Standard Operating Procedures (3.5): Vegetation Mapping

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Standard Operating Procedures: Vegetation Mapping

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Protocol Suitability Evaluation

A habitat suitability table containing appropriate habitat types (of those evaluated) to implement the vegetation mapping protocol is displayed in Table 1. While tidal channel and mudflat habitats are often unvegetated, their delineated areas can still be incorporated at a habitat-level based on elevation and hydrology characteristics. This protocol is appropriate in any habitat type. A comparative assessment of cost, effort, and data quality are shown in Table 2. A matrix of additional detailed categorical evaluations of the vegetation mapping survey protocol can be found in Appendix 3.5A.

Table 1. Appropriate habitat types to implement vegetation mapping survey protocols.

	Habitat Types					
Survey Protocol	**Tidal Channel**	**Mud/sand flat**	**Emergent salt marsh**	**Non-tidal salt marsh**	**Salt pan**	**'Degraded' / fill**
Vegetation Mapping	X	X	X	X	X	X

Table 2. Categorical assessment of cost/effort and data quality for vegetation mapping survey protocols.

	Evaluation Metric	**Vegetation Mapping**	**Notes**
Time / Effort	Office Preparation Time	> 60 minutes	Heads-up digitizing for field verification
	Equipment Construction Time (one time)	Not Applicable	----
	Field Time	Multiple days	Dependent on the complexity and size of the site
	Laboratory Time (per transect)	Not Applicable	----
	Post-Survey Processing / QAQC Time	> 60 minutes	Digitizing maps; very time-intensive, depending on the complexity and size of the site; multiple office days
	Minimum Repetition (site-dependent)	Many Repetitions	Dependent on required level of resolution (more complex areas will require more polygons)
	Relative Cost (equipment and supplies)	> $100	Specialty digitizing software and a high-resolution GPS is required, and price is variable; see Appendix 3.5A
Survey / Data Quality	Accuracy (at a survey area level)	Low to High	Dependent on required level of resolution and survey effort
	Precision (at a survey area level)	Medium	Precision increases in survey areas with well-defined edges
	Qualitative-Quantitative Score	Qualitative and Quantitative	----
	Subjectivity-Objectivity Score	Subjective	Vegetation alliances and associations are partially based on percent cover estimates

Resulting Data Types

The application of the vegetation mapping survey protocol yields both qualitative and quantitative data displayed as vegetation alliance, association, and habitat category polygons for an entire site. Data visualization outputs in the form of polygons on a map are typically represented qualitatively in categories specified by the user; however, these data can be extracted for quantitative analyses (e.g., acres of individual species, percent cover of exotic vs. native, or acres of habitat type). Current Geographic Information Systems (GIS) such as ESRI ArcPro have functionality that allows users to perform a variety of quantitative analyses within the software and represent these data in maps (e.g., percent cover by species). These data can be a useful foundation for designing a habitat-based monitoring or restoration plan. Additionally, vegetation mapping data can help identify large-scale temporal vegetation changes to inform adaptive management for problematic or aggressive non-native species.

Objective

The composition and distribution of vegetation species across wetland habitats directly affects many ecosystem functions such as productivity, soil composition, and nitrogen and carbon exchange dynamics (Schwartz et al. 2000, Keer and Zedler 2002). Additionally, the presence and structure of various plant species may serve as a reliable indicator for several biological and physical conditions such as wildlife and invertebrate populations, soil characteristics, and hydrologic regimes (De Boer 1983). As the primary connection between physical factors and biological activity, vegetation responses to impacts and stressors over time and space have become an essential component to effective environmental management and conservation.

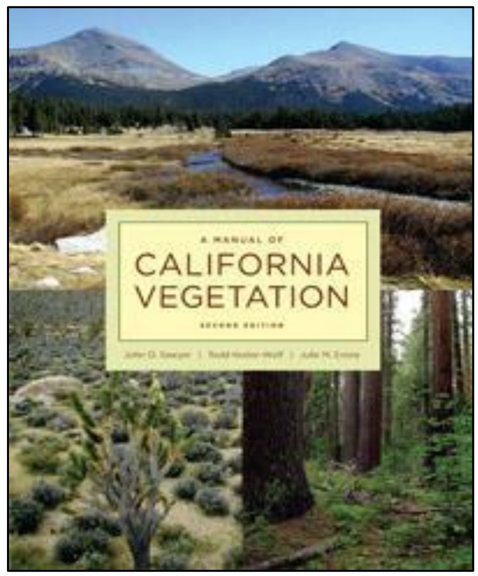

Figure 1. Cover of the *Manual of California Vegetation, 2nd ed.*

The development of high-resolution, standardized vegetation mapping methods by the California Department of Fish and Wildlife (CDFW) Vegetation Classification and Mapping Program (VegCAMP) (CDFW 2014) has increased the accuracy and comparability of vegetation maps across the state of California (https://wildlife.ca.gov/Data/VegCAMP). This SOP is based on the VegCAMP methodology and outlines a synthesized vegetation stand delineation strategy based on a combination of aerial imagery, office-based digitization in a mapping software program (e.g., ArcGIS, QGIS, Grass GIS), and *in situ* field verification. Vegetation mapping methods employ "A Manual of California Vegetation Second Edition" (Sawyer et al., 2009; ISBN 978-0-943460-49-9) (Figure 1) as the standard for classification and delineation of most native and many non-native vegetation alliances and associations based on the presence and relative cover of co-dominant species. An updated version of the Manual can also be found through the California Native Plant Society online at: https://vegetation.cnps.org/. Vegetation communities may be further grouped into distinct habitat categories to allow for broader analyses of condition and function. In the case of unique or transitional communities not currently recognized by Sawyer et al. (2009), or where no single species is dominant, the methodology can be used to designate new community alliances.

As a general note, vegetation mapping is a very time- and labor-intensive survey but yields a robust foundational product capable of informing monitoring plans, small- or large-scale restoration designs, habitat assessments, wetland delineations, and special status species surveys. Survey durations may range from a few days to crossing several years, depending on the size of the mapped area and the level of resolution desired. When determining the level of resolution desired to implement the vegetation mapping SOP, considerations like monitoring objectives, extent of site, resources available, and/or other supplementary protocols used (i.e., vegetation transect cover) are among examples that should be considered. In particular, resolution and effort will vary based on monitoring goals and objectives. This SOP assumes the user has an informed background in GIS, global positioning systems (GPS), and vegetation identification and surveying; therefore, it is recommended for individuals to attend preparatory classes or workshops before attempting to implement this protocol. A course offered by the California Native Plant Society (CNPS) is recommended (http://www.cnps.org/cnps/vegetation/workshops.php).

Equipment

Equipment and supplies needed for this survey include:

1. High resolution aerial imagery (Figure 2). Recently, higher resolution aerial image capture services utilizing drones (e.g., Airphrame) have become more cost efficient and can dramatically shorten survey time/effort. See *Helpful Hint* below.
2. Geographic information system software (e.g., ArcGIS / ArcPro, QGIS, Grass GIS, others)
3. CNPS Relevé and Rapid Assessment Protocols and Datasheets (Appendix 3.5B)
4. GPS or GPS enabled field tablet (mapping grade preferred) with metadata collection functionality or smart forms (e.g., Trimble Terra Sync, Trimble connect, Survey 123, etc.)
5. Camera with GPS capability. On smartphones, the Solocator app is an affordable alternative to GPS-capable camera.
6. “A Manual of California Vegetation” (Sawyer et al., 2009) (MCV)
7. Additional vegetation references [e.g., “Jepson Manual”, “Terrestrial Vegetation of California” (bringing books into the field is optional, but they are recommended office references)]
8. Pre-existing knowledge of local plant species and vegetation cover surveys
9. Additional site-specific background maps [e.g., soils, past vegetation, inundation, elevation, surrounding land use (recommended)]
10. Printed spreadsheet of polygon and attributes (optional) (Example in Appendix 3.5C)

Helpful Hint: High resolution aerial imagery (e.g., ESRI World Imagery, Google maps, and Bing maps) may be sufficient depending on project scope and GIS software. NOAA Coastal Imagery, drone collected imagery, and/or City/County Imagery, if available, may provide higher resolution aerial imagery in some circumstances. When conducting multiple surveys over time for the same area, it is recommended to use aerial imagery from the same source or ensure that the datum and projection of the datasets are comparable.

Helpful Hint: Many mapping software options are available, including, but not limited to pay options (e.g., ArcGIS Pro) and open source options (e.g., QGIS, Grass GIS, others).

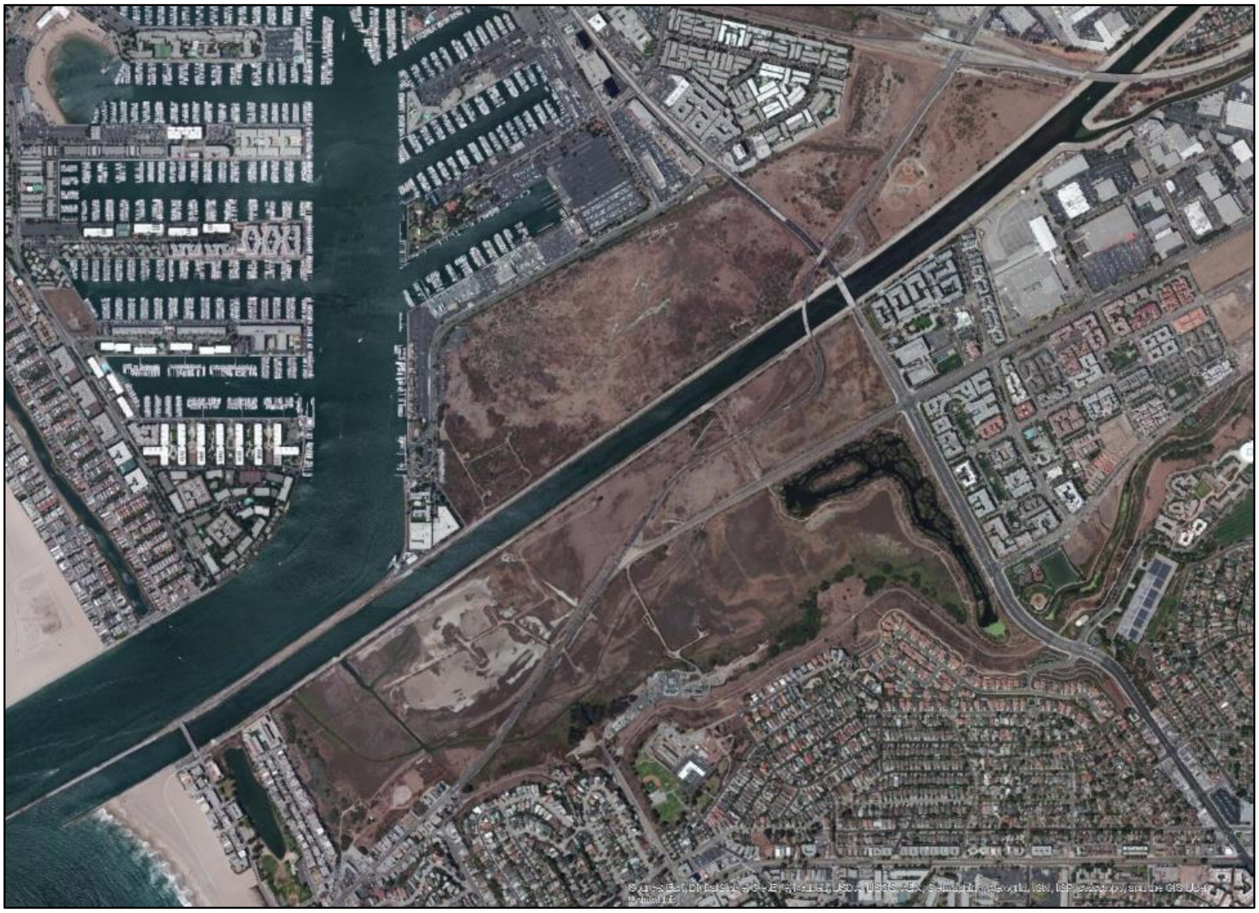

Figure 2. High resolution image of the Ballona Wetlands Ecological Reserve, Los Angeles, CA (credit: ESRI).

Field Preparation

Initial office preparation should include the creation of a geodatabase in a projected coordinate system equipped with a non-overlapping, gapless polygon topology. Multiple tools in ESRI ArcGIS and ArcGIS Pro allow for streamlining and automating topology processes. The database should be developed with an attribute table listing all desired attributes to be recorded for each vegetation stand. Required attributes should include vegetation name (alliance or association according to MCV Volume 2), a unique identification number, and estimates of percent cover ranges for general vegetation parameters which may include total vegetated cover, native cover, nonnative cover, tree cover, shrub cover, and herb cover (Figure 3). Other attributes may be collected on a project dependent basis including estimated cover of specific plant species, hydrology, impacts, soil type, and/or land use.

Table

2013_TBF_ELEV_Matching

FID	VEGNAME	HABTYPE	HEIGHT	SHRUBCOV	HERBCOV	NATIVE	NON_NATIVE	BAREGROUND
0	Salix lasiolepsis alliance	Riparian Scrub and Woodland	3	0	3	5	3	0
1	Cortaderia selloana stand	Pampas Grass	2	0	5	0	5	0

Figure 3. Example of attribute table showing general vegetation parameters quantified into cover classes.

Prior to preliminary field investigations, all aerial images should be reviewed in depth, and vegetation stands with distinct aerial signatures digitized in GIS for field verification and classification (Figure 4). Variations between aerial signatures should be evaluated against multiple criteria including photo attributes such as color, texture, shadows, shape, uniformity, and local site characteristics such as surrounding vegetation, elevation, soil type, and hydrology. Additional site-specific characteristics may also be helpful in discerning differences between vegetation stands. Digital elevation models or other topographic maps may be useful to cross-reference. Depending on project scope, available resources, accessibility, and property size, it may be necessary to assign polygon attributes remotely with selective field validation or *in situ* attribute data collection, but it is recommended to collect on-site data whenever possible. Following office review, maps for each digitized area should either be printed with a supplementary spreadsheet (Appendices 3.5C and D) listing all polygons and attributes for field data collection, or maps should be loaded as a data file into a GPS with data dictionary capabilities. It may also be beneficial to load the digitized map as a background image into the GPS unit to aid with orientation. An increasingly popular alternative to a standard GPS unit is a field-rugged tablet with GPS enabled, or even a standard smartphone with a camera application. Digital maps and backgrounds can be transferred using software tools on most GPS data collection devices.

Figure 4. Example of an aerial image before (A) and after digitization (B).

Equipment described above should be collected prior to the field shift. Batteries for all electronic devices should be checked and recharged as needed, and relevant data sheets should be printed and attached to the clipboards.

Helpful Hint: External power supplies and/or extra fully-charged batteries can extend battery life in the field. Enabling GPS, especially on multi-function devices or smart phones, can quickly drain battery life.

Field Methods

The field verification methods of the vegetation mapping process are designed to provide attribute data for individual vegetation stands, identify the borders of remotely indiscernible vegetation alliances, collect any required species-specific data, and generally validate the accuracy of mapping efforts. Accurate vegetation cover data collected *in situ* are essential to properly classify vegetation alliances and associations in accordance with MCV standards. Depending on the project, there are a range of options for gathering the diversity of plant cover data within vegetation stands which vary in level of detail and time required; however, most mapping projects should use a combination of methods for highest quality results. Vegetation cover assessment method options are listed below in order from the least detailed and most rapid to the most detailed, requiring the greatest time investment. In all methods, geotagged photos should be collected as often as possible to provide an additional reference source for map updates. See Table 3 for a categorical comparison of each method.

Table 3. Comparison of vegetation sampling methods to quantify attribute data for vegetation polygons.

Survey Type	Time / Labor Requirement	Observer Effect / Margin of Error	Data Resolution	Experience Required
Visual Percent Cover Estimates	Low	Diverse Stands: High Monospecific Stands: Low	Low	Low
CNPS / DFW Relevé and Rapid Assessments	Moderate	Moderate	Moderate	Moderate
Level 3 Vegetation Surveys	High	Low	High	Moderate

1. **Visual Percent Cover Estimates** – This method consists of rapid, walk through cover-class estimates for each vegetation attribute (e.g., total cover, percent non-native) of an entire vegetation stand. Unless a project has a large budget and requires an extremely high level of accuracy, the attribute data for most stands should be collected using this method to minimize costs and time required. Visual estimates should be entered either into Appendix 3.5C or the GPS data dictionary.

   Due to the highly subjective nature of this method, its use is not recommended without extensive experience calibrating estimating abilities with more detailed methods (e.g., vegetation cover surveys, see SOP 3.2). It is also important to conduct calibration exercises with all field team members to minimize observer error. See Daubenmire 1959 for basic outline regarding techniques to estimate vegetative cover.

2. **CNPS / DFW Relevé and Rapid Assessment Surveys** – These methods are most useful when the cover of a stand is ambiguous, or finer scale detail and higher quality is desired or required for a particular area. For large areas when it is infeasible to visit the entire site, it may be beneficial to identify the most common, distinct, or characteristic vegetation signatures and perform a more formal survey of the stand's vegetative cover. Additionally, if available resources have limited the majority of the mapping effort to office digitization and remote estimates, it may be necessary to validate estimates with more detailed assessments of some vegetation stands. In general, the Relevé surveys are plot-based as opposed to being based on the entire stand (Rapid Assessment Surveys) and may be simpler for larger vegetation stands. Detailed protocols and datasheets for each survey are found in Appendix 3.5B or through the following link: https://wildlife.ca.gov/Data/VegCAMP/Publications-And-Protocols. Additional information on Relevé and Rapid Assessment Survey workshops and trainings can be found at this link: http://www.cnps.org/cnps/vegetation/workshops.php.

3. **Level 3 Vegetation SOP surveys** – While a vegetation map may provide a site-wide snapshot of the major vegetation alliances, many site-intensive monitoring programs also incorporate quantitative fine scale vegetation surveys. SOP 3.2 – Vegetation Cover Surveys – describes each of the vegetation cover surveys in detail. These surveys are the most time intensive but yield the highest quality data and may be helpful when used in conjunction with classifying vegetation alliances. Typically, unless required for independent vegetation monitoring purposes, the higher-intensity monitoring protocols are not used for vegetation mapping as they are too resource intensive. Additional field methods include the delineation of remotely indistinct or difficult to discern vegetation stands (Figure 5). Some stands or species may be very similar in appearance within an aerial image, especially if the image is taken outside of the growing season for the species; therefore, it is necessary to verify the boundary in the field. This process is achieved by simply walking the boundary between vegetation stands with a GPS and incorporating the track into the vegetation map via GIS. Additionally, advanced aerial image analysts may be able to distinguish differences in vegetation communities based on the presence of the C3, C4, and CAM photosynthesis in infrared images. For more obvious transitions, polygon transitions may be hand drawn onto the field map, attribute data recorded in Appendix 3.5C, and subsequently transcribed into GIS. Areas dominated by herbaceous and/or annual species may require field verification over multiple seasons or years.

Figure 5. Example of vegetation stands with indistinct or difficult aerial signatures (A) and the delineation resulting from walking transition boundaries (B).

Laboratory Methods

Not Applicable.

Data Entry and QAQC Procedures

Data should be entered in the field using the appropriate data sheet (Appendix 3.5C) or GPS data dictionary. All required fields should be completed in full, and the data recorder should assign their name at the top of the document or in file name. Data should be uploaded, transcribed, and/or digitized into the appropriate geodatabase within 24 hours, and if applicable, the hard copies filed in labeled binders. It is also recommended to scan and store copies of raw data sheets electronically. Electronic copies of all data and digitized maps should be housed on an in-house dedicated server and backed up to a cloud-based or off-site server. Hard copies should be saved for five years. Electronic copies should be saved indefinitely.

Quality Assurance and Quality Control (QAQC) procedures should be conducted on all data. QAQC procedures should be conducted by the QA Officer and include a thorough review of all entries, double checking of all formulas or macros, and a confirmation that all data sheets, and field notes are filed appropriately with electronic back-up copies available. QAQC should verify that the entered data match the hard copies of the field data sheets. Any discrepancies should be corrected, and the initial data entry technician notified.

Additional QAQC for remote-attributed vegetation stands should involve *in situ* verification of vegetation classification utilizing either the Relevé or Rapid Assessment Survey methodologies. Target accuracies for remote attributed data should be 80% or greater. Data not meeting these standards should be re-assessed until the minimum accuracy threshold is met and the GIS and field technician notified.

Data Analyses

After data have been entered, corrections made, and QAQC procedures completed, final vegetation maps may be used independently in multiple analyses or as a base for management and conservation decisions. Some basic analyses include tables identifying acreage by nativity, habitat, or alliance / association by area, then exporting maps of habitat types within a site and the associated table listing the area by habitat type (e.g., Figure 6). More complex analyses assessing temporal variations are possible if vegetation has been mapped for multiple years including maps comparing habitat change by location over time, maps tracking the invasion of non-native species over time (e.g., Figure 7), and graphs showing change in acreage by habitat (e.g., Figure 8) or by vegetation species. However, the applications for vegetation map data are far reaching and include the identification of locations for rare plant conservation, alliances which support special status wildlife, habitat modeling to predict special status species populations, disease probability maps, climate change response scenarios, and the identification of high priority conservation areas (CDFW 2014).

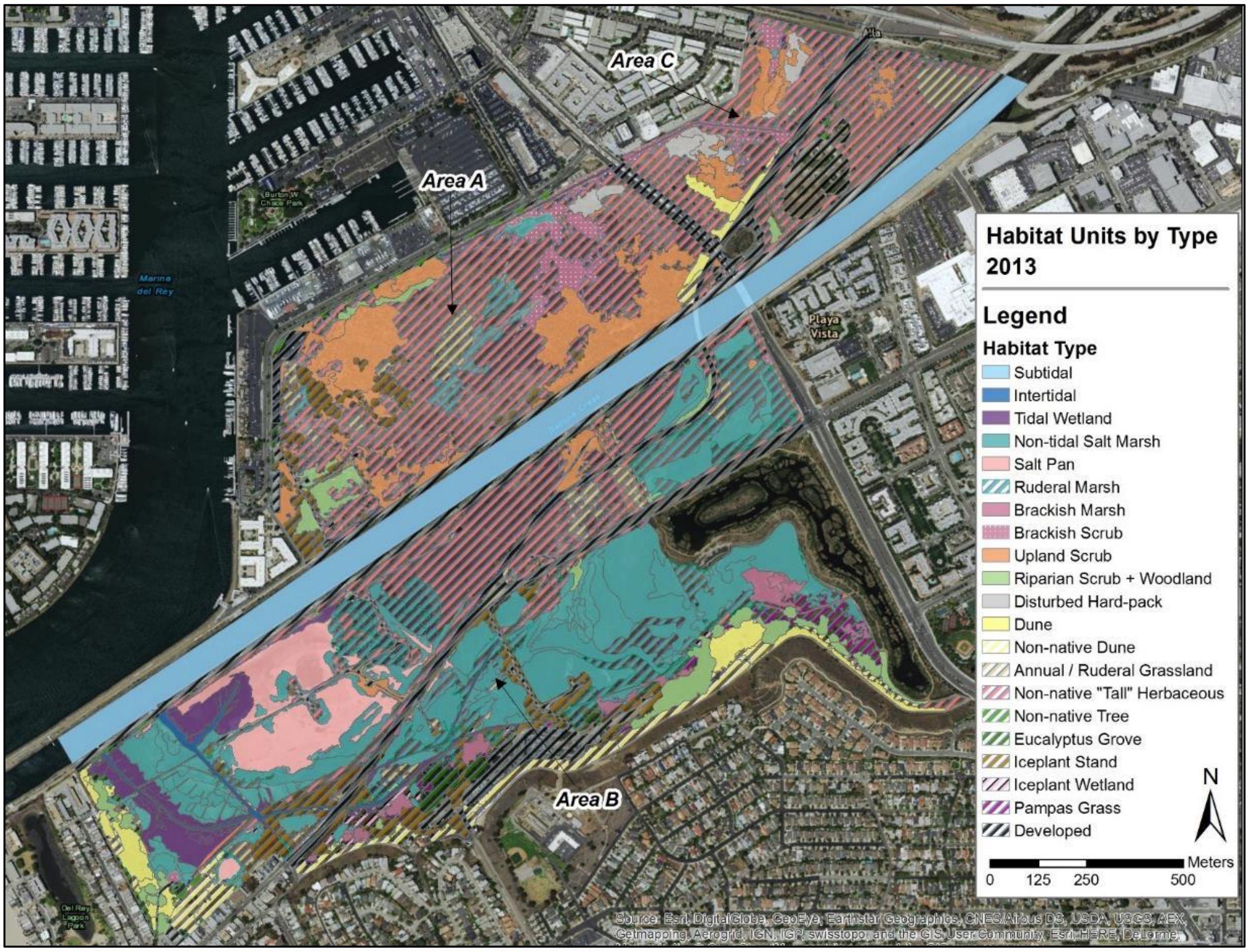

Figure 6. Habitat map (2013) of the Ballona Wetlands Ecological Reserve (replicated from Johnston et al. 2015).

Figure 7. Map depicting *Brassica nigra* change over time (replicated from Johnston et al. 2015).

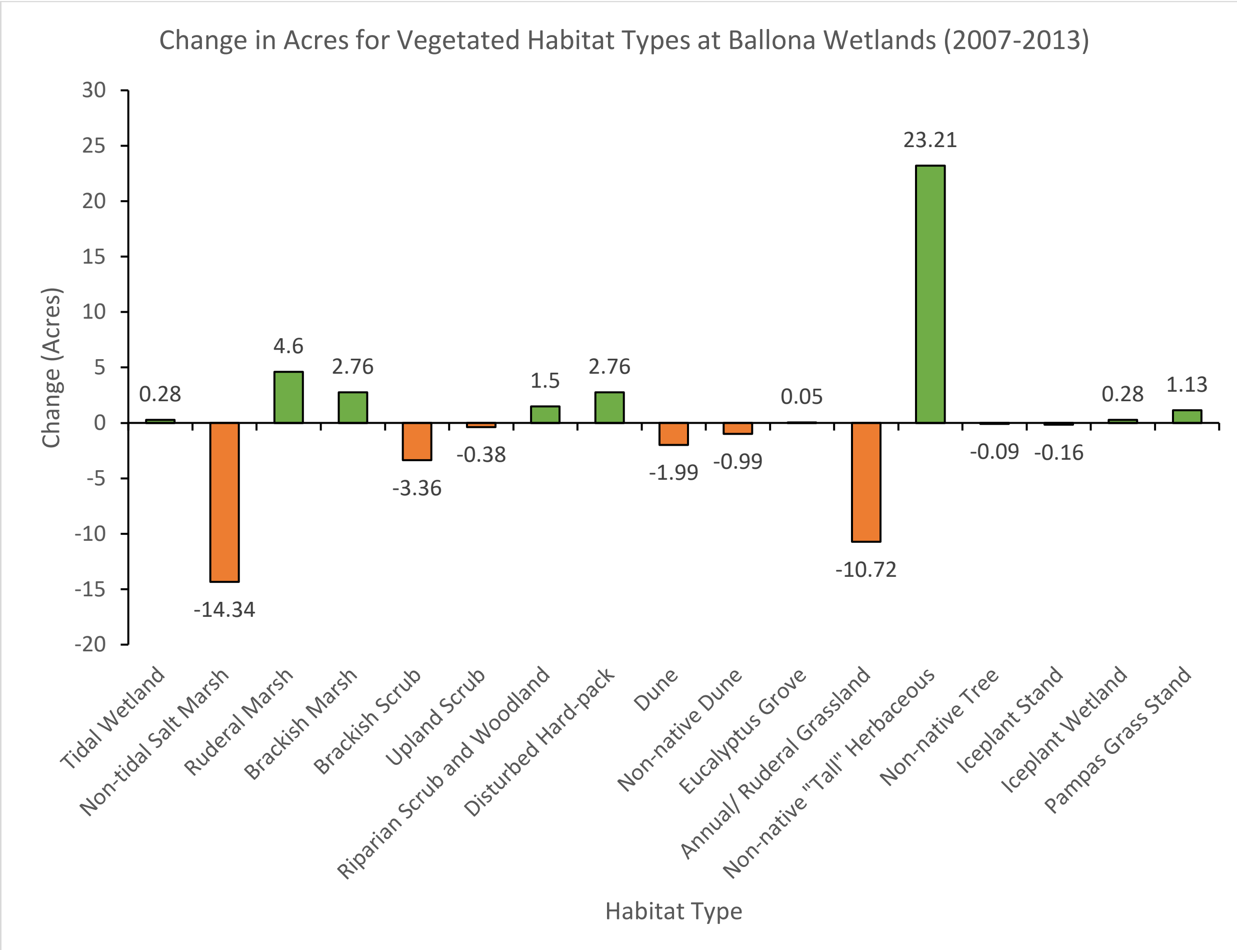

Figure 8. Chart displaying the habitat change in acres between 2007 and 2013 in the Ballona Wetlands Ecological Reserve (replicated from Johnston et al. 2015).

Health and Safety Precautions

Field team members should exercise caution in addition to standard field safety protocols when conducting surveys in remote study areas or those not frequently accessed. Considerations such as difficulty accessing the survey area, difficulty navigating in the survey area, and unhoused people should be made during field preparation.

Applicable Literature

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Jepson Flora Project. "Jepson Online Interchange for California Floristics." University and Jepson Herbaria, University of California, Berkeley. Accessed June 2014. http://ucjeps.berkeley.edu/interchange.html.

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Keer, G.H. and Zedler, J.B. 2002. "Salt Marsh Canopy Architecture Differs with the Number and Composition of Species." *Ecological Applications*. 12(2):456-473

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Contact Information

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APPENDIX 3.5A

	Evaluation Metric	Seed Bank	Notes
	Correlation to L2 CRAM	Attribute 4	----
Personnel Requirements	Specialty Equipment or Clothing Required	Few Specialty Items	Sub-meter GPS is recommended. Camera or smartphone application with GPS capabilities is also recommended.
	Ease of Transport (amount or weight of supplies)	Few Items / Easy	----
	Ease of Implementation	Difficult	----
	Expertise / Skill Level	High Technical Knowledge	Familiarity with species identifications and Geographic Information Systems software is required
	Number of Personnel	2	Multiple teams of people surveying different areas may reduce survey times
	Training Requirements	Specific Training recommended	Courses are offered through CNPS. Additional information may be found here: http://www.cnps.org/cnps/education/workshops/index.php
	Seasonality of Survey Time	early Fall	Peak of the growing season (will vary if habitats are not coastal wetland)
	Suggested Frequency	Every 5 years	Dependent on monitoring program objectives
Survey / Data Quality	Type of Output	Numerical and Non-numerical	Areas will be categorized into non-numerical vegetation categories but may be analyzed for numerical areas
	Active or Passive Monitoring Style	Passive	----
	Specialty Computer Software Required	Yes	GIS computer software (both pay and open source options available); GIS data collection software recommended (ESRI Survey123, Trimble TerraSync, Trimble Connect, etc.)
	Availability of Online / External Resources	Many resources	Resources are available mainly for the identification of vegetation alliance and association categories. Fewer methodological resources are available
Potential Limitations	Wetland Type Applicability	All	----
	Images or Multi-Media Required	Images Required	----
	Degree of Impact / Disturbance	Low Disturbance	----
	Vegetation Height Limitation	No Limitations	----
	Appropriate for Tidal / Wet Habitats	Yes	----
	Tide Height	Low Tide Only	Submersion of low-lying vegetation will reduce accuracy of cover estimates
	Regional or Broad Implementation *	Frequently Used	----
	Potential for Hazards / Risk	Low to No Risk	----
	Restrictions	Special Status Species	----

** based on monitoring literature review*

Appendix 3.5B
(CNPS 2007)

CALIFORNIA NATIVE PLANT SOCIETY RELEVÉ PROTOCOL
CNPS VEGETATION COMMITTEE
October 20, 2000 (Revised 8/23/2007)

Introduction

In *A Manual of California Vegetation* (Sawyer and Keeler-Wolf 1995), CNPS published a Vegetation Sampling Protocol that was developed as a simple quantitative sampling technique applicable to many vegetation types in California. Investigators use an ocular estimation technique called a relevé to classify and map large areas in a limited amount of time.

The relevé method of sampling vegetation was developed in Europe and was largely standardized by the Swiss ecologist Josias Braun-Blanquet. He helped classify much of Europe's vegetation, founded and directed a synecology center in France, and was editor of *Vegetatio* for many years. The relevé was, and is, a method used by many European ecologists, and others around the world. These ecologists refer to themselves as phytosociologists. The use of relevé in the United States has not been extensive with the exception of the US Forest Service.

The relevé is particularly useful when observers are trying to quickly classify the range of diversity of plant cover over large units of land. In general, it is faster than the point intercept technique. One would use this method when developing a classification that could be used to map of a large area of vegetation, for example. This method may also be more useful than the line intercept method when one is trying to validate the accuracy of mapping efforts.

The relevé is generally considered a "semiquantitative" method. It relies on ocular estimates of plant cover rather than on counts of the "hits" of a particular species along a transect line or on precise measurements of cover/biomass by planimetric or weighing techniques.

Selecting a stand to sample:

A stand is the basic physical unit of vegetation in a landscape. It has no set size. Some vegetation stands are very small, such as alpine meadow or tundra types, and some may be several square kilometers in size, such as desert or forest types. A stand is defined by two main unifying characteristics:

1) It has <u>compositional</u> integrity. Throughout the site the combination of species is similar. The stand is differentiated from adjacent stands by a discernable boundary that may be abrupt or indistinct, and
2) It has <u>structural</u> integrity. It has a similar history or environmental setting that affords relatively similar horizontal and vertical spacing of plant species throughout.
   For example, a hillside forest originally dominated by the same species that burned on the upper part of the slopes, but not the lower, would be divided into two stands. Likewise, a sparse woodland occupying a slope with very shallow rocky soils would be considered a different stand from an adjacent slope with deeper, moister soil and a denser woodland or forest of the same species.

Appendix 3.5B
(CNPS 2007)

The structural and compositional features of a stand are often combined into a term called homogeneity. For an area of vegetated ground to meet the requirements of a stand it must be homogeneous.

Stands to be sampled may be selected by assessment prior to a site visit (e.g. delineated from aerial photos or satellite images), or may be selected on site (during reconnaissance to determine extent and boundaries, location of other similar stands, etc.). Depending on the project goals, you may want to select just one or a few representative stands for sampling (e.g., for developing a classification for a vegetation mapping project), or you may want to sample all of them (e.g., to define a rare vegetation type and/or compare site quality between the few remaining stands).

Selecting a plot to sample within in a stand:

Because most stands are large, it is difficult to summarize the species composition, cover, and structure of an entire stand. We are also usually trying to capture the most information with the least amount of effort. Thus, we are typically forced to select a representative portion to sample.

When sampling a vegetation stand, the main point to remember is to select a sample that, in as many ways possible, is representative of that stand. This means that you are not randomly selecting a plot; on the contrary, you are actively using your own best judgement to find a representative example of the stand.

Selecting a plot requires that you see enough of the stand you are sampling to feel comfortable in choosing a representative plot location. Take a brief walk through the stand and look for variations in species composition and in stand structure. In many cases in hilly or mountainous terrain look for a vantage point from which you can get a representative view of the whole stand. Variations in vegetation that are repeated throughout the stand should be included in your plot. Once you assess the variation within the stand, attempt to find an area that captures the stand's common species composition and structural condition to sample.

Plot Size

All releves of the same type of vegetation to be analyzed in a study need to be the same size. It wouldn't be fair, for example, to compare a 100 m2 plot with a 1000 m2 plot as the difference in number of species may be due to the size of the plot, not a difference in the stands.

A minimal area to sample is defined by species/area relationships; as the sampler identifies species present in an area of homogeneous vegetation, the number will increase quickly as more area is surveyed. Plot shape and size are somewhat dependent on the type of vegetation under study. Therefore general guidelines for plot sizes of tree-, shrub-, and herb-dominated upland, and fine-scale herbaceous communities have been established. Sufficient work has been done in temperate vegetation to be confident the following conventions will capture species richness:

Alpine meadow and montane wet meadow: 100 sq. m
Herbaceous communities: 10 sq. m plot, 100 sq. m plot or 400 sq. m plot (Consult with CNPS, and use one consistent size)
Shrublands: 400 sq. m plot
Forest and woodland communities: 1000 sq. m plot
Open desert vegetation: 1000 sq. m plot

Appendix 3.5B
(CNPS 2007)

Plot Shape

A relevé has no fixed shape, plot shape should reflect the character of the stand. If the stand is about the same size as a relevé, you need to sample the entire stand. If we are sampling a desert wash, streamside riparian, or other linear community our plot dimensions should not go beyond the community's natural ecological boundaries. Thus, a relatively long, narrow plot capturing the vegetation within the stand, but not outside it would be appropriate. Species present along the edges of the plot that are clearly part of the adjacent stand should be excluded.

If we are sampling broad homogeneous stands, we would most likely choose a shape such as a circle (which has the advantage of the edges being equidistant to the center point) or a square (which can be quickly laid out using perpendicular tapes). If we are trying to capture a minor bit of variety in the understory of a forest, for example a bracken fern patch within a ponderosa pine stand, we would want both bracken and non-bracken understory. Thus, a rectangular shape would be appropriate.

GENERAL PLOT INFORMATION

The following items appear on each data sheet and are to be collected for all plots. Where indicated, refer to attached code sheet.

Polygon or Relevé number: Assigned either in the field or in the office prior to sampling.

Date: Date of sampling.

County: County in which located.

USGS Quad: The name of the USGS map the relevé is located on; note series (15' or 7.5').

CNPS Chapter: CNPS chapter, or other organization or agency if source is other than CNPS chapter.

Landowner: Name of landowner or agency acronym if known. Otherwise, list as private.

Contact Person: Name, address, and phone number of individual responsible for data collection.

Observers: Names of individuals assisting. Circle name of recorder.

Plot shape: indicate the sample shape as: square, rectangle, circle, or the entire stand.

Plot size: length of rectangle edges, circle radius, or size of entire stand. NOTE: See page 2 for standard plot sizes.

Study Plot Revisit: If the relevé plot is being revisited for repeated sampling, please circle "Yes".

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Photo interpreter community code: If the sample is in area for which delineation and photo interpretation has already been done, the code which the photointerpreters applied to the polygon. If the sample site has not been photointerpreted, leave blank.

Other polygons of same type (yes or no, if applicable), if yes, mark on map: Other areas within view that appear to have similar vegetation composition. Again, this is most relevant to areas that have been delineated as polygons on aerial photographs as part of a vegetation-mapping project. If one is not working from aerial photographs, draw the areas as on a topographic map.

Is plot representative of whole polygon? (yes or no, if applicable), if no explain: Detail what other vegetation types occur in the polygon, and what the dominant vegetation type is if there is more than one type.

Global Positioning System Readings: Due to the recent availability of very accurate and relatively low cost GPS units, we highly recommend obtaining and using these as a standard piece of sampling equipment. Now that the military intentional imprecision (known as "selective availability") has been "turned off" (as of July 2000), it is typical for all commercial GPS units these units to be accurate to within 5 m of the actual location. Also note that the GPS units can be set to read in UTM or Latitude and Longitude coordinates and can be easily translated. Thus, the following fields for Latitude, Longitude, and legal description are now optional. In order for all positional data to be comparable within the CNPS vegetation dataset, we request using UTM coordinates set for the NAD 83 projection (see your GPS users manual for instructions for setting coordinates and projections).

Caveat: Although GPS units are valuable tools, they may not function properly due to the occasionally poor alignment of satellites or due to the complexity of certain types of terrain, or vegetation. We thus also recommend that you carry topographic maps and are aware of how to note your position on them in the event of a non-responsive or inaccurate GPS.

UTMN and UTME: Northing and easting coordinates using the Universal Transverse Mercator (UTM) grid as delineated on the USGS topographic map, or using a Global Positioning System.

UTM zone: Universal Transverse Mercator zone. Zone 10S for California west of the 120^{th} longitude; zone 11S for California east of 120^{th} longitude.

Legal Description: Township/Range/Section/Quarter Section/Quarter-Quarter section/Meridian: Legal map location of the site; this is useful for determining ownership of the property. California Meridians are Humboldt, Mt. Diablo, or San Bernardino. (This is optional, see above discussion of GPS units)

Latitude and Longitude: Degrees north latitude and east longitude. This is optional (see above)

Elevation: Recorded in feet or meters. Please indicate units.

Slope: Degrees, read from clinometer or compass, or estimated; averaged over relevé

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Aspect: Degrees from true north (adjust declination), read from a compass or estimated; averaged over relevé.

Macrotopography: Characterize the large-scale topographic position of the relevé. This is the general position of the sample along major topographic features of the area. *See attached code list.*

Microtopography: Characterize the local relief of the relevé. Choose the shape that mimics the lay of the ground along minor topographic features of the area actually within the sample. *See attached code list.*

VEGETATION DESCRIPTION

Dominant layer: Indicate whether the community is dominated by the Low layer (L), Mid-layer (M), or Tall (T) layer.

Preliminary Alliance name: Name of series, stand, or habitat according to CNPS classification (per Sawyer and Keeler-Wolf 1995); if the type is not defined by the CNPS classification, note this in the space.

Dominant Vegetation Group: Use code list to choose group

Phenology: Based on the vegetative condition of he principal species, characterize the phenology of each layer as early (E), peak (P), or late (L).

WETLAND COMMUNITY TYPES

Community type: Indicate if the sample is in a wetland or an upland; note that a site need not be officially delineated as a wetland to qualify as such in this context.

Dominant vegetation form: This is a four letter code which relates the vegetation of the plot to the higher levels of the NBS/NPS National Vegetation Classification System hierarchy. *See attached code list.*

Cowardin class: See “Artificial Keys to Cowardin Systems and Names” (attached). If the plot is located in a wetland, record the proper Cowardin system name. Systems are described in detail in Cowardin et al. 1979. Classification of wetlands and deepwater habitats of the United States. US Dept. of the Interior, Fish and Wildlife Service, Office of Biological Services, Washington, D.C.

Marine: habitats exposed to the waves and currents of the open ocean (subtidal and intertidal habitats).

Estuarine: includes deepwater tidal habitats and adjacent tidal wetlands that are usually semi-enclosed by land but have open, partly obstructed, or sporadic access to the open ocean, and in which ocean water is at least occasionally diluted by freshwater runoff from the land (i.e. estuaries and lagoons).

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Riverine: includes all wetlands and deepwater habitats contained within a channel, excluding any wetland dominated by trees, shrubs, persistent emergent plants, emergent mosses, or lichens. Channels that contain oceanic-derived salts greater than 0.5% are also excluded.

Lacustrine: Includes wetlands and deepwater habitats with all of the following characteristics: 1) situated in a topographic depression or a dammed river channel; 2) lacking trees or shrubs, persistent emergents, emergent mosses or lichens with greater than 30% aerial coverage; and total area exceeds 8 ha (20 acres). Similar areas less than 8 ha are included in the lacustrine system if an active wave-formed or bedrock shoreline feature makes up all or part of the low tide boundary, of if the water in the deepest part of the basin exceeds 2 m (6.6 feet) at low tide. Oceanic derived salinity is always less than 0.5%.

Palustrine: Includes all nontidal wetlands dominated by trees, shrubs, persistent emergents, emergent mosses or lichens, and all such wetlands that occur in tidal areas where salinity derived from oceanic salts is less than 0.5%. Also included are areas lacking vegetation, but with all of the following four characteristics: 1) areas less than 8 ha (20 acres); active wave-formed or bedrock shoreline features lacking; 3) water depth in the deepest part of the basin less than 2 m (6.6 feet) at low water; and 4) salinity due to ocean-derived salts less than 0.5%.

<u>Vertical distance from high water mark of active stream channel</u>: If the plot is in or near a wetland community, record to the nearest meter or foot the estimated vertical distance from the middle of the plot to the average water line of the channel, basin, or other body of water.

<u>Horizontal distance from high water mark of active stream channel</u>: If the plot is in or near a wetland community, record to the nearest meter or foot the estimated horizontal distance from the middle of the plot to the average water line of the channel, basin, or other body of water.

<u>Stream channel form</u>: If the plot is located in or near a community along a stream, river, or dry wash, record the channel form of the waterway. The channel form is considered S (single channeled) if it consists of predominately a single primary channel, M (meandering) if it is a meandering channel, and B (braided) if it consists of multiple channels interwoven or braided.

<u>Adjacent alliance</u>: Adjacent vegetation series, stands or habitats according to CNPS classification; list in order of most extensive to least extensive. Give the name of the alliance, the direction in relation to stand and list up to four species under Description.

<u>Photographs</u>: Write the name or initials of the camera owner and the JPEG numbers for photos taken. Write the camera's view direction from compass bearings. Take four or eight photos (depending on the project) from the same point as the GPS reading (center of a circle or NW corner of rectangle). Using a compass, take the first photo from the north, and rotate clockwise, taking the photos in sequence, N, NE, E etc, or N, E, S, W. Keep camera at same orientation, zoom level, and distance from ground for all four (or eight) photos., You may take photos close to the ground, if for instance, you are photographing a low herbaceous stand. Additional photos of the stand may also be helpful. If using a digital camera or scanning in the image into a computer, relevé numbers and compass directions can be recorded digitally. If using a 35mm camera, please note the roll number, frame number, compass direction, and the initials of the person whose camera is being used. (e.g. Roll 5, #1, to the NW, SE)

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STAND AND ENVIRONMENTAL INFORMATION

Vegetation trend: Based on the regenerating species and relationship to surrounding vegetation, characterize the stand as either increasing (expanding), stable, decreasing, fluctuating, or unknown.

Impacts: Enter codes for potential or existing impacts on the stability of the plant community. Characterize each as either 1. Light, 2. Moderate, of 3. Heavy. *See attached code list.*

Site location and plot description: A concise, but careful description that makes locating and/or revisiting the vegetation stand and plots possible; give landmarks and directions. Used in conjunction with the GPS position recorded earlier, this should enable precise re-location of the plot. Indicate where the GPS reading was taken within the plot. In general, the location of the GPS reading should be on the Northwestern corner of the plot, if the plot is rectangular (or square), or in the center if the plot is circular. It is also helpful to briefly describe the topography, aspect, and vegetation structure of the site. If you can't take the GPS reading at the Northwest corner (an obstacle in the way) then note where the GPS point was taken. If you can't get a GPS reading, then spend extra time marking the plot location as precise as possible on a topo map.

Site history: Briefly describe the history of the stand, including type and year of disturbance (e.g. fire, landslides or avalanching, drought, flood, or pest outbreak). Also note the nature and extent of land use such as grazing, timber harvest, or mining.

Unknown plant specimens: List the numbers of any unknown plant specimens, noting any information such as family or genus (if known), important characters, and whether or not there is adequate material for identification. Do not take samples of plants of which there are only a few individuals or which you think may be rare. Document these plants with photographs.

Additional comments: Feel free to note any additional observations of the site, or deviations from the standard sampling protocol. If additional data were recorded, e.g. if tree diameters were measured, please indicate so here.

SURFACE COVER AND SOIL INFORMATION

Surface cover: Estimate the cover class of each size at or near the ground surface averaged over the plot. Always remember to estimate what you actually see on the surface as opposed to what you think is hiding under, organic litter, big rocks, etc. However, rocks, organic litter, or fine material visible under the canopy of shrubs or trees should be included in the cover estimate.

One way to consider this is to assume that all of the components of surface cover plus the basal cross-section of living plant stems and trunks (at ground level) will add up to 100%. Thus, estimate the cover value of each of the items in the box on the form for surface cover (including the basal area of plant stems) so that they will add up to 100%. Remember that the basal area of plant stems is usually minimal (e.g., if there were 10 trees, each 1 m in diameter at ground level on a 1000 square meter plot, they would cover less than 1% {0.79%} of the plot).

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These data are asked for because certain categories of surface cover of rock and other materials have been shown to correlate with certain vegetation types and are thus likely influencing the type of vegetation that is growing in a given area. These estimates should be made quickly with the main point to keep in mind being a rough estimate of the relative proportions of different coarse fragments on the plot.

Fines: Fine mineral fragments including sand, silt, soil, “dirt” < 2 mm in diameter

Gravel: rounded and angular fragments 0.2-7.5 cm (0.08 -3 in.) diameter

Cobble: rounded and angular fragments >7.5-25 cm (3 -10 in.) in diameter

Stone: rounded and angular coarse fragments >25 cm-60 cm (10 -24 in.) in diameter

Boulder: rounded and angular coarse fragments >60 cm (>24 in.) in diameter

Bedrock: continuous, exposed, non-transported rock

Litter: extent of undecomposed litter on surface of plot (this includes all organic matter, e.g. fallen logs, branches, and twigs down to needles and leaves).

Living stems of vascular plants: basal area of living stems of the plants at ground surface

<u>% Bioturbation</u>: Estimate percent cover of ground disturbance by animals (e.g., small mammal burrowing trails, cow hoof marks) across the entire plot surface.

<u>Soil texture</u>: Record the texture of the upper soil horizon, below the organic layer if one is present. *See attached key and code list*.

<u>Parent Material</u>: Geological parent material of site. *See attached code list*.

VEGETATION DATA

<u>Assessment of Layers</u>

Data are recorded for five layers (tree overstory, tree understory, shrub, herb, and non-vascular). The layer a species occupies is determined by life-form. The estimates need not be overly precise and will vary among vegetation types. A young tree, if shrub sized, is considered an understory tree. A caveat: if several relevés are being sampled within the same vegetation type, it is important to be consistent when assigning layers. Some types will have more than five layers (e.g. two tree layers of different maximum height); this should be indicated in the relevé description.

<u>Species List</u>

The collection of vegetation data continues with making a comprehensive species list of all vascular plants within the relevé. This list is achieved by meandering through the plot to see all microhabitats. During list development, observers document each taxon present in each layer in which it occurs separately, recording it on a different line of the data form and noting which layer is represented. This is important for data entry because each layer of each represented taxon will be entered separately. Each individual plant is recorded in only one layer, the layer in which the tallest portion of the individual is found. One should reach a point at which new taxa are added to the list only very slowly, or sporadically. When one has reached that point, the list is probably done.

The following sections explain how to perform the actual relevé, the Estimation of Cover Values. The sections prefaced by bold-faced titles explain the technique, and the sections with regular font titles refer to the steps needed to complete the accompanying Field Form.

DBH – see separate field form (optional)

<u>DBH if >10 cm</u>:

The diameter at breast height (dbh) is important in certain studies. It may be recorded next to each tree species name. First indicate the species name by code and then record the number of sprouts/trunks in clonal trees. You should measure the tree dbh of every tree trunk/sprout that has diameter > or = 10 cm at breast height in the plot, and each measurement should be in centimeters (cm) using a dbh tape measure. For trunks that may be fused below breast height and branched at breast height, each trunk at breast height gets a separate measurement.

Also indicate if each tree/clone is in the overstory or understory. Trees in the overstory are generally at canopy level. Trees in the understory are entirely below the general level of the canopy.

If snags are encountered in plot, record the dbh and denote it as dead by circling its dbh measurement. If you are unable to identify the snag to species, put the four letter code “SNAG” in the species column.

Depending on the density of trees in each plot, you can record dbh of trees for every tree trunk in the plot, or you can sub-sample the trunks to estimate dbh for every tree species in relatively dense plots. For woodland/forest plots, sub-sampling is appropriate for half the plot if there are at least 50 trees/resprouts present (e.g., 200 m^2 sub-sample in riparian and 500 m^2 sub-sample in upland).

When sub-sampling, make sure to denote this as a sub-sample (note on the data form) and record the sub-sample of dbh’s for each tree species in the appropriate row on the Field Form. Once the data are post-processed and entered into a database, then you will need to record each sub-sampled dbh reading three additional times to come up with a full sample of dbh readings. For example, with a sub-sampled tree dbh of 15 cm, this value of 15 should be entered four times (not just once) when it is entered in the database.

<u>Lifeform and size class</u>: If dbh <15.2 cm, counts should be made for conifers and hardwoods in two different size classes. Count seedlings (≤ 2.54 cm) and saplings (> 2.54 but < 15.2 cm). First estimate if there are more than 50 seedlings in one half (50% subsample) of the plot. If so, then do counts of seedlings and saplings in five sub-plots of 2x2 m squares. If the plot shape is a

circle, place one square in the center of the plot, and four other squares 10 m to the N, S, E, and W of the plot center. If there are less than 50 seedlings in the 50% subsample plot, then record counts for that subsample instead.

Estimating Cover:

There are many ways to estimate cover. Many people who have been in the cover estimation "business" for a long time can do so quickly and confidently without any props and devices. However, to a novice, it may seem incomprehensible and foolhardy to stand in a meadow of 50 different species of plants and systematically be able to list by cover value each one without actually "measuring" them in some way.

Of course, our minds make thousands of estimates of various types every week. We trust that estimating plant cover can be done by anyone with an open mind and an "eye for nature." It's just another technique to learn.

It is very helpful to work initially with other people who know and are learning the technique. In such a group setting, typically a set of justifications for each person's estimate is made and a "meeting of the minds" is reached. This consensus approach and the concomitant calibration of each person's internal scales is a very important part of the training for any cover estimate project.

An underlying point to remember is that estimates must provide some level of reliable values that are within acceptable bounds of accuracy. If we require an accuracy level that is beyond the realm of possibility, we will soon reject the method for one more quantitative and repeatable. As with any scientific measurement, the requirement for accuracy in the vegetation data is closely related to the accuracy of the information needed to provide a useful summary of it. Put into more immediate perspective - **to allow useful and repeatable analysis of vegetation data, one does not need to estimate down to the exact percent value the cover of a given plant species in a given stand**.

This point relates to two facts: there is inherent variability of species cover in any environment. For example, you would not expect to always have 23% *Pinus ponderosa*, 14% *Calocedrus decurrens*, and 11% *Pinus lambertiana* over an understory of 40% *Chamaebatia foliosa*, 3% *Clarkia unguiculata*, and 5% *Galium bolanderi* to define the Ponderosa pine-Incense cedar/mountain misery/bolander bedstraw plant community. Anyone who has looked at plant composition with a discerning eye can see that plants don't space themselves in an environment by such precise rules. Thus, we can safely estimate the representation of species in a stand by relatively broad cover classes (such as <1%, 1-5 %, 5-25%, etc.) rather than precise percentages.

The data analysis we commonly use to classify vegetation into different associations and series (TWINSPAN and various cluster analysis programs, for example) is likewise forgiving. When analyzed by quantitative mutivariate statistics information on species cover responds to coarse differences in cover and presence and absence of species, but not to subtle percentage point differences. This has been proven time and again through quantitative analysis of vegetation classification. Many of the world's plant ecologists estimate cover rather than measure it precisely. Some of the seminal works in vegetation ecology have been based on cover estimates taken by discerning eyes.

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With this as a preamble, below we offer some suggestions on estimating cover that have proven helpful. These are simply "tricks" to facilitate estimation, some work better for different situations. You may come up with other methods of estimation that may seem more intuitive, and are equally reliable in certain settings. All values on the relevé protocol that require a cover class estimate, including coarse fragment and vegetation layer information, may rely on these techniques. Just make the appropriate substitutions (using the coarse fragment example substitute, bedrock, stone, cobbles, gravel, and litter for vegetation).

Method 1: The invisible point-intercept transect:

This method works well in relatively low, open vegetation types such as grasslands and scrubs where you can see over the major stand components. For those who have worked with the original CNPS line intercept methodology it's like counting hits along an imaginary line at regular intervals of the 50 m tape. Here's how it goes:

> Envision an imaginary transect line starting from your vantage point and running for 50 m (or however many meters you wish, as long as you are still ending up within the same stand of vegetation you're sampling - never keep counting outside of your homogeneous stand). Now "walk" your eye along this tape for 50 m and visually "take a point" every 0.5 m. Don't worry about precision, just try to "walk" your eye along the line and stop every 0.5 m or at any other regular interval until you reach its end and mentally tally what species you hit. Once you come up with a number of hits for each major species in one imaginary transect, take another transect in another direction and estimate the number of hits on that one. Do this several times (usually 3-4 is enough if you are in a homogeneous stand), then average your results.

This can go quickly in simple environments and in environments where the major species are easily discernable (chaparral, bunch-grassland, coastal scrub, desert scrub). Your average number of hits need not be a total of 100 as in the original transect method, but could be 50 along a 25 m imaginary line (in which case you would multiply by two to get your estimated cover), or 25 along a 12.5 m line (multiply average by 4), etc.

Method 2: Subdivision of sample plot into quadrants:

Many plots, whether they are square, circular, or rectangular, may be "quartered" and have each quadrant's plant cover estimated separately. If the plot is a given even number of square meters (such as 100, 400, or 1000 m^2) then you know that a quarter of that amount is also an easily measurable number. If you can estimate the average size of the plants in each of the quarters (e.g, small pinyon pines may be 5 m^2 (2.2m x 2.2m), creosote bush may be $2m^2$ (or 1.41 m x 1.41 m), burrobush may be $0.5m^2$) then you simply count the number of plants in each size class and multiply by their estimated size for the cover in a given quadrant. Then you average the 4 quadrants together for your average cover value.

This method works well in vegetation with open-to-dense cover of low species such as grasses or low shrubs, in open woodlands, and desert scrubs.

Method 3; "Squash" all plants into a continuous cover in one corner of the plot :

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Another way to estimate how much of the plot is covered by a particular species is to mentally group (or "march", or "squash") all members of that species into a corner of the plot and estimate the area they cover. Then calculate that area as a percentage of the total plot area. This technique works well in herb and shrub dominated plots but is not very useful in areas with trees.

Method 4: <u>How to estimate tree cover</u>:

Cover estimates of tall trees is one of the most difficult tasks for a beginning relevé sampler. However it is possible to do this with consistency and reliability using the following guidelines.

1. Have regular sized and shaped plots that you can easily subdivide.
2. Estimate average crown spread of each tree species separately by pacing the crown diameter of representative examples of trees of each species and then roughly calculating the crown area of each representative species.
3. Add together the estimated crown area of each individual of each species of tree on the plot for your total cover.

Method 5: T<u>he process of elimination technique:</u>

This method is generally good for estimating cover on sparsely vegetated areas where bare ground, rocks, or cobbles cover more area than vegetation. In such a situation it would be advisable to first estimate how much of the ground is not covered by plants and then subdivide the portion that is covered by plants into rough percentages proportional to the different plant species present. For example, in a desert scrub the total plot not covered by plants may be estimated at 80%. Of the 20% covered by plants, half is desert sunflower (10% cover), a quarter is California buckwheat (5% cover), an eighth brittlebush (2.5% cover), and the rest divided up between 10 species of herbs and small shrubs (all less than 1% cover).

Any of these techniques may be used in combination with one another for a system of checks and balances, or in stands that have characteristics lending themselves for a different technique for each layer of vegetation.

In a relevé, cover estimates, using the techniques described above, are made for each taxon as it is recorded on the species list. Estimates are made for each layer in which the taxon was recorded. For example, if individuals of coast live oak occur in the tree overstory (canopy trees) and tree understory (seedlings and saplings), an estimate is made for both layers should be recorded.

In a traditional relevé, cover is estimated in "cover classes," not percentages, because of the variability of plant populations over time and from one point to another, even within a small stand. This protocol uses the following 6 cover classes:

Cover Class 1: the taxon in that layer covers < 1 % of the plot area
Cover Class 2: the taxon in that layer covers 1 % - 5 % of the plot area
Cover Class 3a: the taxon in that layer covers >5 - 15 % of the plot area

Cover Class 3b: the taxon in that layer covers >15 - 25 % of the plot area
Cover Class 4: the taxon in that layer covers >25 - 50 % of the plot area
Cover Class 5: the taxon in that layer covers >50 - 75 % of the plot area
Cover Class 6: the taxon in that layer covers > 75% of the plot area

Percentages (optional)

This CNPS protocol also encourages observers to estimate percentages if they feel confident in their estimation abilities. This optional step allows the data to be compared more easily to data collected using different methods, such as a line or point intercept. It also instills confidence in the cover estimate of borderline species that are close calls between two cover classes (e.g., a cover class 2 at 5% as opposed to a cover class 3 at 6%). It is particularly useful for calculating cover by the process of elimination techniques and for estimating total vegetation cover (see below) and coarse fragment cover.

Overall Cover of Vegetation

In addition to cover of individual taxa described above, total cover is also estimated for each vegetation layer. This is done using the same cover classes as described above but combines all taxa of a given category. They can be calculated from the species percent cover estimates, but please make sure to disregard overlap of species within each layer. These estimates should be absolute aerial cover, or the "bird's eye view" of the vegetation cover, in which each category cannot be over 100%.

To come up with a specific number estimate for percent cover, first use to the cover intervals, used in the species cover estimates, as a reference aid to get a generalized cover estimate: While keeping these intervals in mind, you can then refine your estimate to a specific percentage for each category below.

% Overstory Conifer/Hardwood Tree: The total aerial cover (canopy closure) of all live tree species that are specifically in the overstory or are emerging, disregarding overlap of individual trees. Estimate conifer and hardwood covers separately. Please note: These cover values should not include the coverage of suppressed understory trees.

%Low-Medium Tree: The total aerial cover (canopy closure) of all live understory low to medium height tree species, disregarding overlap of individual trees and shrubs. This category contains recruits of overstory tree species (with seedlings and saplings in the understory) and understory tree species that typically do not make up the overstory canopy (e.g. trees that typically do not attain a height >10m).

% Shrub: The total aerial cover (canopy closure) of all live shrub species disregarding overlap of individual shrubs.

% Herb: The total aerial cover (canopy closure) of all herbaceous species, disregarding overlap of individual herbs.

% Total Vascular plants: The total aerial cover of all vegetation. This is an estimate of the absolute vegetation cover, disregarding overlap of the various tree, shrub, and/or herb layers.

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% Total Non-vascular plants: The total cover of all lichens and bryophytes (mosses, liverworts, hornworts) on substrate surfaces (not standing or inclined trees).

Modal height for conifer/hardwood tree, shrub, and herbaceous categories (optional)
If height values are important in your vegetation survey project, provide an ocular estimate of height for each category listed. Record an average height value per each category by estimating the mean height for each group. Please use the following height intervals to record a height class: 01=<1/2m, 02=1/2-1m, 03=1-2m, 04=2-5m, 05=5-10m, 06=10-15m, 07=15-20m, 08=20-35m, 09=35-50m, 10=>50m.

Caveats
Please consult with the members of the vegetation committee for advice and feedback on proposed vegetation surveys prior on initiating projects.

Notes on the Order and Division of Labor for Data Collection: As with every procedure, there are always more and less efficient ways to collect the information requested. Although we respect each field crews' option to choose in what order they collect the data, we suggest the following general rules:

- Work with teams of two for each plot collected.
- Both team members can determine the plot shape and size and lay out the tapes and mark the edges for the plot boundary (see below).
- The two person teams can also divide up tasks of data collection with one member collecting location, environmental (slope, aspect, geology, soil texture, etc.) and plot description information while the other begins the species list. Thus, two clipboards are useful and data sheets that are at first separated (not stapled).
- Following the making of the initial species list and collection of location and environmental data both team members convene to do the estimation of plant cover by species followed by the estimation of total vegetation cover and cover by layer.
- Following that process, the estimation of cover by the up to 10 height strata classes and the listing of the diagnostic species for each is done collaboratively.
- This is followed by the estimation of the coarse fragment information, again done collaboratively.

For egalitarian and familiarization purposes we suggest that the roles be switched regularly between the team members and that if multiple teams are being used in a larger project, that each team member switches frequently between teams, building all-important calibration, and camaraderie among the whole group.

Suggestions for Laying out Plots: If you are laying out a circular plot, work with two or more people. One person stands at the center of the plot and holds the tape case while the other walks the end of the tape out to the appointed distance (radium 5.6 for 100 m^2 circle, radius 11.3 m for a 400 m^2 circle, and radius 17.6 m for a 1000m^2 circle). The walker then fixes the tape end with a pin flag and walks back to the center where he/she instructs the center person to walk in the opposite direction of the already laid out tape radius, stretching the rest of the tape to an equal

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length (another 11.3 or 17.6 m) to the opposite edge of the plot, where he/she affixes it with another pin flag. This process is again repeated with another tape laid out perpendicular to the first so that an "+ " shape is created . The margins of the circle can be further delineated by measuring to the center of the circle with an optical tape measure (rangefinder) and marking mid points between the four ends of the crossed tapes.

When laying out square or rectangular plots work with two or more people per team. If doing a rectangle, determine the long axis of the plot first and have one person be stationed at the zero m end of the tape while the other person walks the unrolling tape case out to the appropriate length. The stationary end person can guide the walker, keeping them moving in a straight line. Once that tape is laid out and the far end staked, the team lays out another tape perpendicular to the first, either at one end, using the same type of process. This establishes the width of the rectangle (or square). Using an optical rangefinder and pin-flags, or colored flagging the team can further mark additional points along the other parallel long axis and short axis of the plot (every 5 m for shorter plots or every 10 m for longer plots is suggested) so that the entire plot boundary can be easily visualized.

References:

Barbour M.G., J.H. Burk, and W.D. Pitts 1987. Terrestrial Plant Ecology, Second Edition. Benjamin/Cummings Publishing Co. Menlo Park, CA. 634 pages.

Sawyer and Keeler-Wolf. 1995. Manual of California Vegetation. California Native Plant Society, Sacramento, CA. 471 pages

The Nature Conservancy and Environmental Systems Research Institute. 1994. Final Draft, Standardized National Vegetation Classification System. Prepared for United States Department of the Interior, National Biological Survey, and National Park Service. Arlington, VA. Complete document available at the following website: http||:biology.usgs.gov/npsveg/fieldmethods.html

Suggested Equipment:
Equipment List: Prices as of May 2000, toll free orders from Forestry Suppliers (1-800-647-5368) (item numbers in parentheses)

Chaining pins, surveyor steel (#39167)	$21.50
Fiberglass tapes 2 - 165'/50 m (#39972)	$42.90
Logbook cover 8 ½ " x 12" (#53200)	$23.95
Perforated flagging (#57960)	$1.95
UTM Coordinate Grid (#45019)	$16.95
Rangefinder, 10-75m (#38973)	$51.60
Silva Compass w/ clinometer (#37036)	$43.90
Garmin GPS 12XL (#39095, #39111)	$244.90

Appendix 3.5B (CNPS 2007)

CALIFORNIA NATIVE PLANT SOCIETY RELEVÉ FIELD FORM CODE LIST (revised 3/0107)

MACRO TOPOGRAPHY

00 Bench
01 Ridge top (interfluve)
02 Upper 1/3 of slope
03 Middle 1/3 of slope
04 Lower 1/3 of slope (lowslope)
05 Toeslope (alluvial fan/bajada)
06 Bottom/plain
07 Basin/wetland
08 Draw
09 Other
10 Terrace (former shoreline or floodplain)
11 Entire slope
12 Wash (channel bed)
13 Badland (complex of draws & interfluves)
14 Mesa/plateau
15 Dune/sandfield
16 Pediment
17 Backslope (cliff)

MICRO TOPOGRAPHY

01 Convex or rounded
02 Linear or even
03 Concave or depression
04 Undulating pattern
05 Hummock or Swale pattern
06 Mounded
07 Other

SITE IMPACTS

01 Development
02 ORV activity
03 Agriculture
04 Grazing
05 Competition from exotics
06 Logging
07 Insufficient population/stand size
08 Altered flood/tidal regime
09 Mining
10 Hybridization
11 Groundwater pumping
12 Dam/inundation
13 Other
14 Surface water diversion
15 Road/trail construction/maint.
16 Biocides
17 Pollution
18 Unknown
19 Vandalism/dumping/litter
20 Foot traffic/trampling
21 Improper burning regime
22 Over collecting/poaching
23 Erosion/runoff
24 Altered thermal regime
25 Landfill
26 Degrading water quality
27 Wood cutting
28 Military operations
29 Recreational use (non ORV)
30 Nest parasitism
31 Non-native predators
32 Rip-rap, bank protection
33 Channelization (human caused)
34 Feral pigs
35 Burros
36 Rills
37 Phytogenic mounding
38 Sudden oak death syndrome (SODS)

PARENT MATERIAL

IGTU	Igneous (type unknown)
VOLC	General volcanic extrusives
RHYO	Rhyolite
ANDE	Andesite
BASA	Basalt
ASHT	Ash (of any origin)
OBSI	Obsidian
PUMI	Pumice
PYFL	Pyroclastic flow
VOFL	Volcanic flow
VOMU	Volcanic mud
INTR	General igneous intrusives
GRAN	Granitic (generic)
MONZ	Monzonite
QUDI	Quartz diorite
DIOR	Diorite
GABB	Gabbro
DIAB	Diabase
PERI	Peridotite
METU	Metamorphic (type unknown)
GNBG	Gneiss/biotite gneiss
SERP	Serpentine
SCHI	Schist
SESC	Semi-schist
PHYL	Phyllite
SLAT	Slate
HORN	Hornfels
BLUE	Blue schist
MARB	Marble
SETU	Sedimentary (type unknown)
BREC	Breccia (non-volcanic)
CONG	Conglomerate
FANG	Fanglomerate
SAND	Sandstone
SHAL	Shale
SILT	Siltstone
CACO	Calcareous conglomerate
CASA	Calcareous sandstone
CASH	Calcareous shale
CASI	Calcareous siltstone
DOLO	Dolomite
LIME	Limestone
CALU	Calcareous (origin unknown)
CHER	Chert
FRME	Franciscan melange
GREE	Greenstone
ULTU	Ultramafic (type unknown)
MIIG	Mixed igneous
MIME	Mixed metamorphic
MISE	Mixed sedimentary
MIRT	Mix of two or more rock types
GLTI	Glacial till, mixed origin, moraine
LALA	Large landslide (unconsolidated)
DUNE	Sand dunes
LOSS	Loess
CLAL	Clayey alluvium
GRAL	Gravelly alluvium
MIAL	Mixed alluvium
SAAL	Sandy alluvium (most alluvial fans and washes)
SIAL	Silty alluvium
OTHE	Other than on list

SOIL TEXTURE

COSA	Coarse sand
MESN	Medium sand
FISN	Fine sand
COLS	Coarse, loamy sand
MELS	Medium to very fine, loamy sand
MCSL	Moderately coarse, sandy loam
MESA	Medium to very fine, sandy loam
MELO	Medium loam
MESL	Medium silt loam
MESI	Medium silt
MFCL	Moderately fine clay loam
MFSA	Moderately fine sandy clay loam
MFSL	Moderately fine silty clay loam
FISA	Fine sandy clay
FISC	Fine silty clay
FICL	Fine clay
SAND	Sand (class unknown)
LOAM	Loam (class unknown)
CLAY	Clay (class unknown)
UNKN	Unknown
PEAT	Peat
MUCK	Muck

DOMINANT VEGETATION GROUP

Trees:	
TBSE	Temperate broad-leaved seasonal evergreen forest
TNLE	Temperate or subpolar needle-leafed evergreen forest
CDF	Cold-deciduous forest
MNDF	Mixed needle-leafed evergreen-cold deciduous. forest
TBEW	Temperate broad-leaved evergreen woodland
TNEW	Temperate or subpolar needle-leaved evergreen woodland
EXEW	Extremely xeromorphic evergreen woodland
CDW	Cold-deciduous woodland
EXDW	Extremely xeromorphic deciduous woodland
MBED	Mixed broad-leaved evergreen-cold deciduous woodland
MNDW	Mixed needle-leafed evergreen-cold deciduous woodland
Shrubs:	
TBES	Temperate broad-leaved evergreen shrubland
NLES	Needle-leafed evergreen shrubland
MIES	Microphyllus evergreen shrubland
EXDS	Extremely xeromorphic deciduous shrubland
CDS	Cold-deciduous shrubland
MEDS	Mixed evergreen-deciduous shrubland
XMED	Extremely xeromorphic mixed evergreen-deciduous shrubland
Dwarf Shrubland:	
NMED	Needle-leafed or microphyllous evergreen dwarf shrubland
XEDS	Extremely xeromorphic evergreen dwarf shrubland
DDDS	Drought-deciduous dwarf shrubland
MEDD	Mixed evergreen cold-deciduous dwarf shrubland
Herbaceous:	
TSPG	Temperate or subpolar grassland
TGST	Temperate or subpolar grassland with sparse tree
TGSS	Temperate or subpolar grassland with sparse shrublayer
TGSD	Temperate or subpolar grassland with sparse dwarf shrub layer
TFV	Temperate or subpolar forb vegetation
THRV	Temperate or subpolar hydromorphic rooted vegetation
TAGF	Temperate or subpolar annual grassland or forb vegetation
***Sparse Vegetation*:**	
SVSD	Sparsely vegetated sand dunes
SVCS	Sparsely vegetated consolidated substrates

Appendix 3.5B
(CNPS 2007)

Simplified Key to Soil Texture
(Adapted from Brewer and McCann 1982)

Place about three teaspoons of soil in the palm of your hand. Take out any particles ≥ 3 mm in size.

A. Does soil remain in ball when squeezed in your hand palm?

Yes, soil does remain in a ball when squeezed.. **B**

No, soil does not remain in a ball when squeezed.. **sand**

SAND Sand (class unknown)
Very coarse texture…………………………………………COSA Coarse sand
Moderately coarse texture…………………………………… MESN Medium sand
Moderately fine texture……………………………………….. FISN Fine sand

B. Add a small amount of water until the soil feels like putty. Squeeze the ball between your thumb and forefinger, attempting to make a ribbon that you push up over your finger. Does soil make a ribbon?

Yes, soil makes a ribbon; though it may be very short...**C**

No, soil does not make a ribbon...**loamy sand**

Very gritty with coarse particles…..COLS Coarse, loamy sand
Moderately to slightly gritty with medium to fine particles.........MELS Medium to very fine, loamy sand

C. Does ribbon extends more than one inch?

Yes, soil extends > 1 inch..**D**

No, soil does not extend > 1 inch...Add excess water

Soil feels gritty………………………..……………….…..............**loam or sandy loam**

LOAM Loam (class unknown)
Very gritty with coarse particles…..MCSL Moderately coarse, sandy loam
Moderately gritty with medium to fine particles.......................MESA Medium to very fine, sandy loam
Slightly gritty ....MELO Medium loam

Soil feels smooth...**silt loam**

MESIL medium silt loam

D. Does soil extend more than 2 inches?

Yes, ribbon extends more than 2 inches, and does not crack if bent into a ring..........................**E**

No, soil breaks when 1–2 inches long; cracks if bent into a ring………………..Add excess water

Soil feels gritty…..**sandy clay loam or clay loam**

Very gritty…………...…………………………………………...MFSA Moderately fine sandy clay loam
Slightly gritty……………………………………………………MFCL Moderately fine clay loam

Soil feels smooth...…..**silty clay loam or silt**

Moderately fine texture…………………………………………..MFSL Moderately fine silty clay loam
Very fine texture……………………………………………….. MESI Medium silt

E. Soil makes a ribbon 2+ inches long; does not crack when bent into a ring...............Add excess water

Soil feels gritty...**sandy clay or clay**

CLAY Clay (class unknown)
Very gritty……………………………………………………… FISA Fine sandy clay
Slightly gritty………………………………………………….. FICL Fine clay

Soil feels smooth...………..........**silty clay**

FISC Fine silty clay

UNKN = UNKNOWN PEAT = PEAT MUCK = MUCK

Appendix 3.5B
(CNPS 2007)

Artificial Key to the Systems and Classes

Key to the Systems

1. Water regime influenced by oceanic tides, and salinity due to ocean-derived salts 0.5% or greater.
   2. Semi-enclosed by land, but with open, partly obstructed or sporadic access to the ocean. Halinity wide-ranging because of evaporation or mixing of seawater with runoff from land . . . . ESTUARINE
   2'. Little or no obstruction to open ocean present. Halinity usually euhaline; little mixing of water with runoff from land 3
      3. Emergents, trees, or shrubs present . . . . ESTUARINE
      3'. Emergents, trees, or shrubs absent. . . . . MARINE

1'. Water regime not influenced by ocean tides, or if influenced by oceanic tides, salinity less than 0.5%
   4. Persistent emergents, trees, shrubs, or emergent mosses cover 30% or more of the area . . . . . .PALUSTRINE
   4'. Persistent emergents, trees, shrubs, or emergent mosses cover less than 30% of substrate but nonpersistent emergents may be widespread during some seasons of year 5
      5. Situated in a channel; water, when present, usually flowing . . . . RIVERINE
      5'. Situated in a basin, catchment, or on level or sloping ground; water usually not flowing. 6
         6. Area 8 ha (20 acres) or greater . . . . .LACUSTRINE
         6'. Area less than 8 ha 7
            7. Wave-formed or bedrock shoreline feature present or water depth 2 m (6.6 feet) or more . . . . LACUSTRINE
            7'. No wave-formed or bedrock shoreline feature present and water > 2 m deep . . . . . . PALUSTRINE

Key to the Classes

1. During the growing season of most years, aerial cover by vegetation is less than 30%.
   2. Substrate a ridge or mound formed by colonization of sedentary invertebrates (corals, oysters, tube worms) . . . . REEF
   2'. Substrate of rock or various-sized sediments often occupied by invertebrates but not formed by colonization of sedentary invertebrates 3
      3. Water regime subtidal, permanently flooded, intermittently exposed, or semipermanently flooded. Substrate usually not soil 4
         4. Substrate of bedrock, boulders, or stones occurring singly or in combination covers 75% or more of the area . . . . ROCK BOTTOM
         4'. Substrate of organic material, mud, sand, gravel, or cobbles with less than 75% areal cover of stones, boulders, or bedrock. . . . . UNCONSOLIDATED BOTTOM
      3'. Water regime irregularly exposed, regularly flooded, irregularly flooded, seasonally flooded, temporarily flooded, intermittently flooded, saturated, or artificially flooded. Substrate often a soil 5
         5. Contained within a channel that does not have permanent flowing water (i.e., Intermittent Subsystem of Riverine System or Intertidal Subsystem of Estuarine System) . . . . STREAMBED
         5'. Contained in a channel with perennial water or not contained in a channel 6
            6. Substrate of bedrock, boulders, or stones occurring singly or in combination covers 75% or more of the area . . . . .ROCKY SHORE
            6'. Substrate of organic material, mud, sand, gravel, or cobbles; with less than 75% of the cover consisting of stones, boulders, or bedrock. . . . . UNCONSOLIDATED SHORE

1'. During the growing season of most years, percentage of area covered by vegetation 30% or greater.
   7. Vegetation composed of pioneering annuals or seedling perennials, often not hydrophytes, occurring only at time of substrate exposure 8
      8. Contained within a channel that does not have permanent flowing water. . . . . STREAMBED (VEGETATED)
      8'. Contained within a channel with permanent water, or not contained in a channel . . . . UNCONSOLIDATED SHORE (VEGETATED)
   7'. Vegetation composed of algae, bryophytes, lichens, or vascular plants that are usually hydrophytic perennials 9
      9. Vegetation composed predominantly of nonvascular species 10
         10. Vegetation macrophytic algae, mosses, or lichens growing in water or the splash zone of shores . . . . AQUATIC BED
         10'. Vegetation mosses or lichens usually growing on organic soils and always outside the splash zone of shores . . . . .MOSS-LICHEN WETLAND
      9'. Vegetation composed predominantly of vascular species 11
         11. Vegetation herbaceous 12
            12. Vegetation emergents. . . . . .EMERGENT WETLAND
            12'. Vegetation submergent, floating-leaved, or floating. . . . . .AQUATIC BED
         11'. Vegetation trees or shrubs 13
            13. Dominants less than 6 m (20 feet) tall . . . . .SCRUB-SHRUB WETLAND
            13'. Dominants 6 m tall or taller . . . . .FORESTED WETLAND

CNPS and CDFW Combined Vegetation Rapid Assessment and Relevé Field Form

(Revised February 27, 2014)

For Office Use **Final database #:**	**Final vegetation type:** **Alliance**________________________ **Association**

I. LOCATIONAL/ENVIRONMENTAL DESCRIPTION

Stand ID:	**Date:**	**Name of recorder:** **Other surveyors:**

☐ ☐ ☐

GPS name: ________ **Datum: NAD83 or** _______ For Relevé: **Bearing°,** left axis at SW point_____ of **Long / Short** side

UTME ___ ___ ___ ___ ___ ___ **UTMN** ___ ___ ___ ___ ___ ___ ___ **Zone: 10 / 11** (circle one) **Error: ±**______ **ft / m / pdop**

GPS within stand? Yes / No If No, cite from GPS to stand: distance (m) _____ bearing ° _____ inclination ° _____
and record projected UTMs: UTME ____ ____ ____ ____ ____ ____ UTMN ____ ____ ____ ____ ____ ____ ☐

Elevation: ft / m **Camera Name/Photograph #'s**: ☐

Stand Size (acres)**: <1, 1-5, >5 | Plot Size** (m^2)**: 10 / 100 / 400 / 1000 | Plot Shape** ___ **x**___ ft / m **or Circle Radius**____ft / m ☐

Exposure, Actual °: ______ **NE NW SE SW Flat Variable All | Steepness, Actual °:** ______ **0° 1-5° 5-25° > 25** ☐

Topography: Macro: top upper mid lower bottom | Micro: convex flat concave undulating ☐

Geology code: _____________ **Soil Texture code:** ______________ **| Upland** or **Wetland/Riparian** (circle one) ☐

% Surface cover: (Incl. outcrops) (>60cm diam) (25-60cm) (7.5-25cm) (2mm-7.5cm) (Incl sand, mud)

H20: BA Stems: Litter: Bedrock: Boulder: Stone: Cobble: Gravel: Fines: =100% ☐

% Current year bioturbation ______ **Past bioturbation present? Yes / No | % Hoof punch** ______ ☐

Fire evidence: Yes / No (circle one) If yes, describe in Site history section, including date of fire, if known. ☐

Site history, stand age, comments: ☐

Disturbance code / Intensity (L,M,H): _____/____ _____/____ _____/____ _____/____ _____/____ **"Other"** _______________ / ____ ☐

II. HABITAT AND VEGETATION DESCRIPTION

Tree DBH : T1 (<1" dbh), **T2** (1-6" dbh), **T3** (6-11" dbh), **T4** (11-24" dbh), **T5** (>24" dbh), **T6** multi-layered (T3 or T4 layer under T5, >60% cover) ☐

Shrub: S1 seedling (<3 yr. old), **S2** young (<1% dead), **S3** mature (1-25% dead), **S4** decadent (>25% dead) ☐

Herb: H1 (<12" plant ht.), **H2** (>12" ht.) **Desert Riparian Tree/Shrub: 1** (<2ft. stem ht.), **2** (2-10ft. ht.), **3** (10-20ft. ht.), **4** (>20ft. ht.) ☐

Desert Palm/Joshua Tree: 1 (<1.5" base diameter), **2** (1.5-6" diam.), **3** (>6" diam.) **% NonVasc cover:**____ **% Vasc Veg cover:**______ ☐

% Cover: Conifer tree / Hardwood tree: _____/_____ **Regenerating Tree:** _____ **Shrub:** _____ **Herbaceous:** _____ ☐

Height Class: Conifer tree / Hardwood tree: _____/_____ **Regenerating Tree:** _____ **Shrub:** _____ **Herbaceous:** _____

Height classes: 01=<1/2m 02=1/2-1m 03=1-2m 04=2-5m 05=5-10m 06=10-15m 07=15-20m 08=20-35m 09=35-50m 10=>50m

Species, Stratum, and % cover. Stratum categories: T=Tree, S = Shrub, H= Herb, E = SEedling, A = SApling, N= Non-vascular.
% cover intervals for reference: <1%, 1-5%, >5-15%, >15-25%, >25-50%, >50-75%, 75%. ☐

Strata	**Species**	**% cover**	C	**Strata**	**Species**	**% cover**	C

Unusual species: ____

III. INTERPRETATION OF STAND

Field-assessed vegetation alliance name: ______________________________________ ☐

Field-assessed association name (optional): ______________________________________ ☐

Adjacent alliances/direction: ________________________/__________, ________________________/________ ☐

Confidence in alliance identification: L M H Explain: ______________________________________ ☐

Phenology (E,P,L)**: Herb Shrub Tree Other identification or mapping information:** ☐

CNPS and CDFW Combined Vegetation Rapid Assessment and Relevé Field Form

RELEVE SPECIES SHEET (Revised 2/27/2014)

Page _______ of Polygon/Stand #: ____________

Stratum categories: T = Tree, S = Shrub, H = Herb, E = SEedling, A = SApling, and N=Non-vascular
% Cover Intervals for reference: r = trace, + = <1%, 1-5%, >5-15%, >15-25%, >25-50%, >50-75%, >75%

Strata	Vascular plant name or lichen/bryophyte	% Cover	Collection	Final species determination (or DBH)

Appendix 3.5C

FID	VEGNAME	HETEROGEN	HEIGHT	SHRUBCOV	HERBCOV	ARUNDO	EUTE	RICO	GLCO	CAED	BRNI	NATIVE	NON_NATIVE	BAREGROUND	COMMENTS
0	Salix lasiolepsis alliance														
1	Salix lasiolepsis alliance														
2	Cortaderia selloana stand														
3	Cortaderia selloana stand														
4	Cortaderia selloana - Salicornia pacifica mu														
5	Typha spp. alliance														
6	Cortaderia selloana stand														
7	Salix lasiolepsis alliance														
8	Glebionis coronaria mu														
9	Baccharis salicifolia alliance														
10	Clematis lingusticifolia mu														
11	Salicornia pacifica alliance														
12	Ricinus communis - Raphanus sativus mu														
13	Bromus diandrus - Avena spp. stand														
14	Encelia californica - Artemesia californica association														
15	Artemesia californica alliance														
16	Isocoma menziesii alliance														
17	Schoenoplectus (S. americanus, Bulboschoenus maritimus, B. robustus) mu														
18	Salicornia pacifica alliance														
19	Salicornia pacifica - Symphyotrichum subulatum mu														

Appendix 3.5D