

7. MONITORING PLAN

7.1 INTRODUCTION

Ecological monitoring is an essential element in any natural resource management activity. The information that is gained through monitoring allows for the focusing of management activities on the areas of greatest need, and provides a method for evaluating the success of restoration and conservation projects. The SFRPD Natural Areas Program is focused on the conservation and restoration of a diversity of Natural Areas that host populations of indigenous native species and natural communities. The general management goal for these areas is to protect and enhance native species and communities, and to contain and control invasive species and communities. A variety of methods may be used to achieve these goals, including active removal to control the impacts of invasive non-native species, restoration activities to enhance and expand the area occupied by indigenous natural communities, and reintroduction of extirpated species. In order to carry out these activities it is necessary to track the status of native and non-native species and communities to evaluate their overall environmental quality and ecological integrity. The effectiveness of management practices will be assessed through the monitoring program outlined in this chapter. Specific monitoring protocols are given in Appendix I. This program includes both quantitative and qualitative methods for measuring changes in the populations of species at risk and the general health of ecological communities. Many of the monitoring procedures outlined in this chapter are currently ongoing. Results from these and future monitoring efforts will be available through the Natural Areas Program website at <http://www.parks.sfgov.org>.

Native ecological communities in the City of San Francisco have been affected by an array of stressors, such as urban development, human recreation, air pollution, and invasive species introductions. Fortunately, a few relatively intact native communities still exist; these areas are referred to as Natural Areas. The SFRPD stewardship program is designed to protect and enhance native diversity within Natural Areas by carrying out a stewardship program that will, to the extent possible and feasible, offset the impacts of these stressors. The monitoring program consists of a framework for interactively tracking change in critical ecological elements and the effects of stewardship activities on the status of these elements.

Monitoring in the Natural Areas will be conducted for two general purposes: (1) to track changes to the populations and distributions of special-status species; and (2) to assess the effectiveness of active restoration and conservation efforts. By evaluating the effectiveness of stewardship activities over time, the monitoring plan will contribute to an adaptive management program that will enhance the long-term status of indigenous biodiversity elements.

7.2 CONCEPTUAL FRAMEWORK

The biota of the Natural Areas today derives from conditions that prevailed prior to European colonization. Both then and now, the physical context (precipitation, temperature, substrate,

relief, wind exposure, etc.) and historic processes (fires, grazing, disease, landslides, etc.) shape patterns of vegetation that in turn provide habitat for wildlife.

At a coarse-grained scale, the physical context of the Natural Areas is largely determined by an east-west climatic gradient running from the oceanic coastline to the shores of San Francisco Bay. Coast-side conditions are typically cool, foggy, windy, and characterized by high levels of sea-salt aerosol. Bay-side conditions tend to be warmer, sunny, less windy, and present lower levels of sea-salt aerosol. At a fine-grained scale, the physical context is further determined by degree of slope, aspect, hydrology, and substrate. An extensive dune system in western San Francisco created large areas of coarse, sandy soil. On upland sites a diversity of geologic types (chert, pillow basalts, sandstone, shale, and serpentine) weathered into a variety of fine clay and loam soils. Prior to European colonization, processes that influenced community formation included storm events (e.g. windthrow and heavy salt deposition), fires, grazing, browsing, predation, nutrient cycling, disease outbreaks, insect infestations, and moderate physical disturbance by Native Americans.

Pre-European vegetation patterns were a reflection of this physical context and these processes. Coast-side plant assemblages were dominated by coastal scrub, coastal grasslands, and an array of freshwater wetlands. Stands of maritime chaparral occurred on rocky uplands and stable dunes around the southern margin of Lake Merced. Dune scrub and dune wildflower assemblages were prominent. Bay-side plant assemblages included more extensive perennial grasslands, wildflower fields, coastal scrub, riparian forest and scrub, freshwater and salt marsh, maritime chaparral, and stands of broad-leaved evergreen forest in protected canyons and coves around the bay-shore.

These diverse plant communities provided a rich tapestry of habitats for native wildlife. Larger land animals included grizzly bears (*Ursus arctos horribilis*), mountain lions (*Felis concolor californicus*), elk (*Cervus Canadensis*), antelope (*Antilocapra american*), and black-tailed deer (*Odocoileus hemionus columbianus*). Marine mammals and marine birds were abundant around the peninsula. Other species that were common included gray fox (*Urocyon cinereoargenteus*), bobcats (*Lynx rufus californicus*), coyote (*Canis latrans*), raccoons (*Procyon lotor*), and skunks (*Mephitis mephitis*). Numerous reptiles (snakes and lizards) and amphibians (frogs and salamanders) occupied uplands and wetlands. Rodents and terrestrial birds were diverse and abundant. Many different insects, fungi, lichens, and microbes provided a fine-grained texture to each local environment.

During the last 200 years, all of these Natural Areas have been impacted by factors associated with European colonization. Intense grazing and cultivation, water diversions, urban habitat destruction and fragmentation, disruption of processes such as the fire regime, and the introduction of numerous new plants, animals, fungi, and microbes have dramatically altered the landscape. Today, less than 5 percent of the land area of San Francisco can be recognized as containing these original native communities. These biotic remnants are still shaped by their physical context (e.g., local climate, substrate, and topographic relief) and historic processes (e.g., storm events, grazing, and fire); however, a new suite of factors is now impinging on this

system. These factors include species loss, loss of predators, reduced native populations, habitat fragmentation, suppression of natural processes, competition with invasive species, and continuing urbanization.

Human-generated disruption of historic natural patterns and processes has placed most if not all of these remnant communities and native populations at high risk of progressive degradation and eventual extirpation. If long-term preservation of San Francisco's indigenous biota is to be achieved, conservation management of these Natural Areas must track the status of natural populations and evaluate the impacts of human activities, and adjust and adapt management activities based upon on-going experience in meeting conservation goals.

7.3 MONITORING PLAN STRATEGY

Although the number and size of the Natural Areas is relatively small, the diversity and complexity of the ecosystems within these areas is high. Thousands of species of plants, mammals, birds, insects, spiders, lichens, fungi, algae, and microbes persist and form complex and delicately balanced communities in each Natural Area. Given the constraints of budget, scientific expertise, trained staff, volunteers, and other resources, only a small segment of these resources can be effectively monitored. Consequently, the stewardship program, and its complementary monitoring program, must be concentrated on the most critical elements. Stewardship activities are focused on Management Areas although the intensity of monitoring activities within these areas may vary. Management Areas have been ranked in terms of the ecological value and sensitivity of each site (MA-1, MA-2, and MA-3). Because MA-1 sites have the greatest concentrations of native species, and MA-2 sites will receive the bulk of restoration activities, sites with these designations will be the focus of the monitoring program. Given the pivotal role of vegetation as a reflection of physical context and historical processes as well as its importance as wildlife habitat, native plant communities will serve as the focus of the monitoring program. Monitoring of wildlife will be limited due to the expense necessary to conduct wildlife surveys; however, it may be possible to partner with the Audubon Society, California Academy of Sciences, San Francisco State University, or other organizations or institutions with the appropriate wildlife expertise.

Sites where restoration and conservation activities take place will be evaluated in the context of their management goals. Success criteria for project areas will be measured in a quantitative fashion and used to assess the effectiveness of management actions so that activities can be revised as is appropriate. An experimental approach, known as "adaptive management," will be used to test the success of new restoration methods. Monitoring will be conducted in a spatial context using a Geographic Information System (GIS) to examine data at both a system-wide and a local scale. The system-wide scale will be capable of integrating data from local Management Areas to provide comparisons within and between Natural Areas as well as within and between other programs that manage natural areas in the northern San Francisco Peninsula landscape as well as within the central California Coastal region. The local-scale monitoring program will

focus on Management Areas (containing special-status plant and wildlife species and indigenous native plant assemblages), and active restoration sites.

Monitoring activities will be designed within the conceptual framework to address the following questions:

1. What is the population status of selected special-status species? Where are these populations located? What are the growth trends for each of these populations, and for the species as a whole within the Natural Areas?
2. How successful are restoration and enhancement projects in terms of project goals? What are the best ways to measure success criteria? How do selected management activities, including restoration and conservation projects, affect the diversity and abundance of native species in relation to the diversity and abundance of invasive species within the project areas?

7.4 MONITORING PROGRAM

Implementation of the goals outlined above will be accomplished using a set of standardized protocols (Appendix I). These protocols have been designed and adapted to provide critical information using methods that are easily repeatable by SFRPD personnel and volunteers. It is imperative that the methods outlined in this plan, and the referenced protocols, are applied uniformly through time on all sites. Comparability of data between years and between sites is dependent on the consistent application of these methods. The primary purpose of data collection is to track the dynamics of special-status species populations in Management Areas through time and to measure the success of restoration activities. The results will also be used to build an inventory of species observations in each park. Data and metadata collected with these methods will be stored in a permanent database using a GIS platform.

GOAL 1: MONITORING POPULATIONS OF SPECIAL STATUS SPECIES

The population dynamics of special-status species will be monitored through time.¹ The species to be monitored will be selected by the SFRPD staff. The list may be revised at any time. However, a list of eight plant and three wildlife species have been selected for monitoring priority (Table 7-1). Because vegetation is a key component of all ecological communities, and the monitoring of plants uses the least amount of resources, vegetation resources should be considered the first priority.

¹ The term special-status species (or sensitive species) refers to species that are: 1) federally listed as endangered, threatened, candidate, or food plants for those species; 2) state-listed as endangered, rare, threatened, California fully protected, species of special concern, or food plants for these species; 3) listed on the California Native Plant Society *Inventory of Rare and Endangered Vascular Plants of California* (CNPS 2001); 4) on the National Audubon Society's Watch List; 5) under threat of local extirpation as determined by the Yerba Buena chapter of the California Native Plant Society, or the Golden Gate Chapter of the National Audubon Society.

Table 7-1. The species listed below have been selected by SFRPD staff for monitoring.

Vegetation	CNPS	State/Federal
Coast Rock Cress (<i>Arabis blepharophylla</i>)	4	
Dune Gilia (<i>Gilia capitata</i> ssp. <i>chamissonis</i>)	1B	
Fragrant Fritillary (<i>Fritillaria liliacea</i>)	1B	
San Francisco Campion (<i>Silene verecunda</i> ssp. <i>verecunda</i>)	1B	FSC
San Francisco Collinsia (<i>Collinsia multicolor</i>)	1B	
San Francisco Gumplant (<i>Grindelia hirsutula</i> var. <i>maritima</i>)	1B	FSC
San Francisco Spineflower (<i>Chorizanthe cuspidata</i> var. <i>cuspidata</i>)	1B	FSC
San Francisco Wallflower (<i>Erysimum franciscanum</i>)	4	
Wildlife		
California Red-legged Frog (<i>Rana aurora draytonii</i>)		FT
Western Pond Turtle (<i>Clemmys marmorata</i>)		CSC
Mission Blue Butterfly (<i>Icaricia icarioides missionensis</i>)		FE

1. Monitoring of Special-Status Plant Species:

The plant species currently cited on the first-level priority list include three annual herbaceous species (*Chorizanthe*, *Collinsia*, and *Gilia*), three herbaceous perennials (*Arabis*, *Silene*, *Fritillaria*), one is a biennial to subshrub (*Erysimum*), and one woody perennial subshrub (*Grindelia*). In order to facilitate monitoring efforts and reduce the resources necessary for each monitoring project a unified protocol has been developed for all of these species (Appendix I).

Monitoring of many of the species listed on the first-level priority list has been proceeding for several years, though it has not been continuous. Monitoring of San Francisco spineflower was conducted in 2001 at Lake Merced and in 2003 at Golden Gate Heights at the time of peak flowering (July-August). San Francisco collinsia was sampled at Bayview Park in 2003 between April and May. Dune gilia was monitored at Hawk Hill in 2002, also between April and May. Coast rock cress was monitored at Twin Peaks in 2002 and Mount Davidson in 2001 and 2002. San Francisco campion was monitored at Mount Davidson and Rock Outcrop in 2001 with peak flowering in August. Several populations of San Francisco wallflower have been located at Grandview Park, Golden Gate Heights, and Lake Merced but have yet to be monitored. Monitoring for all eight species will begin with the next monitoring season following adoption of the Management Plan.

Action 1.A: Locating Populations

The specific locations of all special-status plant populations in each Management Area will be identified.

Action 1.B: Mapping Populations

Each population will be mapped in the field using Global Positioning System (GPS). The GPS unit will be used to record either the perimeter of each population or locations of individual plants. This data will then be entered into the GIS as either a polygon or point-data for each population. All data will be stored in the same GIS and linked so that population changes can be analyzed by individual populations, by site, or throughout all of the Natural Areas.

Action 1.C: Estimating Population/Cover

Data on the population of all species will be collected within each mapped population.

The population of all species (*Arabis*, *Chorizanthe*, *Collinsia*, *Erysimum*, *Fritillaria*, *Gilia*, *Grindelia*, and *Silene*) will be estimated using a combination of census and sampling procedures. A census will be conducted for populations of less than 1,000 individuals. For populations of greater than 1,000 individuals a system of randomly located sample plots will be used. Population estimates need not be conducted for the extent of the 20-year lifespan of the Plan. Annual herbaceous species will be counted annually for 3 to 5 years or until a population trend is evident. Perennial species will be counted every other year until a population trend is evident. If the perennial species population trend is stable or increasing, then a census will be conducted once every 3 or 5 years. If the perennial species' populations are decreasing, a census will be conducted every year. In addition, fieldwork will be conducted during the flowering period of each species in order to optimize the ability of fieldworkers to recognize the species.

Action 1.D: Assessing Population/Cover Change

The data collected will provide an annual assessment of the status of selected special-status plant species. Data will be entered into the database and linked to the SFRPD digital map using GIS. Data will be analyzed to determine if there are significant changes in populations, or cover, of each species over time. In order to conduct this analysis, data will need to be collected over multiple years. The preferred tool for these comparisons is regression analysis.

2. Monitoring of Special-Status Wildlife Species

Three wildlife species have been selected for monitoring due to their rarity. These species include California red-legged frog, western pond turtle, and mission blue butterfly. Each of these species has a specific protocol for monitoring (Appendix I-2). General requirements for monitoring are listed below (Action 2.A – 2.B).

Currently one population of the California red-legged frog exists in Sharp Park and has been monitored annually since 2002. Populations are estimated by counting egg masses in ponds where the frog has been sighted. Surveys are conducted every three weeks throughout the rainy season (November through April).

Western pond turtle populations have been located at East Lake at Lake Merced and at Pine Lake. Pond turtle populations will be monitored annually by conducting basking surveys. Surveys of basking turtles are taken on warm sunny days, when the animals are likely to be out of the water.

Mission blue butterfly populations have been monitored at Twin Peaks since 2001. The populations are estimated by counting eggs, larvae, and adults on host plants (*Lupinus albifrons* and *Lupinus variicolor*) at four known population sites on Twin Peaks. Monitoring of the population in Sharp Park will begin when resources are available.

Action 2.A: Locating Populations

The specific locations of all special-status wildlife populations in each Management Area will be identified. Habitat surveys will be conducted at a time interval appropriate for the sensitive species. The presence or absence of species will be noted within areas containing target habitat. Specific coordinates where each population occurs will be recorded using a GPS unit where feasible. Presence and absence data will be recorded in the SFRPD database and will be linked to the digital map using GIS.

Action 2.B: Assessing Population Change

An annual assessment of the status of selected wildlife species will be conducted based upon monitoring findings. Data collected will be used to determine the viability of each population, and to track general population changes in the Natural Areas as a whole. Data will need to be collected for several successive years to allow a meaningful analysis.

GOAL 2. MEASURING THE SUCCESS OF RESTORATION AND CONSERVATION PROJECTS

The success of projects designed to enhance or restore natural systems will be analyzed in terms of the management goals of the project. In general, the goal of this Final Draft is to increase the abundance and diversity of native species, and to decrease the abundance and diversity of invasive species. The target levels for these metrics are site dependent and will be determined by the restoration project manager as part of the restoration project planning process. Both qualitative and quantitative approaches will be used to assess these projects.

1. Qualitative methods for assessing project success

General site conditions for each project area will be recorded through photo-monitoring because a visual record can be useful in understanding the broad-scale changes that have taken place on a site. Photo-monitoring will take place on all major restoration sites and will be combined with quantitative information to create a complete record of site characteristics throughout the restoration process.

Action 1.A: Timing of photo-monitoring

Initial photo-monitoring will take place prior to the commencement of any large project. It is crucial that baseline images are available for comparison with future site conditions. Photo-monitoring will be repeated following each major step in the restoration process, including removal of trees, removal of invasive species, and planting of native species. Monitoring will then be continued at intervals of two to five years as determined by the project manager. The photos will be used to help with the interpretation of data collected through other methods.

Action 1.B: Location of photo-monitoring

It is important that each series of photos taken for a project area are taken at exactly the same spot, in the same direction, and with the same angle lens. The best way to accomplish consistency between photo sessions is to link each photo-point to a permanent landmark. A GPS reading can be taken for each point as well and can be used to locate the landmark. All location information will be recorded with the photo. The angle of the direction of the shot can be measured with a compass and recorded as well. This information will be archived with the photo along with the date it was taken, the name of the photographer, the type of camera used, and the camera settings.

2. Quantitative methods for assessing project success

A unified monitoring protocol has been developed to provide general information on the relative diversity and abundance of native and non-native plant species on selected project areas (see Appendix I-3). This protocol was developed to provide a simple repeatable method for data collection that can be applied to restoration and conservation sites within Natural Areas. These methods will provide data about changes in the composition and distribution of vegetation over time. Analysis of data over successive years will provide a measurement of progress toward the goal of increasing the cover and diversity of native species, and reducing the cover and diversity of invasive species. More specific goals, such as the restoration of wildlife communities, will require more specific success criteria. Measurement of plant species will be used as the primary method of measuring project success, because it has relatively low cost, the comparability between sites is high, and measures of habitat can serve as a basis for determining presence and health of wildlife populations.

It is essential that this monitoring protocol be applied to each project area prior to beginning the project so that base line data is available for analysis.

Action 2.A: Mapping Project Area

A map of each project area to be monitored will be created. The project area should include the extent of all project activities including soil disturbance, weeding, and planting. The map can be created using analog or digital methods, but will need to be stored within the GIS.

Action 2.B: Randomizing Samples

Data collection will take place using randomly placed sample nested plots. The number of plots used will be based on the size of the project area. Samples may be located using a GIS based procedure, or by hand. Once sample locations have been determined, however, they should be recorded as digital data points on the project area map.

Action 2.C: Point Intercept Sampling

Vegetation sampling will take place using the point intercept method to estimate coverage. This method reduces the amount of error associated with multiple samplers. Training is minimal with this method, and easily conducted by SFRPD staff and volunteers.

Action 2.D: Recording and Analyzing

Data recorded for each site will be stored in the SFRPD database and linked as metadata to the GIS. Several analysis options are available with this protocol. Paired tests can be used to compare baseline data (collected prior to project initiation), to first year restoration data. This option allows managers to demonstrate project success quickly. Collection of data over several years will provide a data set that can be analyzed in terms of long-term trends. Regression is the preferred tool for this analysis.

3. Tracking changes in avian and butterfly diversity and abundance

In certain instances the Natural Areas Program staff may determine that avian species data will be collected in addition to vegetation data in order to help measure the success of restoration and management actions. Terrestrial wildlife species are not included in the monitoring plan because of the high cost in terms of time, labor, and equipment necessary for such monitoring. Data collected through the methods described below will be included in the data set for individual sites and for the Natural Areas as a whole.

Action 3.A: Qualitative Avian Species Monitoring

An avian species list will be developed for each site. This list will be linked to the data set for each site. Qualified Natural Areas Program staff, volunteers, and local bird enthusiasts will collect data on bird sightings. This data will be recorded in a database for each site. A website link will be developed by SFRPD to allow local residents to submit species sightings. The date, time, exact location of the sighting, and the qualifications and contact information for each submitter will be required so that data can be authenticated.

Action 3.B: Quantitative Methods for Avian Species Monitoring

If precise quantitative methods for monitoring avian species are required, methods developed by the Pacific Southwest Research Station (USDA) will be used. (Ralph, et al. 1993). These methods are the standard for this region. Several methods are described in this document, including point count, spot map, area search, mist nets, and nest search. In general, the least labor-intensive methods are advisable, and consistency between sites is essential. In order to compare between sites, the same methods must be used.

Action 3.C: Qualitative Methods for Monitoring Butterfly Species

A list of butterfly species will be developed for each site and for the Natural Areas as a whole. Qualified Natural Areas Program staff, volunteers, and local butterfly enthusiasts will collect data on butterfly sightings. This data will be recorded in a database for each site. A website link will be developed by the SFRPD staff to allow local residents to submit species sightings. The date, time, exact location of the sighting, and the qualifications and contact information for each submitter will be required so that data can be authenticated.

Action 3.D: Quantitative Methods for Monitoring Butterfly Species

If the Natural Areas Program staff determine that more precise data is required on butterfly diversity abundance, the transect method developed by the Butterfly Monitoring Scheme. Pollard and Yates (1993) have published a detailed discussion of these methods. A more concise version is also available on the Butterfly Monitoring Scheme website at <http://bms.ceh.ac.uk/>. The transect method is straightforward, and can be used to record the abundance of a single species or multiple species. Trained personnel should be used for this type of monitoring so that data will be collected consistently and species identifications can be made with confidence.

7.5 ADAPTIVE MANAGEMENT

Restoration and management of natural systems occasionally require the employment of new, untested, methods. On these occasions the monitoring of the results of these new methods needs to be conducted using an experimental approach known as “adaptive management”. Adaptive management differs from standard monitoring in three ways.

- *Hypothesis testing*: Specific management goals must be articulated as an experimental hypothesis.
- *Treatments and controls*: In order to determine if a new method is successful it must be tested against alternative methods used for the same purpose (if available), and against a control or no action alternative.
- *Replication*: Multiple replicates of each treatment must be conducted in order for statistical analysis to be meaningful. An equal number of replicates is suggested for each treatment. The number of replicates needed depends on the natural variation of the site. However, a minimum number of three replicates for any adaptive management are suggested.

7.6 UNIFORMITY AND CONSISTENCY OF MONITORING

A monitoring program can only be successful if it is applied uniformly and consistently. Once a monitoring effort has commenced the methods for collecting data must continue in the manner that they were initially implemented, or the data will not be comparable through time and between sites. The protocols associated with this monitoring plan should not be altered in any significant way.