reference sites within preserves	*Extent created:* • 2 acres of created seasonal wetland for every affected acre of same *Hydrology:* • Maintain pooled surface water in normal rainfall years[6] similar in duration to reference sites within preserves *Native plants:* • Self-sustaining populations of native vernal pool plants are maintained *Shrimp:* • Self-sustaining populations of covered shrimp affected by covered activities are maintained

Table 7-1. Continued

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Conservation Measure	Performance Period[1]	Example Performance Indicators[2]	
		Example Minimum Value[3]	Example Target Value[4]

Notes:

a   This table provides a framework for evaluating the success of certain conservation measures. The Implementing Entity will develop values for assessing success during the Monitoring Design Phase (see Chapter 7, Section 7.3.1).

1   The estimated period following enhancement/creation/restoration of a natural community at a site during which performance standards should be achieved.

2   Performance indicators are shown in italics.

3   The example minimum value is the minimum measured value for each performance indicator that must be achieved during the performance period.

4   The example target value represents the optimal desired value for each performance indicator and the design and management objectives for enhanced/created/restored natural communities.   If performance objectives are not achieved, adaptive management actions may be triggered.

5   Acres restored are estimates based on the preliminary draft initial permit area and application of required restoration ratios in Table 5-20a. Actual restoration performance standard/target may vary depending on actual field-verified impacts.

6   Normal rainfall years are defined as within 1 standard deviation of the annual average rainfall as measured at the California Irrigation Management Information System (CIMIS) Brentwood rain gauge over the hydrologic record of the gauge (October-September). Dry years are defined as less than 1 standard deviation from the annual mean.

7   These performance periods, minimum and target values only apply if habitat is created under the HCP/NCCP to compensate for impacts on habitat with implementation of covered activities. Compensation may also be provided through purchase of mitigation credits from an USFWS/DFG-approved mitigation bank.

8   It is anticipated that performance indicators and values for created habitat will be developed in coordination with USFWS/DFG and the Science Advisors and will be based on the type and condition of habitat that is affected by covered activities.

Table 7-2. Potential Experimental Pilot Projects

Conservation Measure	Potential Experimental Pilot Project
Natural Community-Level Measures	
2.2 Manage Wetlands and Ponds	• Determine the effectiveness of small checkdams in arresting stream-channel erosion in seasonal alkali wetlands. • Use experimental-management techniques to test different creation/restoration methods (i.e., use pre- and post-treatment monitoring, replication, controls). • Conduct pilot project to determine the relative benefit to California red-legged frog, California tiger salamander, and western pond turtle of different pond treatments such as access/exclusion by livestock, vegetated/unvegetated banks, and pond depth and duration.
2.4 Manage Grassland	• Develop a pilot project to determine the feasibility of grassland enhancement on a large scale: investigate the effect of management actions on native grassland species. • Develop projects that test the effect of different grazing practices (e.g., grazing intensity, duration, season, type of livestock) on the maintenance and regeneration of native grasses and forbs. If possible, combine grazing treatments with other management techniques such as prescribed burns and hand seeding to detect interactions among management treatments.
2.5 Manage Natural Burrow Availability and Prey Base in Grasslands	• Develop a pilot project of management methods to increase prey for covered grassland species. Consider using methods already developed and applied to the Los Vaqueros Watershed to monitor ground squirrel population density as an indicator of habitat quality for San Joaquin kit fox.
2.6 Manage Oak Woodland and Oak Savanna	• Test alternative methods of oak plantings, irrigation, and herbivory protection to maximize sapling survival.
2.10 Restore Streams and Riparian Woodland/Scrub to Compensate for Habitat Loss and Increase Biodiversity	• Initiate a pilot project to develop restoration measures for individual sites or stream reaches based on specific geomorphic, hydraulic, and hydrologic conditions; extent and quality of existing habitats (e.g., percent native vegetation and presence/absence of exotic wildlife such as bullfrogs or cowbirds); existing wildlife use; and the potential for adverse effects (e.g., disturbance and/or removal of existing wetland habitat.

Table 7-2. Continued

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Conservation Measure	Potential Experimental Pilot Project
Species-Level Measures	
3.1 Protect and Enhance Roosting Habitat for Townsend's Western Big-eared Bat	• Develop a pilot project to evaluate the suitability of artificial hibernacula for use by Townsend's big-eared bat.
3. 4 Temporarily Create Artificial Burrows in Grasslands to Attract and Retain Burrowing Owls	• Determine the most effective artificial-burrow designs and placement strategies for attracting burrowing owls and ensuring reproductive success of owls that use artificial burrows.
3.5 Install Temporary Artificial Perches to Attract and Retain Burrowing Owl	• Determine the effectiveness of artificial perch sites in attracting use by burrowing owls and the most effective perch designs and placement strategies (e.g., height above ground level, location relative to available burrows).
3.10 Plant Salvage when Impacts are Unavoidable	• Use pilot projects to develop methods for salvaging and propagating covered-plant species from impact sites and for reestablishing salvaged plants at new locations to establish new populations.