Appendix E Biological Effectiveness Protocols

This section provides draft biological effectiveness monitoring protocols to evaluate progress of the LOHCP toward attaining the biological goals and objectives (Section 5.1). Specifically, these protocols are designed to examine the status and trends in populations of the covered species, and the distribution, structure, and species composition of the plant communities of the Baywood fine sands ecosystem. Monitoring protocols are also provided to track general habitat conditions and map populations of invasive plants within the Preserves and facilitate evaluation of the effectiveness of the LOHCP at achieving the Plan's biological goals and objectives (Section 5.1, Table 5-1).

Monitoring is an essential component of the adaptive management framework which will be used to promote long-term effectiveness of the LOHCP conservation program (Section 5.5). These draft protocols can be used to develop the monitoring component of the LOHCP Preserve Adaptive Management and Monitoring Plan early during implementation of the LOHCP to guide monitoring within lands managed as part of the LOHCP Preserve System (Section 5.3.3.2).

Many of the draft biological effectiveness monitoring studies are based on sampling, in which the state of the entire system of interest (i.e., community or population) is inferred based on statistical analysis of a random sample. Sampling can provide a cost effective and accurate means of detecting and tracking biologically meaningful changes. To be effective, sampling studies must be carefully planned and implemented considering valid sampling techniques, the biology of the species, and the monitoring goals and objectives. These protocols should be refined based on the biological inventory of the Preserve System, and then refined through implementation of a pilot study, as well as any new scientific information.

Each quantitative monitoring protocol contains five main elements:

1. Sampling Objectives: These specific objectives of the study, including the minimum detectable change, statistical power, and false-change error rate. Sampling objectives link specific aspects of the sampling design to the conservation objective(s) which they are designed to track.
2. Sampling Design: Other critical elements of the study, including the universe of interest (statistical population), the variables measured, the sample unit, the sample size and shape, the manner in which samples are allocated, whether samples are temporary or permanent, and the sample size.
3. Implementation: specific guidelines for implementing the study, including aspects of seasonality, duration, and frequency.
4. Analysis: the analyses and statistical tests appropriate for data collected.
5. Potential Modifications: A list of potential changes in the event that the monitoring protocol as drafted does not achieve the sampling objectives.

E.1 Plant Community Monitoring

Two proposed monitoring studies have been designed to track the ecosystem and community goals of the LOHCP (Table 5-1):

1. Areal mapping of the plant communities; and
2. Plant community structure and species composition sampling.

The plant community structure and species composition monitoring can also greatly inform work to monitor populations of the covered species, by quantifying important habitat conditions.

E.1.1 Areal Mapping of Plant Communities

This study is designed to track the distribution and extent of the different plant community (vegetation) types within the LOHCP Area. In spring 2004, plant communities within the LOHCP Area were delineated using a combination of aerial imagery interpretation and ground reconnaissance (J. Legato, pers. comm. 2004). As part of work to expand the Plan Area in the current LOHCP, the mapping was expanded through examination of high-resolution aerial imagery. The resulting GIS-based map reveals a mosaic of 23 different plant associations or 'series' (Section 3.1.5). These communities vary in their structure and species composition in ways that influence their use as habitat for the covered species.

E.1.1.1 Monitoring Objective

The objective of monitoring is to detect biologically meaningful shifts in the distribution and extent of the plant associations within lands managed as part of the LOHCP Preserve System.

E.1.1.2 Study Design

Using the same protocol as implemented to develop the GIS vegetation layer in 2004 (CMCA 2004), the distribution of plant communities will be mapped within the LOHCP Preserve System. Specifically, new high-resolution aerial imagery of the region should be used to delimit the boundaries of the series based on their described differences in structure and species composition, which are discernible based on their unique 'signature' in the imagery. Field-based verification should be conducted for at least 5% of the mapped patches, with areas of identified change being most important for ground truthing.

E.1.1.3 Implementation

Areal extent mapping should be conducted approximately every 10 years in perpetuity. This is the anticipated temporal scale during which changes in plant communities will occur, as a result of:

- natural dynamics, including new disturbances (e.g., fire and erosion) and succession;
- anthropogenic factors, including management and restoration projects (e.g., vegetation management) and recreational use; and
- climate change, which can cause shifts in plant community composition.

The precise timing of the monitoring may depend on the availability of new, high-resolution aerial imagery of the Preserve System.

Spatial analyses in geographic information system should be used to determine the location and extent of changes in plant community types. For each area where a shift is detected, the original aerial photographs should be examined to determine whether the putative change is due to mapping error

(i.e., the accuracy or precision with which communities are mapped) or represents an actual transition in plant community structure and species composition.

E.1.1.4 Analyses

Descriptive statistics can be used to examine the number of patches, the mean and total patch area, and the percent of each community type, which changed in the monitoring interval. Assembling a matrix depicting the percent change each community type to every other type will enable evaluation of trends due to succession, management, and climate change.

E.1.1.5 Potential Modifications

The monitoring protocol used to track this objective will be adjusted if biologically important differences between plant communities cannot be adequately distinguished through interpretation of vegetation signatures using aerial photographs. For example, if coastal sage scrub with high cover of veldt grass (*Ehrharta calycina*) is found to support lower diversity of herbaceous native plants or abundance of Morro shoulderband snail relative to uninvaded coastal sage scrub, then the communities should be split. If the two types of coastal sage scrub cannot be distinguished via examination of aerial photographs, then additional ground mapping may be required.

E.1.2 Plant Community Structure and Species Composition Monitoring

This study is designed to evaluate changes in the structure and species composition of the plant communities within the LOHCP Preserve System and detect changes in habitat conditions that should trigger management. It can be used to evaluate effectiveness of the community goals of the LOHCP, as well as help achieve the objectives for the covered species, by tracking the conditions of their habitat. The study details should be refined based on results of the pilot study.

E.1.2.1 Sampling Objectives

The objectives of the monitoring protocol are to have 90% power to detect 20% declines in habitat conditions relevant to long-term viability of the covered species, including the diversity and relative cover of exotic plants and the diversity and relative cover native plant species, with a 10% chance of indicating a statistically significant decline occurred when one did not.

E.1.2.2 Sampling Design

In this study, the percent cover of each plant species will be estimated visually using cover classes in permanent square quadrats (5 m x 5 m). In addition to plant cover, relevant habitat variables including the cover of litter, the cover of dead woody vegetation, and the amount of soil disturbance (e.g., percent of the quadrat disturbed by trails or animal diggings) will be estimated.

The quadrats will be located throughout the LOHCP Preserve System using a stratified-random sampling regime in which the main plant community types (i.e., coastal sage scrub, central maritime chaparral, etc.) are the strata within which the number of samples allocated to each community type is proportional to their acreage within the Preserve System. There are presently no current estimates for the mean or variability in diversity and relative plant cover within the community types, upon which the

initial sample size could be based. It is estimated that 100 quadrats in total, with at least 5 per stratum (community type) will be needed to attain the sampling objectives.

E.1.2.3 Implementation

Sampling should be conducted every five years when annual plant species are in flower (mid-March through mid-May). Because cover estimates can vary depending on the phenology of the system and the observer, sampling should occur during a 1 to2-week period during peak phenology each year, rather than during a consistent calendar time. Sampling should be conducted by the same observer or team of observers, which has standardized their visual estimates to the greatest degree possible.

E.1.2.4 Analyses

The species data will be used to calculate the following composite variables:

1. Cover and richness of exotic plants; and
2. Cover and richness of native plants.

Paired t-tests can be used to evaluate whether a decline of 20% has occurred in native plant cover and richness, or an increase of 20% has occurred in exotic plant cover and richness, between the current sample and the baseline. Least squares regression or route regression can be used to determine whether a significant decline in gamma richness (a measure among samples) has occurred over a minimum of a five sampling periods. Similar statistical tests can be used to evaluate changes in other relevant habitat variables, including litter cover and disturbance.

E.1.2.5 Potential Modifications

The proposed monitoring protocol should be modified to increase its efficiency for attaining the sampling objectives based on results of the pilot study and during the course of implementation, as necessary. The following are potential modifications that might promote success toward the sampling objectives.

1. Sampling Method: If high variability results from visual estimation of plant cover, line intercept or point intercept sampling may be used to estimate cover within the quadrats. In these methods, plant cover is estimated by sampling plants intersecting the length of a series of transect (line intercept) or specific points along transects (point intercept) traversing the quadrat. Because these methods will likely miss rare species, richness (number of plant species) should be counted within the entire quadrat.

2. Sample size: Increasing the number of quadrats will increase the statistical power and thus facilitate the sampling objectives. This must be weighed against other methods of reducing standard deviation, such as quadrat size and shape, and other sampling objectives, including maintaining low costs.

E.1.2.6 Thresholds

The thresholds to trigger remedial management for communities are a 20% decline in native diversity or cover, and a 20% increase in exotic diversity or cover compared to the baselines measured during initial sampling.

E.2 Morro Shoulderband Snail Population Monitoring

The proposed study is designed to detect declines in Morro shoulderband snail (MSS) distribution and abundance that exceed the designated threshold. Such declines should be evaluated along with the results of other monitoring studies, including monitoring of the plant communities, in order to evaluate the potential causes and determine the need for remedial habitat management. Details of the protocol should be refined based on results of an initial MSS inventory and pilot monitoring study.

E.2.1 Sampling Objectives

The objectives of the monitoring protocol are to have 90% power to detect 20% declines in frequency (a measure of distribution) and density (a measure of abundance) of MSS, with a 10% chance of indicating a statistically significant decline occurred when one has not.

E.2.2 Sampling Design

The density (number of individuals) of MSS will be measured in square permanent quadrats (5 m x 5 m) located within the LOHCP Preserve System using a stratified-random sampling regime in which the individual lands managed (i.e., the Preserves) are the strata in which an equal number of samples are randomly located. There are presently no density estimates for MSS, nor frequency estimates for this sized quadrat, upon which the initial sample size could be based. It is estimated that a minimum of 80 quadrats in total, with 10 per stratum (Preserve) will be needed to attain the sampling objectives.

Within each quadrat, the vegetation, litter, and top one inch of soil should be carefully searched for a specified period of time to standardize the level of effort; this approach is designed to avoid inadvertent bias (e.g., searching plots located in perceived 'good habitat' longer). The number of live snails in each class (juvenile, adult) should be recorded. The number of empty shells in each age class (Roth 1985) should also be recorded then removed from the quadrat so that they are not counted in future monitoring. If MSS searches are too destructive or time consuming in a 5 m x 5 m area, five to 10, 1 m x 1m quadrats randomly located (i.e., nested) within the larger quadrat could be subsampled.

E.2.3 Implementation

Sampling should be conducted during the rainy season (November-March) during or immediately following precipitation. All plots should be sampled within a 1-to-2-week period.

Pilot (Years 1 and 2): Sampling will be conducted following the identical protocol in the first two years, after which analyses of the data, including power analyses, will be used to determine whether the monitoring protocol attains the sampling objectives and, if not, develop necessary modifications.

First 10 Years Post-Pilot: Sampling will then be conducted every two years during the next 10 years of LOHCP implementation. At each sampling interval, data will be analyzed to determine whether declines in frequency and density exceed the threshold. Such declines will be evaluated in the context of other available information, including climate data, and results of other monitoring studies, to determine whether remedial management is necessary.

In Perpetuity: Once sampling has occurred using the same protocol five times, trend analysis will be used to detect significant declines in frequency or density over a minimum of five consecutive sampling intervals. Power analysis will again be required to determine whether the objectives of a trend analysis can be met with the sampling study. The frequency of sampling following the first ten years should be determined in consideration of the variability observed due to natural fluctuations, but an interval of 3 years is suggested preliminarily.

E.2.4 Analyses

Paired t-tests can be used to evaluate whether a decline of 20% has occurred between the current sample and the baseline. Significant declines in the frequency of occurrence between two intervals can be tested using a G-test. If more than one-time step is evaluated at the same time, repeated measures ANOVA to detect significant declines in density, and Cochrane's Q test to determine whether frequency has declined through time.

Over longer time intervals, least squares regression or route regression can be used to determine whether a significant decline in density or frequency exceeding the threshold (20%) has occurred over a minimum of a five sampling periods.

E.2.5 Potential Modifications

The proposed monitoring protocol should be modified to increase efficiency at attaining the sampling objectives based on results of the initial MSS inventory and the pilot study. The following are potential modifications that might promote success of the sampling objectives.

E.2.5.1 Narrowing the Universe of Interest

The present protocol calls for randomly locating samples within the Preserves, irrespective of habitat conditions. This is done to initially evaluate the community types in which the species occurs; it also renders monitoring results be generalizable throughout the Preserve System. If the initial inventory for MSS or future research reveals that the species do not occur within certain areas of the LOHCP Preserve System, such as specific community types, these areas could be excluded from the universe of interest; remaining samples could be relocated within the suitable habitat, increasing the precision of the estimates and likely statistical greater power. If sampling is limited to in the absence of conclusive evidence for the MSS restricted distribution, monitoring results will not necessarily be generalizable to the true universe of interest.

E.2.5.2 Quadrat Size and Shape

Quadrat size will be increased if the initial MSS frequency of occurrence is too low (<50%) or if the standard deviation of the difference between density in a given sampling interval is too high. Alternative quadrat shapes might be used to reduce these parameters; however, a square or perhaps circular

quadrat is recommended to reduce the variability due to MSS locomotion that would likely results from narrow, rectangular quadrats. Previous research found a correlation between the abundance of live MSS and their shells in 20m^2 quadrats (Adams et al. 2000), suggesting these 100m^2 should be effective in tracking occurrences.

E.2.5.3 Sample size

If the standard deviation of the difference between sample intervals is too high, an increase in sample size might also increase power and thus facilitate the sampling objectives. This must be weighed against other methods of reducing standard deviation (sample size) and other sampling objectives, including maintaining low costs.

E.2.6 Thresholds

The thresholds to trigger evaluation of remedial management for Morro shoulderband snail are: 1) 50% decline in distribution in any one Preserve, or 2) a 20% decline in distribution (frequency) or abundance (density) compared to the baseline measured in the LOHCP Preserve System as a whole.

E.3 Morro Manzanita Population Monitoring

Two complementary monitoring studies are recommended to track effectiveness of the LOHCP at achieving the biological goals and objectives for Morro manzanita:

1. Areal extent mapping of Morro manzanita, to track the species distribution and general abundance; and
2. Demographic monitoring of Morro manzanita, to evaluate plant performance including survivorship.

The following outlines general aspects of the monitoring studies, for which detailed protocols should be developed based on pilot studies conducted during initial implementation of the LOHCP.

E.3.1 Areal Extent Mapping of Morro Manzanita

Conducted as part of the areal mapping of plant communities (Section E.1.1), this protocol is designed to track the distribution and extent of the Morro manzanita within the LOHCP Area. The range-wide areal extent of Morro manzanita was mapped first on paper by Mullany (1990) and then updated and incorporated into a GIS by Tyler et al. (2000).

E.3.1.1 Monitoring Objective

The objective of this monitoring protocol is to detect declines in the distribution of Morro manzanita within the Preserve System that exceed 20% of the baseline acreage or result in extirpations from individual Preserve Areas.

E.3.1.2 Study Design

Following the methods of Mullany (1990) and Tyler et al. (2000), patches of habitat occupied by Morro manzanita will be delimited using GIS based on aerial image analysis and field verification, as necessary.

The distinctive shape (round or oval) and color (grey-green) of Morro manzanita canopy can be used to be distinguished the covered species from co-occurring shrubs and trees by a biologist or another trained observer. The polygons developed by Tyler et al. (2000) can be updated and used as a baseline for the distribution of Morro manzanita in the LOHCP Preserve System. New, high-resolution aerial photographs will be used to evaluate changes in the distribution of Morro manzanita through time.

E.3.1.3 Implementation

Areal extent mapping should be conducted approximately every 10 years in perpetuity, with the exact interval dependent upon the availability of new, high resolution aerial photographs of the LOHCP Area. This is the anticipated temporal scale during which changes in the distribution of the species are anticipated to result from:

1. natural dynamics, including new disturbances (e.g., fire and erosion) and succession;
2. anthropogenic factors, including management and restoration projects (e.g., vegetation management) and recreational use; and
3. climate change, which can cause mortality events directly or indirectly, by increasing vulnerability to pathogens.

Spatial analyses in GIS can be used to quantify changes in the acreage of habitat occupied by Morro manzanita. For each area in which a change is detected, the original aerial photographs and polygons should be examined to determine whether the change is due to mapping error (i.e., the accuracy or precision with which patch boundaries are delimited) or represents an actual change in the extent of this covered species.

E.3.1.4 Analyses

The percent change in the areal extent (acres) of Morro manzanita can be calculated simply as:

$[\text{Acres}_{(t)} - \text{Acres}_{(\text{baseline})}]/\text{Acres}_{(\text{baseline})}$.

where t represents the year in which subsequent mapping occurs and baseline represents the acreages mapped during the initial monitoring early during implementation of the LOHCP. Additional statistics will be used to describe the changes that are observed, in terms of the percentage change in the distribution by patch and by Preserve (individual property) to assess the extent to which changes are occurring range-wide or in discrete areas.

E.3.2 Demographic Monitoring of Morro manzanita

Demographic monitoring is designed to detect declines in survivorship of Morro manzanita, which may signal the need for management to promote population persistence.

E.3.2.1 Monitoring Objective

The objective of demographic monitoring is to track the survivorship of Morro manzanita individuals to detect increases in mortality that would signal the need for management to promote stand regeneration and thus avert the 'senescence risk' posed by fire suppression in the region.

E.3.2.2 Study Design

Monitoring will be used to evaluate the demographic performance of Morro manzanita located throughout the LOHCP Preserve System. A sample of individual shrubs will be chosen using a stratified-random sampling regime in in which an equal number of plants will be randomly chosen for monitoring in each LOHCP Preserve. At least 20 shrubs should be monitored in each Preserve where the species is located.

Each randomly chosen Morro manzanita individual will be permanently marked using a discrete, permanent identifier (e.g., numbered metal tag), and their location recorded in the GIS. At each monitoring event, plant canopy height, width, and percentage of dead cover will be recorded, along with any observations regarding the plant's condition, such as evidence of disease, desiccation stress, senescence, herbivory, or other factors that could influence performance. The community type, approximate stand age (based on historical aerial photographs), and any other factors hypothesized to influence performance will also be recorded for each individual.

E.3.2.3 Implementation

Demographic monitoring will be conducted early during the implementation of the LOHCP and at 10-year intervals. The interval can be shortened if observations suggest a decline in individual plant vigor or survivorship of the population that should be further evaluated for management.

E.3.2.4 Analyses

Morro manzanita survivorship, size (volume calculated using the formula for a cylinder), and percentage dead or damaged canopy will be tracked through time. Paired t-tests can be used to test for differences in size and canopy cover between sampling intervals. Logistic regression can be used to evaluate factors influencing survivorships, including community type, stand age, size, and percent dead foliage, among other factors measured for each individual during the study.

E.3.2.5 Thresholds

The thresholds to trigger remedial management for Morro manzanita are: 1) 1 50% decline in areal cover, canopy cover, or survivorship in any one Preserve, or 2) a 10% decline in distribution (areal extent), abundance (cover), or survivorship compared to the baselines measured in the Preserve System as a whole.

E.4 Indian Knob Mountainbalm Population Monitoring

Indian Knob mountainbalm population monitoring is designed to detect changes in the distribution, abundance, and demographic performance of Indian Knob mountainbalm. Details of the protocol should be refined based on results of the initial inventory of lands to be managed as part of the LOHCP Preserve System and then again based on results of the pilot study. If management projects are implemented to enhance Indian Knob mountainbalm populations, detailed experimental management project monitoring will also be used to evaluate the status of the narrowly distributed and rare plant.

Presently, Indian Knob mountainbalm has a very limited distribution and abundance in the LOHCP Area. Thus, census and demographic monitoring are proposed rather than sampling. If the distribution and/or

abundance are found to exceed a level for which the entire population can be efficaciously monitored, it may be necessary to conduct demographic monitoring on a sample of the population.

E.4.1 Monitoring Objective

The objectives of the monitoring protocol are to track changes in the areal extent, density, survivorship, and reproduction (flowering and seedling establishment) of Indian Knob mountainbalm to evaluate success of management designed to increase population abundance and distribution.

E.4.2 Study Design

Within each discrete patch (occurrence, colony) of Indian Knob mountainbalm located within the LOHCP Preserve System, the following will be conducted:

1. The perimeter of the patch will be delimited using a global positioning system (GPS) and the area of the resulting polygon calculated;
2. All individual plants (ramets) will be permanently marked with a unique identifier (e.g., numbered metal tag) and geolocated using a GPS; and
3. The life stage (seedling/juvenile/adult), and number of flowers produced by each adult plant will be recorded.

Additional information about individuals (e.g., height) or the habitat patch in which they occur (community, successional stage, disturbance, etc.) will also be recorded.

E.4.3 Implementation

Sampling will be conducted when Indian Knob mountainbalm is in flower, in approximately June and July. Demographic monitoring should be conducted at 5-year intervals and continue until the distribution and abundance of the species within the LOHCP Preserve System necessitates population sampling. It is anticipated that this will occur as a result of successful experimental management designed to enhance populations of this very rare plant.

E.4.4 Analyses

Census data should be analyzed using descriptive statistics to track changes in patch size, density, survival, and seedling establishment. Lefkovitch matrix models can be used to calculate the population growth rate based on survivorship and fecundity estimates, which can be used to generate population density protections based on current density values. These useful tools of demographic monitoring can also be used to determine the life history transitions (e.g., seedling survivorship to become a juvenile) are most influential on the population growth (e.g., seedling survivorship, etc.) through sensitivity analyses (Caswell 2000, Parker 2000).

Demographic models can continue to be used once sampling is initiated, at which time univariate statistical tests including paired t-tests can be used to determine whether the population has increased significantly compared to the baseline distribution and density established during the initial year of the study.

E.4.5 Thresholds

The threshold to trigger remedial management for Indian Knob mountainbalm is a 10% decline in areal extent or number of ramets compared to the baseline inventory.

E.5 Morro Bay Kangaroo Rat Monitoring

Because the distribution of Morro Ban kangaroo rat within the LOHCP Area is currently unknown (USFWS 2011b), a presence/absence survey for the species will be conducted as part of the initial inventory of all lands anticipated to be included within the LOHCP Preserve System. Additional private lands where the species is most likely to occur, based on occurrence of suitable habitat and historical sightings, will also be surveyed, if permission is granted by the landowners.

Results of the initial inventory will determine the approach to monitoring this covered species. If Morro Bay kangaroo rat not detected, presence/absence surveys will continue to be conducted at 5-year intervals. Once the species is detected, a monitoring protocol will be developed to monitor the population of this very rare animal. The details of this monitoring protocol will depend on the distribution and abundance of the species revealed through the presence/absence survey and will be developed in close coordination with the USFWS and CDFW.

The following initial protocol for the presence/absence survey is based on the Survey Protocol for the Morro Bay Kangaroo rat (USFWS and CDFW 1996). The details of the methods that will be used to inventory the preserve will be developed early during implementation of the LOHCP, in close coordination with the USFWS and CDFW.

Presence/absence survey will consist of two, tiered components:

- Visual surveys for diagnostic sign, including burrows, tail drag marks, dust bath sites, and surface seed pit caches; and
- Live trapping.

Positive identification of sign can be used to document presence of the species; however, for species present at very low abundance, there is a low probability of detecting sign. If potential sign of kangaroo rats is detected, such as a scat or burrow, tail drag, or other tracks, that resembles that of a kangaroo rat, then live trapping will be conducted when conditions are appropriate, as described below.

E.5.1 Visual Surveys

E.5.1.1 Monitoring Objectives

The objective of the visual survey is to detect known or potential sign of Morro Bay kangaroo rat within the LOHCP Area, including all lands managed as part of the LOHCP Preserve System, as well as other suitable and potentially occupied habitat.

E.5.1.2 Study Design

In the visual survey, a qualified biologist will traverse each Preserve using a series of transects that are close enough to allow comprehensive visual examination of the ground surface.

E.5.1.3 Implementation

Surveys will be conducted by a qualified biologist approved in advance by the USFWS and CDFW. As the timing of surveys can greatly influence the likelihood of detection, surveys will be conducted during the following time periods:

- between April 1 and June 30, or in March if weather conditions are warm and dry for three days prior to initiation of the visual survey;
- during the week preceding or the week following a new moon, when the species is expected to be generally more active;
- when conditions allow sign from daily activity of other small mammals to be visible; and
- during the morning or late afternoon, if there has been no wind, when shadows make tail drag easier to detect.

E.5.1.4 Reporting

Reports from visual surveys will document all relevant information, including:

- The survey area, providing a map and GPS coordinates;
- The survey dates and times;
- The weather and other abiotic conditions during the surveys that could influence activity, including temperature, wind speed, moon phase, and the preceding week's weather conditions;
- The number of person-hours per acre spent searching for sign; and
- A description of the results, including all species sign detected, including that of other species, as feasible.

E.5.2 Live Trapping

E.5.2.1 Monitoring Objectives

The objective of the live trapping is to definitively document the presence of Morro Bay kangaroo rat when potential sign is detected during visual surveys.

E.5.2.2 Study Design

Trapping will be conducted for a minimum of three nights. Traps will be located:

- in areas where sign was detected, including near active burrows, dust baths, or apparent runways, as well as other suitable habitat;
- at 10-to15-meter intervals along potential movement corridors, with at least two traps per station.

Traps will be baited with a mixture of food items including crimped oats, wild bird seed, applies, walnuts, and peanut butter, provided the latter does not attract ants. They will be opened and baited in the late afternoon and checked two to four hours after sunset and again at dawn, with a maximum interval of six hours between trap checks. Traps will be closed after then are checked a dawn.

If Morro Bay kangaroo rats are trapped, the biologist will notify the US Fish and Wildlife Service immediately. Any trapped Morro Bay kangaroo rats will be removed from the wild and placed in the captive breeding facilitate at UC Berkeley, unless the USFWS provides other authorization.

E.5.2.3 Implementation

Surveys will be conducted by a qualified biologist approved in advance by the USFWS and CDFW. As the timing of surveys can greatly influence the likelihood of detection, surveys will be conducted during the following time periods:

- during the week preceding or the week following a new moon; and
- during periods lacking increment weather (e.g., rain or high wind), and at least 3 days following inclement weather, when small mammals are less active.

E.5.2.4 Reporting

Reports from visual surveys and live trapping will document all relevant information, including:

- The trap numbers, locations, and number of nights operated (providing a map);
- The survey dates and times;
- The weather and other abiotic conditions during the surveys that could influence activity, including temperature, wind speed, moon phase, and the preceding week's weather conditions; and
- A description of the results, including all species observed in the traps.

E.6 General Habitat Condition Monitoring

This monitoring protocol will be used to evaluate habitat conditions within the LOHCP Preserve System, in order to detect new threats or impacts to habitat for the covered species. It is designed to complement the other monitoring protocols, by providing more general data collected across a broader area. Results of the study can be used to inform habitat maintenance activities as well as help interpret results of the community and species monitoring protocols, such as provide information about potential causes of declines in species diversity or increases in populations.

E.6.1 Monitoring Objective

The objective of the general habitat monitoring is to evaluate changes in the condition of the land within the LOHCP Preserves over time.

E.6.2 Study Design

In this study, observational data will be collected and photomonitoring will be conducted in each area managed as part of the LOHCP Preserve System. Large or heterogeneous Preserves will be subdivided into management units—contiguous areas featuring similar habitat conditions—for purposes of the assessment.

E.6.2.1 Qualitative Assessment of Habitat Conditions

In each area, observations will be made to assess the habitat conditions based on the factors that affect the covered species populations, which include:

- **native plant cover**: assess native plant cover to detect issues that might reduce it, including disease, senescence due to fire exclusion, trampling due to incompatible uses, or other factors that might necessitate management;
- **exotic plant species:** assess the general distribution and abundance of exotic plants to detect rapid spread or new invasions that necessitate management, including eradication of new species as part of an early detection-rapid response program for the Preserve System (Section D.1.3.2);
- **erosion**: assess condition of eroded areas being restored or managed, and identify new erosion issues early, so that they can be corrected before they damage habitat; and
- **use:** assess user compliance with the recreation provisions of each preserve, and identify habitat impacts associated with trespass, unauthorized uses, and vandalism.

For each factor, detailed qualitative observations will be recorded on data sheets designed to characterize habitat conditions and inform management treatments. The narrative descriptions will be used to assign numerical scores to facilitate tracking changes in each factor over time. Table E-1 identifies initial factors, criteria, and scores to illustrate the protocol.

These elements of the protocol will be refined through work to prepare the LOHCP Preserve System AMMP to ensure that they reflect the results of the Preserve System inventory and baseline monitoring, and address the factors affecting the covered species and their habitats. The final monitoring protocol will include performance criteria designed to trigger remedial actions in response to observed degradation of habitat conditions. For example, any Preserve receiving a score of 3 or less will be subject to remedial management actions to address the factor(s) degrading habitat.

E.6.2.2 Photomonitoring

In addition to the qualitative assessments, photomonitoring will be used to evaluate changes in habitat conditions over time. At each Preserve or management unit therein, permanent photomonitoring points will be established in locations that will complement observations that can be made through analysis of high-resolution aerial imagery, to collectively enable comprehensive examination of the habitat conditions. Photopoint locations will be established in areas that are prone to changes in habitat conditions, including areas of authorized and unauthorized uses and along boundaries of Preserves, as well as any highly sensitive habitat areas.

Photomonitoring points will be permanently monumented on the ground (e.g., using a stake) and their locations recorded using a resource-grade GPS. At each point, the general subject and view direction (azimuth) will be recorded for each photograph. The digital photographs will be stored in files that enable comparisons.

Table E-1: Habitat Condition Assessment Factors, Criteria, and Scores

Factors	Criteria	Score
Native Vegetation	Native plant cover intact	4
	Native plant cover reduced somewhat (up to 10%) as a result of factors that are subject to management	3
	Native plant cover reduced fairly substantially (up to 50%) as a result factors that are subject to management	2
	Native plant cover greatly reduced (>50%) as a result of factors that are subject to management	1
Exotic Plants	Exotic plants limited in distribution and cover (<5%)	4
	Exotic plants limited in distribution and only patchily abundant (5-15%)	3
	Exotic plants fairly widespread and patchily abundant	2
	Exotic plants dominate vegetation, at least in some areas	1
Erosion	No erosion or erosion causing no habitat impacts	4
	Limited erosion causing limited habitat impacts	3
	Moderate erosion causing moderate habitat impacts	2
	Severe erosion causing severe habitat impacts	1
Use	No habitat impacts caused by unauthorized uses.	4
	Limited habitat impacts caused by unauthorized uses	3
	Moderate habitat impacts caused by unauthorized uses	2
	Severe habitat impacts caused by unauthorized uses	1

E.6.3 Implementation

The general assessment of habitat conditions will be conducted annually during the spring (e.g., May), when annual plant growth is at its peak. Preserves or management units prone to habitat management issues, including unauthorized use and erosion, will be assessed at additional times during the year. These follow-up assessments will be timed to evaluate impacts; for example, areas of erosion will be examined in the winter rainy season, while areas prone to unauthorized uses might best be examined during the summer.

E.6.4 Reporting

Results of the qualitative monitoring will be presented in annual reports included as part of the overall LOHCP Annual Report. Tables and graphs will be used to depict changes in the factor scores over time in each preserve; mean scores will be used to characterize changes in habitat conditions across the Preserve System. The reports will identify management actions and other measures designed to address any negative habitat impacts; these recommendations will be integrated into the work plan for the Preserve System in the subsequent year.

E.7 Exotic Plant Species Mapping

This monitoring protocol is designed to track changes in the distribution and abundance of exotic plant species over time within the LOHCP Preserve System. Results will be used to evaluate effectiveness of exotic plant management efforts, as well update the prioritized list of future treatments. Importantly, project-specific monitoring will be necessary to evaluate the effectiveness of specific exotic plant control treatments (Section 5.4.2.2). To enable comparisons of the results as well as enhance cost-effectiveness of the monitoring program, this protocol will be conducted in conjunction with the plant community mapping (Section E.1.1).

E.7.1 Monitoring Objective

Track changes in the richness and relative abundance of exotic plant species within the LOHCP Preserve System that will be used to inform management to control, and eradicate species, where possible.

E.7.2 Study Design

Exotic plant species will be tracked within the Preserve System by characterizing their distribution and relative abundance within each of the plant community (vegetation) patches mapped in the Preserve System. This approach is recommended over mapping the areal extent of each exotic plant species independently for the following reasons:

1. Accurately mapping the thousands of individual polygons needed to depict individual patches of each exotic plant species in the LOHCP Preserve System and differentiating them according to their abundance (e.g., covered classes) as needed to evaluate changes would be extremely time consuming.
2. Mapping individual polygons depicting relatively homogenous cover for each species would be extremely difficult to replicate, thus precluding accurate evaluation of changes over time.

In contrast, plant community patches delineate areas of relatively homogeneous species composition. Using the existing polygons not only facilitates accurate and repeatable field mapping, but also enables examination of exotic plant distribution and abundance patterns with respect to the plant communities, which can be helpful in informing management.
During the initial mapping, many of the larger vegetation polygons will need to be split into two or more new patches in order to:

1. **Delineate relatively homogeneous areas:** Where the cover of one or more exotic plant species varies dramatically within a patch, the patch will be split to delimit relatively homogeneous patches of exotic plant cover.
2. **Subdivide large polygons into smaller areas to facilitate field evaluation**: Polygons that are too large for field examination will be divided into two or more areas in which cover could be accurately assessed.

Within each plant community patch (i.e., polygon), the abundance of each exotic plant species will be estimated using one of ten cover classes (Table E-2). These classes enable rapid and repeatable estimation of exotic plant abundance based on their absolute cover: the percent of the area of the polygon they occupy. The greater resolution in the lower portion of the range (<25%) enables detection of more subtle, yet biologically meaningful, changes in exotic abundance.

Table E-2: Exotic Plant Species Cover Classes

Cover Class	Range of Percent Cover (%)	Midpoint of Percent Cover Range (%)
0	0	0.0
1	<1	0.5
2	1-5	3.5
3	6-10	8.0
4	11-15	13.0
5	16-26	20.5
6	27-50	38.0
7	51-75	63.0
8	76-90	83.0
9	91-110	95.5

E.7.3 Implementation

Exotic plant mapping will be conducted during the spring when most plant species are in flower and annual plant species are at their peak.

It will be conducted every 5 years, in order to provide updated information needed to evaluate the effectiveness of the exotic plant management program and reprioritize species and treatment areas, where needed. General habitat condition monitoring (Section E.6) will be conducted annually to detect new invasions or other changes in exotic plant abundance on a shorter time frame, that merit more immediate management actions. Project-specific monitoring will be conducted to track effectiveness of specific exotic plant treatment projects (Section 5.4.2.2).

During initial implementation, and every ten years thereafter, this protocol will be implemented in conjunction with the areal extent mapping of communities. This will enable results of the two studies to be evaluated (e.g., examine communities that are more or less invaded), and also reduce overall monitoring costs.

E.7.4 Analysis

The abundance (cover class) of each exotic plant observed in each vegetation patch (polygon) will be entered into MS Excel using the midpoint of the range (Table E-2). This will enable the following quantitative analyses:

1. Exotic species abundance, frequency, and area: the mean cover, mean frequency (number of polygons), and total area occupied by each species;
2. Exotic species richness: the mean number of annual, perennial, and all exotic species;
3. Exotic species cover: the mean cover of annual, perennial, and all exotic species.

The data can be integrated into the GIS which can be used to produce maps illustrating exotic plant species distribution, cover, and richness patterns.