APPENDIX I-1. SPECIAL STATUS PLANT SPECIES MONITORING PROTOCOL

This appendix section provides an updated, user-friendly, field sampling protocol for special-status plant species. The protocol can be used for collecting population data for herbaceous species and cover data for woody species. Population estimates need not be conducted for the extent of the 20-year lifespan of the Significant Natural Resource Areas Management Plan. Annual herbaceous species will be counted for 3 to 5 years or until a population trend is evident. Perennial herbaceous species will be counted every other year until a population trend is evident. If the perennial herbaceous species population trend is stable or increasing, then a census will be conducted once every 3 or 5 years. If the perennial herbaceous species' populations are decreasing, a census will be conducted every year. Data collected will be used to determine population/cover trends for individual sites, and for the San Francisco Natural Areas as a whole.

MONITORING PROCEDURE

I. Delineating and mapping populations
II. Data collection
III. Data recording and analysis

I. DELINEATING AND MAPPING POPULATIONS

Surveys of all special-status plant species have been conducted. Maps of current populations are available in the SFRPD office (see Section 6.1-6.26).

In order to delineate the perimeters of existing populations for the current year the locations and perimeters of the populations measured in the previous year need to be studied. The perimeter of each population indicated on the previous year's map will be checked in the field and redefined for the current year's mapping effort.

Mapping of the population can be achieved by one of two methods. The preferred method requires the use of a GPS unit to record the perimeter of each population. This data then imports directly into the GIS. If a GPS unit is not available the perimeter can be drawn on an aerial photograph in the field and later transferred by hand into the GIS.

List of Equipment

- Population map from the previous year
- Several bundles of flags
- Pens, pencils
- GPS unit
- Computer with appropriate GIS software

Delineating populations

1. Locate sites on the previous year's population map (note any differences from previous year's pattern).
2. Flag the extent of current population while walking along the margin.
3. In the field, collect GPS data that corresponds to the perimeter of the population. Most professional-grade GPS units allow the collection of polygon data in the field. If this is not possible, walk along the flagged edge of the population and collect a new single waypoint every 3 meters.
4. If a GPS unit is not available the perimeter may be hand drawn onto an aerial photo.

II. DATA COLLECTION

Data will be collected by one of two methods: census or random sampling. Populations of 1,000 individuals or less will be measured by census. Populations greater than 1,000 individuals will be estimated using random sampling.

List of Equipment

For census

- Three 300-foot measuring tapes
- 200 marking flags
- Mechanical counting device
- Pens, pencils
- Field notebook

For random sampling

- 3 by 1-foot quadrat
- GPS unit with plot coordinates uploaded (if plots are randomized by ArcView)
- Compass
- Map of sample area and plots
- 10 marking flags
- Three 300-foot measuring tapes (only necessary if a GPS unit is not being used for locating plots)
- Datasheets
- Pens, pencils

Census - If the previous year's population was estimated at less than 1,000 individuals the census method will be used.

1. Use measuring tapes and flags to divide population into (1-square foot to 3-square foot) manageable sections.

2. Count every individual in the section with a mechanical counting device and record the number in the field notebook.

3. Add the number recorded in the field notebook to obtain the total for the population.

Random sampling **–** If the previous year's population was estimated at greater than 5,000 to 10,000 individuals the random sampling method will be used.

Determining sample size

The following formula will be used to determine sample size. This formula is based on a minimum sampling level determined from data collected on populations of *Lessingia germanorum* for five years at the Presidio of San Francisco (Archbold and Schwartz 2000).

$$\mathbf{n = P_o(0.002)}$$

Where n = the number of samples, P_o = the estimated population for the previous year.

After data collection is complete for a population the following procedure will be followed to determine if the sampling level has been adequate.

1. Enter the data collected through bipartite sampling in a Microsoft® Excel spreadsheet.

2. Using the Data Analysis under Tool Menu, calculate the cumulative sample variance additively for plots groups of ten plots (1-10, 1-20, 1-30, 1-40, etc.).

3. Create a graph with the sample variance on the Y axis and the number of plots on the X axis.

4. Determine the percent difference between each consecutive calculated variance.

5. If the variance is within 20 percent consecutively for three sample variances, the level of sampling is adequate.

6. If the variance is not adequate, randomly select another set of 10 plots and repeat the sampling procedure.

Locating sample points

There are two methods for locating randomly locating plots. The preferred method uses ArcView; the second uses a grid and an aerial photograph. Both methods are listed below.

A. Locating random points using ArcView.

1. Open ArcView on the computer.
2. Choose “AlaskaPak” and “Gradicules and Measured Grids.”
3. Open a View Window and add necessary themes (including the aerial photo and the polygon of the population).
4. Select the Theme representing the population area (make the theme active).
5. Choose AlaskaPak on Menu, and go to “Create Random Sites.”
6. Check “selected polygons of active theme” in the box.
7. Enter the number of sample plots needed for the population (start with the previous year’s number).
8. Name/specify the shapefile for the sample plots.
9. Choose “Create Random Sites.”
10. Choose “Yes” to add new shapefile with random plot locations on the View Window.
11. Assign XY coordinates for those random plots by going to “Add XY Attributes” under AlaskaPak on Menu. This will give you the California Zone-3 State Plane Coordinates (SPC) for the plots.
12. Create a map with the random plots in Layout Window.

13. Place the SPC grid system over the Layout by clicking on "Gradicules and Measured Grids" on Tool Bar.
14. Upload the coordinates onto GPS unit (consult GIS specialist for methods for uploading the coordinates; methods can vary depending on the available GPS unit).
15. Locate each sample plot with the GPS unit.

B. Locating random points using grid system.

1. Draw grid on population map with 10-foot separation between gridlines.
2. Number each grid on a grid map.
3. Generate random numbers to determine the sample plot locations.
4. Use compass and measuring tapes to locate each sample plot in the field.

Plot sampling

Each plot consists of a 3-by-1-foot rectangular sampling area. If a plot frame is not available a plot frame can be easily constructed out of 0.5-inch diameter PVC pipe.

Collecting plot data for herbaceous species

1. Locate each plot using either GPS unit or measuring tapes as described above.
2. The alignment of the quadrat follows the disposition of the quadrat's elongate shape and the shape of the population (If the population stretches west-to-east, the quadrat lays down west-to-east as well).
3. Count each individual within the quadrat and record on the datasheet.

Collecting plot data for woody species

1. Locate each plot using either GPS unit or measuring tapes as described above.
2. The alignment of the quadrat follows the disposition of the quadrat's elongate shape and the shape of the population (if the population stretches west-to-east, the quadrat lays down west-to-east as well).
3. Use an ocular estimate to determine the percentage cover of the species being recorded within the quadrat and record on the datasheet (Appendix 1).

III. DATA RECORDING AND ANALYSIS

1. All data collected through plot sampling will be entered in a Microsoft® Excel spreadsheet.
2. (*HERBACEOUS SPECIES*) - Estimated population (P) is calculated by multiplying the sample mean (sm) by the measured area (ft^2) of the population (a) multiplied by two.

   $$P = sm \times 2a$$

3. (*WOODY SPECIES*) - Estimated cover (C) is calculated by multiplying the sample mean (sm) by the measured area (ft^2) of the population (a) multiplied by two.

C= sm x 2a

4. All data collected through census will be recorded in a Microsoft® Excel spreadsheet.
5. (*HERBACEOUS SPECIES*) - Total population will be calculated adding the population estimates for all populations.
6. (*WOODY SPECIES*) - Average cover will be calculated by taking the mean of the cover estimates for all populations
7. General linear models, such as the models fitted by Regression Analysis or Analysis of Variance, will be used to analyze changes from year to year. The project manager, with the help of a qualified statistician, should conduct this analysis.

Data Collection Sheet

Special Status Plant Sample Datasheet

Site: Recorder: Date:

Plot ID		# individuals/%cover		Note	
Plot ID		# individuals/%cover		Note	
Plot ID		# individuals/%cover		Note	
Plot ID		# individuals/%cover		Note	
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APPENDIX I-2: SPECIAL STATUS WILDLIFE MONITORING PROTOCOL

The purpose of the Significant Natural Resource Areas Management Plan is to provide an updated, user-friendly field sampling protocol for special status wildlife species. There are currently three wildlife species designated for monitoring: the California red-legged frog, western pond turtle, and mission blue butterfly. Optimally data will be collected on an annual basis for each species. This data will be used to track changes in abundance through time for each site where the species occurs, and for the San Francisco Natural Areas cumulatively.

MONITORING PROCEDURES

I. California Red-legged Frog (*Rana aurora draytonii*)

II. Western Pond Turtle *(Clemmys marmorata)*

III. Mission Blue Butterfly (*Icaricia icarioides missionensis*)

I. MONITORING CALIFORNIA RED-LEGGED FROG ABUNDANCE

The California red-legged frog is a federally listed threatened species under the federal Endangered Species Act. California red-legged frogs are prolific breeders, laying egg masses following large rainfall events in late winter or early spring. Females can lay between 2,000 and 5,000 eggs in a single mass. The eggs masses are attached to vertical aquatic vegetation such as bulrushes or cattails, and are easily visible from the shore. Because they are easy to see, egg masses are often used to locate populations and estimate population size. A population of red-legged frogs exists at Sharp Park (Section 6.4). This protocol gives step-by-step directions for collecting data on this population and for locating new populations.

List of Equipment
- Binoculars - Camera - Staff gauge - Thermometer - Small plastic ruler - Data sheet (see attached)

Locating populations

Currently only one population of California red-legged frog is know to occur in the San Francisco Natural Areas. In order to determine if new populations are emerging, an annual survey of small ponds with the proper habitat features will be conducted. SFNAP personnel can conduct this survey casually as part of their regular routine. However, the survey needs to be conducted during the period of time when egg masses are most likely to occur. Egg masses are most likely to be seen in the late winter and early spring (December-May). For best results the survey should be conducted at the same time that egg masses are visible at known sites. If an egg mass is located at a new site it should be recorded in GIS format as a possible site. The site should then be checked every three weeks to see if mature frogs develop, and if they are indeed California red-legged frogs. If they are, the new site will be upgraded from a possible site to a new population, and will be monitored annually. If mature frogs are not detected the same procedure will be repeated the following year.

Locating egg masses

At each location where red-legged frogs are known to occur the following procedure will be conducted every three weeks between the beginning of December and the end of March.

1. Record weather conditions.
2. With thermometer measure air temperature 3 feet above the water surface.
3. With thermometer measure water temperature 1.5 feet from the edge of the water body.
4. Slowly walk the perimeter of the water body (do not enter the water).
5. Search the water body for egg masses. Focus on emergent vegetation. Often egg masses are found attached to live vegetation slightly under the water surface.

Characterizing egg masses

Note what the egg mass is attached to. If it is attached to vegetation record the species. If it is attached to another structure (stick, rock, etc.) record that.

1. Estimate the dominant vegetation in percent cover.
2. Use the staff gauge to measure the depth of the water at the locality of the egg mass. Be careful not to disturb the egg mass.
3. Use the staff gauge to measure the depth of the eggs below the water surface. Again, be careful not to disturb the egg mass.
4. With a small plastic ruler measure the dimensions of the egg mass in inches in two directions.
5. Measure the dimensions of a representative egg in two directions.
6. Characterize the shape of the egg
7. Record all data on the sheet provided below.
8. Transfer all data from data sheet to the monitoring database at the SFNAP office.

Red-Legged Frog Data Sheet

Date:__________________Begin Time:___________________________Total Time_____________________
Observers:____________________________________Location:_______________________________________

Weather Conditions (circle one): **Clear, Overcast, Rain, Partly Cloudy, Mostly Cloudy**
Air Temperature: _______________________Water Temperature:_____________________________

Egg Mass Data:

Mass ID #	Mass Dimensions (in)	Egg Dia. (in)	Dominant Veg.	Water Depth in)	Attachment	Stage	Comments
	X X	Sphere _ sphere cube	__%________ __%________ __%________	Tot: Mass:			
	X X	Sphere _ sphere cube	__%________ __%________ __%________	Tot: Mass:			
	X X	Sphere _ sphere cube	__%________ __%________ __%________	Tot: Mass:			
	X X	Sphere _ sphere cube	__%________ __%________ __%________	Tot: Mass:			
	X X	Sphere _ sphere cube	__%________ __%________ __%________	Tot: Mass:			
	X X	Sphere _ sphere cube	__%________ __%________ __%________	Tot: Mass:			
	X X	Sphere _ sphere cube	__%________ __%________ __%________	Tot: Mass:			
	X X	Sphere _ sphere cube	__%________ __%________ __%________	Tot: Mass:			
	X X	Sphere _ sphere cube	__%________ __%________ __%________	Tot: Mass:			
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	X X	Sphere _ sphere cube	__%________ __%________ __%________	Tot: Mass:			
	X X	Sphere _ sphere cube	__%________ __%________ __%________	Tot: Mass:			

II. MONITORING WESTERN POND TURTLE ABUNDANCE

The western pond turtle has been listed as a sensitive species by the U.S. Fish and Wildlife Service, and is considered a species of special concern by the California Department of Fish and Game. Population declines for this species are the result of habitat loss and collection for pets (Hays et al. 1999). The western pond turtle is an amphibious reptile with a marble pattern on its shell up to 7.5 inches in length (shell) (Bury 1986). These turtles are common in small ponds and slow-moving streams. The following methods have been adapted from Reese (1996).

List of Equipment

- Binoculars
- Thermometer
- Small plastic ruler
- Data sheet (see attached)

Locating Populations

Currently two populations of western pond turtles are known to occur in the San Francisco Natural Areas. These populations occur at East Lake at Lake Merced and at Pine Lake. In order to determine if new populations are emerging an annual survey of small ponds with the proper habitat features will be conducted in a similar manner as was conducted for red-legged frogs. SFRPD personnel can conduct these surveys as part of their regular routine. The surveys need to be conducted during the period of time when turtles are most likely to be visible. Turtles tend to leave the water on warm sunny days that occur most frequently in the late spring (May-July) and early fall (September-November). If turtles are located at a new site the location will be recorded as a new population in GIS format.

Basking surveys

At each location where western pond turtles are known to occur the following procedure will be conducted approximately every three weeks in the late spring (May-July) and early fall (September-November). Surveys will be conducted on warm sunny days (>70^{o} F) between 10 a.m. and 3 p.m.

1. Record weather conditions.
2. With thermometer measure air temperature 3 feet above the water surface.
3. Make an initial visual scan of the water body from a stationary position. Record the presence of any turtles present. Turtles often remain partially submerged even when basking. Sometimes only their head, or the very tip if their nose is visible above the water. Take your time on this step.
4. Slowly walk the perimeter of the water body. Be careful not to disturb turtles. They will dive under water if they see you coming, but with time will resurface.

5. Select a stationary spot approximately every ten steps and scan the water body again. Record any turtles (Do not record the same individuals that were recorded at the last stationary spot).

Characterizing turtles

1. Record the presence of all turtles sighted.
2. Note where the turtle is basking. If it is in contact with vegetation record the species. If it is basking on a rigid structure (stick, rock, etc.) record that.
3. Note the dominant vegetation in percent cover using an ocular estimate.
4. Record the size of the turtle (length x width). **Do not touch the turtle**. Use the plastic ruler to estimate the size. You will need to get close enough to the animal to estimate its size without startling it and causing it to submerge.
5. Record all data on the sheet provided below.
6. Transfer all data from data sheet to the monitoring database at the SFRPD office.
7. Data will be used to calculate the average number of basking turtles per visit.

Western Pond Turtle Data Sheet

Date:_________________Begin Time:_________________________Total Time____________________
Observers:__________________________________Location:__________________________________

Weather Conditions (circle one): **Clear, Overcast, Rain, Partly Cloudy, Mostly Cloudy**
Air Temperature: _____________________

Basking Data:

ID #	Body Dimensions (cm)	Dominant Veg.	Basking location	Comments
	X	__%_______ __%_______ __%_______		
	X	__%_______ __%_______ __%_______		
	X	__%_______ __%_______ __%_______		
	X	__%_______ __%_______ __%_______		
	X	__%_______ __%_______ __%_______		
	X	__%_______ __%_______ __%_______		
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	X	__%_______ __%_______ __%_______		

III. MONITORING MISSION BLUE BUTTERFLY ABUNDANCE

The mission blue butterfly is a federally listed endangered species. The butterfly is dependent on the coastal scrub habitat type that is widely threatened in California. In the San Francisco Natural Areas the life cycle of the mission blue is specifically tied to two perennial lupine species (*Lupinus albifrons* and *Lupinus variicolor*). The adult butterflies feed on the nectar of the lupine and lay eggs on the plants (Arnold 1987). The eggs hatch within a few days releasing the larvae. Larvae feed for several weeks, then enter dormancy until the following spring. The butterflies emerge in the early spring when their host species begins to flower. The following methods will be used to study trends in mission blue butterfly abundance over time.

List of Equipment

- Thermometer
- Data sheet (see attached)

Locating populations

Currently a total of six populations of mission blue butterflies on two separate sites are known to occur in the San Francisco Natural Areas. Five of these populations occur at Twin Peaks. The locations of these populations include the lower grasslands, two populations at the upper grasslands, the eastern bowl, and the southern peak. A sixth population is located at Sharp Park (a map of these locations is available in the SFRPD office). In order to determine if new populations are emerging an annual survey of suitable habitat will be conducted. SFRPD personnel can conduct these surveys as part of their regular routine. The surveys will be conducted in the early spring during March to May. If the host species is located at a new site the site will be added to the SFRPD database as a potential site for the mission blue. Once a new site has been located it will be monitored annually for eggs and adults.

Population site conditions

At each location where mission blue butterflies are known to occur the following procedures will be conducted approximately every two weeks in the early spring (March-May).

1. Measure the air temperature with a thermometer.
2. Record the general weather conditions.

Egg surveys

1. Randomly select 50 plants in each population.
2. Count the number of plants with eggs and record the number
3. Make a visual determination if eggs are hatched or un-hatched (un-hatched eggs will be milky-white in color).
4. Count the number of eggs occurring on each host plant that has eggs.
5. Record the information for each population on the data sheet.

Adult surveys

1. For a period of one hour walk slowly through the population area. For best results walk in a crisscross pattern to cover as much territory as possible.
2. Record the number of male and female butterflies: Male mission blues are pale silvery-blue with dark margins on top. Females are brown above, often with blue highlighting near wing bases, and dark margins. Below, both sexes are pale gray or silvery with variable black spots.
3. Observe each individual adult and record how many individuals of each gender are observed in the following behaviors: flying, mating, courting, male-male interaction, resting on ground, resting on vegetation.
4. Record a total for each gender.
5. Record a total for all adults.

Mission Blue Butterfly Data Sheet (*Page 1*)

Date:__________________Observers:____

Weather Conditions (circle one):

Site										
Begin time										
End time										
Air temp										
Weather conditions (circle one)	**Clear Overcast Rain Partly Cloudy Mostly Cloudy**		**Clear Overcast Rain Partly Cloudy Mostly Cloudy**		**Clear Overcast Rain Partly Cloudy Mostly Cloudy**		**Clear Overcast Rain Partly Cloudy Mostly Cloudy**		**Clear Overcast Rain Partly Cloudy Mostly Cloudy**	
Egg survey										
# of host plants with eggs										
Condition of eggs	**Hatched Unhatched (white)**		**Hatched Unhatched (white)**		**Hatched Unhatched (white)**		**Hatched Unhatched (white)**		**Hatched Unhatched (white)**	
Number of eggs/plant	**Use table on back of sheet**									
Adult survey	male	female	male	female	male	female	male	female	male	female
Flying										
Mating										
Courting										
Male-Male Int.										
Rest on Ground										
Rest on Veget.										
Subtotal										
Total										

Mission Blue Butterfly Data Sheet Date:__________ (page 2)

Site							
Eggs per plant							
host 1							
host 2							
host 3							
host 4							
host 5							
host 6							
host 7							
host 8							
host 9							
host 10							
host 11							
host 12							
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host 40							

APPENDIX I-3: PROTOCOL FOR MONITORING PLANT COMMUNITIES

This protocol was developed to provide a simple repeatable method for data collection that can be applied to management areas in the Natural Areas where native vegetation is being restored. The data collected with this method will provide general information regarding the composition and distribution of vegetation on each site. 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 exotic species.

MONITORING PROCEDURE

Sampling will be conducted prior to restoration, and repeated at regular intervals on all restoration sites. Population estimates need not be conducted for the extent of the 20-year lifespan of the Plan. Annual herbaceous species will be counted for 3 to 5 years or until a population trend is evident. Perennial herbaceous species will be counted every other year until a population trend is evident. If the perennial herbaceous species population trend is stable or increasing, then a census will be conducted once every 3 or 5 years. If the perennial herbaceous species' populations are decreasing, a census will be conducted every year. Sampling will occur between May and July in order to include the greatest number of flowering plants. Qualified field technicians should conduct all field sampling. Vegetation cover and composition will be estimated using a system of randomly located, nested quadrats. Data from each site will be recorded in a Microsoft® Excel spreadsheet. Results will be used to compare native and non-native richness, cover and importance value over time. The following steps will be conducted to insure accurate and comparable data:

I. Determining the number of samples

II. Using extended 900-square-foot quadrats

III. Randomizing quadrats within the study area

IV. Preparing for sampling

V. Locating quadrats within the study area

VI. Point intercept sampling

VII. Data recording

VIII. Data analysis

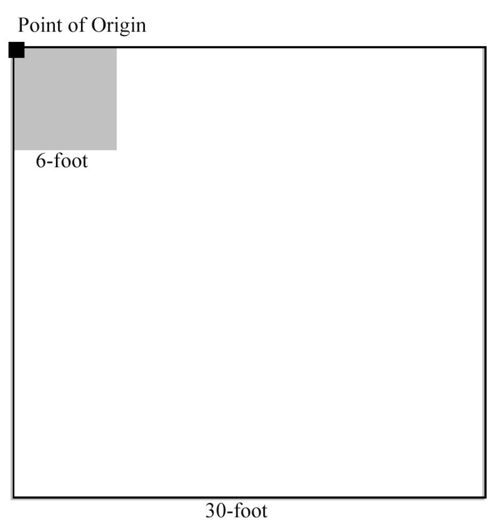
I. DETERMINING THE NUMBER OF SAMPLES

Project managers will determine the location and area of each project to be monitored. A digital map of the project areas will be used to determine the project area. On each site a minimum of 1 percent of each study area will be sampled. The species-area curve method described by Barbour et al. (1987) was used to determine quadrat size for sampling vegetation, resulting in a 6-by-6-foot quadrat.[1] This quadrat size will be applied at all study sites. A higher sampling density can be used at the discretion of the project manager.

II. USING EXTENDED 30-BY-30-FOOT QUADRATS

A 300-square-foot quadrat is used in instances where mature live trees are present within 30 feet of the point of origin. The point of origin for each quadrat is defined as the northwest corner. For purposes of this monitoring protocol, mature trees are defined as any woody plant with a single stem emerging from the soil of greater than 4 inches in basal diameter. This plot is used in addition to, not instead of, the 6-by-6-foot quadrat. The 300-square-foot quadrat is installed by extending the arms of the original quadrat an additional 24 feet on each side to create a 30-by-30-foot plot. On study sites where trees are present care must be taken not to overlap 300-foot quadrats. The placement of both quadrats results in a nested quadrat design (Figure 1).

Figure 1. Nested quadrat design



III. RANDOMIZING SAMPLE POINTS WITHIN THE STUDY AREA

Sample points can be randomized by placing a grid over an aerial photo or map of the study area, numbering each grid and then generating random numbers to determine the sample quadrat locations. Use either a GPS unit or a compass and measuring tapes to locate the quadrats in the

1 In the event that a study of grassland systems is desired, a 1.5-foot by 1.5-foot plot size will be used with 25 intercept points.

field. Sample points can also be randomized using the AlaskaPak extension of ArcView 3.1. Buffer zone and restoration shape files are selected as active themes. The number of sample quadrat locations desired is entered. The program automatically locates random sample points on the Arcview map, and provides California Zone-3 State Plane Coordinates (SPC). For every year of sampling, points should be re-randomized using the identical procedure.

IV. PREPARING FOR SAMPLING

Prior to sampling, field crews should check to see that they have all the equipment and expertise necessary to carry out the tasks in an efficient manner. In addition to the equipment listed below, crewmembers should be certain that they have adequate protective clothing. Poison oak (*Toxicodendron diversilobum*) is a common plant throughout the region, and it can be best avoided by covering the skin.

List of Field Equipment

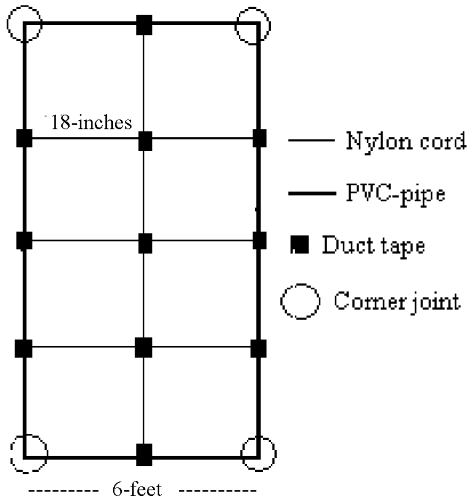
- 3-by-6-foot quadrat frame (see instructions below for assembly)
- Spherical densiometer
- 30-foot measuring tape
- Diameter tape
- GPS unit or compass
- Data sheets
- Site map
- Pencils, pens
- Plastic bags for samples of unknown species
- Plant identification materials (books and lists)

In order to sample efficiently a sample frame is used. The frame is used to sample half of each 6-by-6-foot quadrat. After the first half of the quadrat is sampled the frame is flipped over to sample the second half of the quadrat resulting in a total of 25 sample points per quadrat. A point is taken at the corner of each square in the quadrat. This compact design makes transportation of the frame from quadrat to quadrat much easier. Check to see if the appropriate frame is available; if not, use the following procedure to construct a new one.

Procedure for constructing 1-meter x 2-meter quadrat frame

1. Materials: 2 (6-foot PVC pipes), 2 (6-foot PVC pipes), 4 (PVC corner joints), PVC joint cement, 6-meters of nylon cord, duct tape.
2. Connect PVC pipes to corner with PVC joint cement to create a 3-foot-by-6-foot rectangle.
3. Attach nylon cord to PVC-pipe at 6-inch intervals. Nylon cord should first be tied, then fixed to PVC-pipe with duct tape. Intersections of nylon cord should also be reinforced with duct tape (Figure 2).

Figure 2. Quadrat frame diagram



V. LOCATING QUADRATS WITHIN THE STUDY AREA

In order to locate quadrats within each study area, the California Zone-3 State Plane Coordinates (SPC) for each sample quadrat are uploaded or typed into a GPS unit. The GPS unit is carried into the field and set to locate a point. When the GPS unit indicates that the point has been located, sampling can begin.

Acquiring California Zone-3 State Plane Coordinates (SPC) for quadrats

1. Select the Theme representing quadrats
2. Click "AlaskaPak" on the menu, and go to Add XY Attributes. This provide the California Zone-3 State Plane Coordinates (SPC) for the quadrats created.
3. To view the coordinates, open the theme table by clicking "Open Theme Table" on the tool bar.

The point of origin for each quadrat is set as the northwest corner. Canopy cover is measured at the point of origin with a spherical densiometer on each quadrat. The field sampling includes a nested quadrat. A 6-by-6-foot quadrat was used for herbaceous and shrub species. The point intercept method (Grieg-Smith 1983) is used for this quadrat. A larger 30-by-30-foot quadrat is used if trees were present within 10 meters of the point of origin.

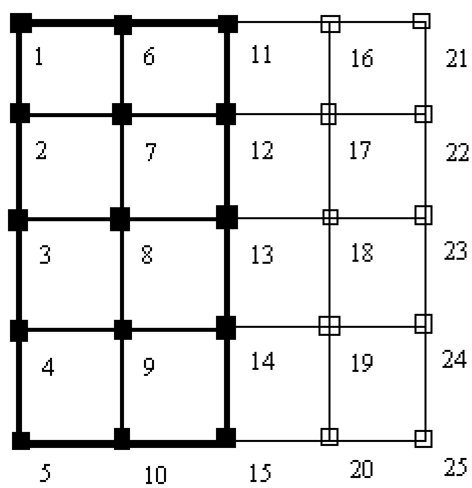
VI. POINT INTERCEPT SAMPLING

The point intercept method will be used within each quadrat to collect data on vegetation composition and cover. This method gives consistent results and does not require the same level of training as ocular estimates of percent cover. A horizontal grid of nylon cord, with 25 points, is included in each 6-by-6-foot sample quadrat (Figure 3). A vertical line is extended from each point on the grid using a straight narrow stick. The first, and only the first, object that the line intercepts is recorded. Otherwise the point is categorized as impervious ground (pavement, cement, etc.), bare ground (soil), or duff (litter). If an individual plant is hit under multiple grid points, it is recorded each time. The occurrence of tall herbs and shrubs requires that the quadrat frame be elevated from the ground. No effort should be made to compress the frame downward. The frame should be placed on top of the shrub mat, and sampling should proceed. In some instances adding legs to the PVC frame may be helpful.

For each quadrat tree canopy cover will be estimated using a spherical densiometer at the point of origin. In addition, if mature trees are present on the site a 30-by-30-foot quadrat is used in addition to the smaller quadrat. The species and diameter at base height (dbh) of each individual tree is measured with a calibrated diameter tape. For trees with multiple or branching stems, stems are recorded separately, then added together and treated as a unit with a single dbh.

Randomized sampling inevitably underestimates rare species (Barbour et al. 1987). Therefore, all plant species that are rooted within the quadrats, but were not hit by point intercept sampling, will be recorded as additional species.

Figure 3. Sample point locations using 6-by-6-foot sample frame.



VII. DATA RECORDING

Data collected in the field will be recorded on a field data sheet below. Point intercept data are recorded on the numbered rows. Species occurring within the plot frame that were not hit by points are recorded under the section titled "additional species". Data from the 30-by-30-foot plot are recorded at the bottom of the data sheet under the heading Trees (30-by-30-foot plot). Information from the data sheets will then be entered into a Microsoft Excel® spreadsheet. These data will be compiled over several years and used to analyze changes to native and non-native cover and diversity. Project managers will conduct analysis of data with support from qualified natural resource staff.

VIII. DATA ANALYSIS

The variables used for analysis will depend on the specific restoration goals of each site to be set by the project manager. For the most basic analysis, it is suggest to use species richness and cover. Richness and cover will be divided into native and exotic species classes so that changes to the native to exotic ratio for both of the measures can be tracked over time. The Shannon Diversity Index is suggested as a method for managers who would like to perform a more detailed analysis of diversity for their site. Calculation of frequency can be a useful tool for tracking individual species. Tree canopy cover and basal area are used only if mature trees occur on or near the site. All of the measures listed above will be calculated on an annual basis and eventually analyzed in regard to change over time using statistical regression analysis.

Calculating sample variables

Species Richness

Species richness will be calculated in two ways. First, a species list will be created for the entire site. This list will include all species recorded through the point intercept method and all species recorded as additional species. The total number of species on this list is the sampled species richness for the site.

The second method of calculating species richness will require a calculation of the number of species for each individual sample quadrat. The mean richness will then be taken from the sum of the richness from all sample plots giving mean richness per plot. See formula below:

$$\text{Mean Richness} = \frac{(sr^1+sr^2+\ldots sr^n)}{n}$$

Where: sr = species richness
n = number of sample quadrats

Cover

Percent cover is calculated by multiplying by four the number of hits for a particular species, species type (native or exotic), or cover versus bare ground within a single quadrat. The number of points within the quadrat was set at 25 to make this simple calculation to percent possible. Once cover has been calculated for each quadrat the mean cover is calculated in the manner described for species richness:

$$\text{Cover} = \frac{(cov^1+cov^2+\ldots cov^n)}{n}$$

Where: cov = percent cover
n = number of sample quadrats

Diversity

The Shannon Diversity Index will be used to describe the overall diversity of each site. This index includes both species richness and species evenness (or distribution) in a single metric (Pielou 1975). In order to calculate this index the proportion of individuals (p*i*) of the total sample belonging to each species must be calculated. Because percent cover is used as part of the calculations only species recorded through point intercept sampling will be used. P*i* is calculated as follows:

$$pi = cov^{i}/sr$$

Where: cov^{i} = The relative cover of each species found on the plot.
sr = the number of species on the quadrat.

The Shannon Diversity Index is calculated as follows:

$$\text{Shannon Diversity} = \sum_{i=1}^{sr} (pi)(ln\,pi)$$

Where: sr = species richness
p*i* = the proportion of individuals of the total sample belonging to the *i*th species

Frequency

Frequency is a simple measure of the relative occurrence of individual species and is calculated as follows:

$$\text{Frequency} = \frac{\text{number quadrats with species}^{i}}{\text{total quadrats sampled}}$$

Tree Canopy Cover

Mean tree canopy cover is calculated for sites where mature trees occur on or near the site. The measure is calculated as follows:

$$\text{Canopy Cover} = \frac{(cc^{1}+cc^{2}+\ldots cc^{n})}{n}$$

Where: cc = percent canopy cover
n = number of sample quadrats

Basal Area

Basal area is calculated when mature trees are found on site. Basal area and mean basal area will be calculated for individual tree species, and for all species combined as follows:

$$\text{Basal area} = (d/2)^{2}$$

Basal area/acre = total basal area/acres sampled

Where: d = diameter

$$\text{Mean basal Area} = \frac{(ba^1+ba^2+\ldots ba^n)}{n}$$

Where: ba = basal area for each species
n = number of sample quadrats

Native/Invasive Ratio

A native versus invasive ratio can be calculated for any of the variables listed above by splitting the data set into these categories and then dividing the native portion by the exotic portion. This ratio offers a compact variable that can be used to analyze progress toward management goals directly. The example below uses native and invasive cover.

$$\text{Native/Exotic Cover Ratio} = \frac{cov^{nat}}{cov^{ex}}$$

Where: cov^{nat} = cover of native species
cov^{ex} = cover of exotic species

Statistical analysis

The project manager should consult with a trained statistician prior to attempting the statistical analysis portion of this protocol. The data collected with this protocol will be used to analyze changes in species composition and distribution over time. General linear models, such as the models fitted by Regression Analysis or Analysis of Variance, are commonly used methods for this type of analysis. Data collection will occur on an annual basis for each site resulting in a continuous independent time variable measured in years. Calculations of dependent variables used for analysis are described in the previous section. In order to use regression as an analysis tool several assumptions must be met. Project managers should consult with a trained statistician if they have questions about these assumptions in regard to their data. To fit standard general linear models, all variables must be continuous and independent. In addition, the dependent variable must tend toward a normal distribution, and the variance of the dependent variable at each level of the independent variables must be constant across all levels of the independent variables. If these assumptions are not met, other methods for detecting change can be considered. For example, discrete variables, or variables that are not continuous, can be analyzed using log-linear models. Data that are not independent can be modeled using repeated measures models. And data that violate normality or constant variance assumptions can sometimes be transformed into a more suitable variable for analysis. Statistical tests yielding a p-value 0.05 will be considered significant. Specific instructions for performing the analysis will not be given in this protocol, as they are dependent on the statistical software being used.

CONCLUSIONS

These plant monitoring protocols have been designed as data collection tools that can easily be employed by field technicians. The data will be used to test the success of management objectives of increasing native diversity and cover, and reducing exotic diversity and cover, in restored areas. In order to test these goals effectively, data must be collected prior to the restoration on all restoration sites. In addition, these sampling methods need to be implemented in an identical manner following restoration so that baseline data will be available for comparison to future conditions. With these data, it will be possible to compare trends from year to year on individual sites. This protocol is not intended to address the project goals specific to every individual site, but rather to create a system whereby all sites will be sampled in the same manner so that a comparable dataset will be created for all of the Natural Areas. In some cases, depending on the goals for the site, additional monitoring procedures may be warranted. In such cases, these additional procedures should be implemented in addition to, not instead of, the procedures outlined in this document.

Field Data Sheet

Vegetation Data Sheet

Site: **Date:** **Crew:**

	Sample #		Sample #		Sample #
1		1		1	
2		2		2	
3		3		3	
4		4		4	
5		5		5	
6		6		6	
7		7		7	
8		8		8	
9		9		9	
10		10		10	
11		11		11	
12		12		12	
13		13		13	
14		14		14	
15		15		15	
16		16		16	
17		17		17	
18		18		18	
19		19		19	
20		20		20	
21		21		21	
22		22		22	
23		23		23	
24		24		24	
25		25		25	
	Additional species		**Additional species**		**Additional species**
	Canopy cover		**Canopy cover**		**Canopy cover**
	Trees (30-by-30-foot)		**Trees (30-by-30-foot plot)**		**Trees (30-by-30-foot plot)**
	species		**species**		**species**
	dbh		**dbh**		**dbh**
	species		**species**		**species**
	dbh		**dbh**		**dbh**
	species		**species**		**species**
	dbh		**dbh**		**dbh**