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## **Fine-Scale Vegetation Classification, Mapping and Rare Plant Monitoring in the Sierra Nevada Foothills**

### ***Introduction***

The Sierra Foothills region includes the longest continuous block of California hardwood woodland in the world (Figure 1). According to Ricketts (1991), the region is considered to be part of the "California Interior Chaparral," a globally outstanding and highly biologically distinct ecoregion. The protection of remaining habitat and extensive restoration of oak woodlands, grasslands and riparian systems of the Sierra Nevada foothills support high numbers of plant and wildlife species. Many of these species are at risk; CNDDDB has records for 176 such taxa in the foothills (CDFG 2003). Vegetation communities of the foothills also provide critical wintering habitat for animal species that inhabit the higher elevations of the Sierra Nevada in the summer. However, the region is largely in private ownership and is under increasing development pressure from both suburban encroachment (particularly in the Sacramento and Fresno areas) and subdivision for rural ranchettes and summer homes. For these reasons, DFG leadership has determined this region is a high priority for resource assessment.

Figure 1. Typical scene in the Sierra Foothills Ecoregion west of Mariposa, Mariposa Co.

A fine-scale vegetation classification and map can serve as a surrogate for wildlife and plant habitat for many species, and thus as the baseline for monitoring habitat quality and quantity. Such a map and classification can also facilitate planning for wildlife resource assessment by identifying potential habitat for surveys and allowing habitat stratification for monitoring and sampling. However, no such map and classification currently exist for the Sierra Nevada foothills. The best landcover/vegetation data available is compiled by the California Department of Forestry and Fire Protection (CDF) and the U.S. Forest Service (USFS) Remote Sensing Lab (CDF 2003). Although this vegetation data is the best currently available, the largest portion of the foothills area is depicted in maps based on 30 meter pixel satellite imagery and on a classification system that has little ground-truthing, representing only broad and well-known categories of vegetation or habitat. Many of the species of concern in the Sierra Foothills rely on fine-scale habitats such as riparian stringers, ephemeral wetlands, and certain combinations of vegetative cover that are not possible to depict at a minimum pixel size of 30 m. For multi-level decisions regarding conservation planning at local (watershed) and regional (Sierra Foothills) levels, maps need to be able to display detailed floristic and structural information that is thematically and spatially accurate (see comparative example of maps in Figure 2).

Vegetation classification work focused on the foothills has also been limited. The California Native Plant Society is currently producing a fine-scale vegetation map and classification of the Bureau of Reclamation's 4,000-acre Peoria Wildlife Area at New Melones Dam, which is within the Sierra Foothills region. Allen and Holzman (1991) described twelve blue oak (*Quercus douglasii*)-dominated vegetation communities in



California, based mostly on Vegetation Type Map (VTM) plots from the 1930s that included data on understory tree, shrub and herbaceous species and environmental factors. Seven of their blue oak types occur in the Sierra Nevada foothills. Their work related community structure to environmental variables and provided a subseries (sub-alliance) level classification they believed useful for linking research to management of these communities.

Detailed vegetation classification projects have been conducted in Yosemite (Figure 2), Sequoia, and Kings Canyon national parks and in portions of the National Forest lands of the Sierra Nevada. However, the majority of these federal lands lie outside of the formal foothill belt and their classifications only treat a minute portion of the foothills.

We propose to produce a fine-scale vegetation map and classification of the Sierra Nevada foothills (to the alliance and association level). To most accurately depict the habitat or likely suitable habitat for all species, it is best to work with the smallest and most precise units practicable. From those units, we will be more likely to depict potential or real habitat and ecosystem requirements for species of concern. It is very important to address the multiple scales of vegetation so we can work finely or broadly in the hierarchy to address habitat needs for sensitive species, as well as track significant changes in habitat quality over time (based on major plant species, structure, density, or seasonality of vegetative cover), not just on habitat name alone. Aggregating up from these smallest units of classification, we can have a flexible approach to define many more habitats for many more species.

Classifying vegetation at this scale relies on substantial quantitative vegetation sampling data collected in the field, which allows objective definitions for vegetation types. This facilitates repeatable map updates for monitoring and better modeling of wildlife habitat. It also allows aggregation and crosswalks to coarser classifications, such as CWHR and CalVeg. Such field sampling will also allow collection of vegetation or environmental characteristics that are important for species of concern.

The classification will follow the National Vegetation classification system developed by NatureServe (Grossman et al 1998) and adapted for California in *A Manual of California Vegetation* (Sawyer and Keeler-Wolf 1995 and new revisions in manuscript). This classification system addresses the hierarchical concerns mentioned above, and coupled with the mapping methodology developed for the National Park vegetation mapping protocol (<http://biology.usgs.gov/npsveg/classification/sect1.html>), enables the greatest flexible approach yet devised for mapping in the nation.

Mapping and classification at the level proposed will result in a product that will be useful for modeling and predicting plant and animal distributions and associated project impacts; monitoring and evaluating the status, health, and trends of wildlife; and identifying critical habitat and conservation priorities for endangered species. Other uses include developing land management plans and assessing risks of exotic species infestations, and identification of restoration or acquisition lands and reference sites for restoration projects. Changes in habitat type or acreage can be monitored because the map will be able to be updated in a standardized fashion; the vegetation keys we will provide will also facilitate change detection. The detailed field data records provide specific location information for rare or invasive plant species, and can serve as reference or baseline vegetation data.

***Applications to Plant and Animal Monitoring and the Foothills-wide Assessment.***



A properly designed vegetation sampling and mapping project can serve a multitude of purposes. With minor modification to the overall scheme of vegetation sampling and mapping, there are many additional components of the foothills-wide assessment planned by The Department, which can be tiered directly or indirectly from these vegetation data. Among these are:

- Using field locations for vegetation sampling to double for monitoring points for other sensitive plants and animals, i.e., co-locating vegetation and species monitoring points to detect change over time simultaneously at the species and community levels
- Modifying vegetation sampling protocols to be directly applicable for a wide range of habitat assessments for species of plants and animals of concern, e.g., collecting data on snag density, nesting hole cavities, and sightings of sensitive species while also collecting basic vegetation data on species cover and structure
- Using the resultant map as a tool for modeling habitat of different species by selecting the proper scale of classification unit and the proper attributes of the map to develop best predictors for locating various species with a variety of habitat requirements.

### ***Specific Application to Rare Plant Monitoring***

One of the specific applications not otherwise planned for the foothills assessment is rare plant monitoring. During the overall planning stage for the vegetation sampling, all records of rare plants in the CNDDDB will be reviewed. A subset of accessible plant locations will be identified for field inventory. Many of these CNDDDB locations have not been revisited for several years and their individual population structure and viability have not been thoroughly or recently studied. During the first field season of the vegetation project, a separate rare plant team will work with the vegetation teams to revisit these localities and, using a standardized protocol, amass current information on rare plant populations to set up a permanent baseline for status and trends.

In the second field season, following the development of the draft vegetation map, additional likely sites will be identified based on habitat modeling for specific rare plant species. These modeled locations will be identified using GIS analysis of vegetation, soils, geology, climatic, topographic, and other data. The rare plant monitoring team will locate these modeled locations and attempt to identify new populations of selected species and establish new baseline population monitoring for those successfully located, while simultaneously refining the habitat requirements of many species through testing their predictive habitat models.

### ***Study area and geographic scale***

The assessment area is defined here as the Sierra Nevada Foothills Section, as described in the USDA's Ecological Subregions of California (Miles and Goudey 1997), including all subsections (M261Fa-e) (see Figure 1). The area encompasses approximately 4.49 million acres, of which roughly 700,000 acres are developed (i.e., have housing densities up to one unit per 40 acres). Elevation ranges from 200 to 5,000 feet. Predominant vegetation communities include the Blue oak, Annual herb and grasslands, Needlegrass grasslands, Chamise, wedge-leaf ceanothus, Foothill pine, and Valley oak alliances (Miles and Goudey 1997). However based on the current state vegetation classification it is likely that there are over 240 different types of alliances or



association level classification units in the area. Numerous rivers and streams flow west from the Sierra Nevada, which are characterized by riparian vegetation such as the Arroyo willow and California sycamore alliances.

## **Methods**

This project will involve a field team and a photo interpreter team. The following general steps are envisioned for this project:

- 1) Inventory and Organize Imagery and Data (Photo Interpreter Team)
  - a) Inventory and organize all necessary imagery of the area usable within an ARC-View and ARC-Info Geographic Information System environment. This includes digital orthorectified aerial photographs of all areas to be mapped (Digital Orthophoto Quarter Quadrangles, existing true color photographs flown previously within the study area, segmented satellite imagery for the study area processed by the USFS remote sensing lab); existing digital vegetation maps; 30 m Digital Elevation Model; and all existing information on vegetation classification for the project area
- 2) Refine Vegetation Classification based on Field Sampling (Field Team)
  - a) Derive preliminary vegetation classification from published and unpublished information based on local data
  - b) Conduct field reconnaissance to refine classification and become familiar with their unique aerial photo signatures
  - c) Identify field sample sites using a combined GIS -based environmental stratification and opportunistic approach based on access to public and private lands
  - d) Conduct field sampling
    - i) Identify and document all plant communities to the alliance level or below, using the California Native Plant Society (CNPS) Vegetation Rapid Assessment Protocol
    - ii) Describe new plant alliances and associations using CNPS relevé method
  - e) Archive and classify vegetation data from sample sites
    - i) Store rapid assessment data in a Microsoft Access database at CDFG
    - ii) Store relevé data in the Web-based California Vegetation Information System
  - f) Develop a vegetation classification based on field samples, using hierarchical classification techniques (e.g. TWINSPLAN and Cluster Analysis).
    - i) Develop decision rules for each association and use these to assign vegetation names to all existing data.
    - ii) Develop key and descriptions for each vegetation type
- 3) Delineate Map Polygons in Sample Field Sites (Field team)
  - a) Delineate polygons of vegetation units across the study area by differentiating the aerial photo signatures that correspond to different vegetation types
  - b) Assign vegetation attributes to each polygon, digitize and geo-reference the polygons, and edit for quality control
  - c) Provide mapped information from sample sites to photo interpreter team
- 4) Identify Preliminary Photo Signature (Photo Interpreter Team)
  - a) Use digital imagery and any ancillary photography covering the study area to delineate preliminary vegetation units.



- 5) Field Reconnaissance (Field Team)
  - a) Conduct on-site visits to correlate the interpretation of the vegetation classification relative to the photo signatures
  - b) Establish repeatable correlations for use during the photo interpretation process. If necessary, the interpretations, mapping criteria, and/or classification will be modified.
  - c) Field check areas not previously delineated on the aerial photos, such as areas between initially selected sites, areas of noteworthy or unusual significance, or areas the photo interpreter deems important in transit from site to site
  
- 6) Rare Plant Survey (Field Team)
  - a) The first field season the rare plant survey team will visit selected known locations of rare plant populations in CNDDDB for detailed population monitoring.
  - b) The second field season, using the environmental stratification (see step 2c above) and preliminary results from the vegetation and habitat mapping, the rare plant team will employ habitat modeling to further select likely predicted habitat and search for further populations of rare plant taxa.
  
- 7) Photo Interpretation (Photo Interpreter Team)
  - a) After interim vegetation classification is developed, initiate photo interpretation.
  - b) Assign a mapping label (such as alliance, association complex, or "super" alliance), disturbance, and density code to each polygon delineated during this task.
  - c) Use descriptions and keys available for existing alliances to set the criteria for the interpretation of the vegetation units. Descriptions and keys for new classes that may emerge from the vegetation mapping process will be added by the field ecologists and provided to photo interpreters.
  - d) Interpret vegetation units across the entire study area using heads-up digitizing techniques using custom ArcView editing tools. Delineate to a minimum mapping unit (MMU) size of two acres. Where necessary, such as areas with critical habitats and critical water sources, delineate units to one-acre sizes.
  - e) Edgematch the vegetation delineations and codes between adjacent digital images to ensure that there are no gaps in the vegetation coverage.
  
- 8) Quality Control Prior to Field Checking (Photo Interpreter Team)
  - a) Conduct a comprehensive quality control effort to ensure the accuracy and completeness of the photo interpretations and delineations
  
- 9) Field Check and Field Revisions (Field Team)
  - a) Generate field-check edit plots containing both the vegetation delineations and project imagery for all problematic polygons.
  - b) Conduct field checks to ground-truth both specific polygons and general signatures on photos for which initial interpretation was complete.
  - c) Conduct a formal field accuracy assessment of the map, using a random sampling strategy. The field ecology team will collect accuracy assessment data across the entire fine-scale mapping area. Data will be sufficient to assess accuracy of all vegetation types determined to be important in this fine-scale effort. Strive to use the same plots as used in the medium-scale effort.
  
- 10) Quality Control After Field Checking (Photo Interpreter Team)



- a) Produce a set of edit-plots to verify accuracy of data capture and any revisions made to the database because of the field check effort.
- 11) Final Data Processing and Quality Control (Photo Interpreter Team)
- a) Convert individual data files into ArcInfo coverages and join them to create a single coverage of the entire study area.
  - b) Run automated quality checks to identify anomalies from joining process. Correct any resulting anomalies
- 12) Reporting (Field Team and CDFG staff)
- a) write detailed classification report including methods, results, descriptions, and keys to all vegetation types defined in the project
  - b) write detailed report on mapping including methods, crosswalks to field classification, report on accuracy assessment.

### **Equipment**

- a) Seven vehicles will be needed continuously during the first field season, and two more on a semi-regular basis for use by the field leaders. These vehicles are expected to come largely from DFG Headquarters and Regional RAP programs through the end of May/early June, when they will be used for existing RAP projects (e.g., Sierra meadows). The second field season will require 4 vehicles continuously and one on a semi-regular basis.
- b) Although some PDA's will in part be available through existing projects, at least ten more will need to be purchased. A total of 14 will be needed during the peak data collection in the first field season. Other equipment needed for each crewmember includes a camera, rangefinder, binoculars, storage media/cords, gps units, clipboard, and batteries.

### **Duration of Project**

Field sampling would begin during the last week of February, following initiation of the study, *provided sufficient lead time to allow hiring of field staff, collection of aerial photography, stratification of field samples, and acquisition of letters of permission to access private land* (since DFG employees must have written landowner permission). Two field seasons (from late February-August) will be required for data collection and map accuracy assessment.

The map and classification will take about 21 months to complete for the area. However, preliminary classification and delineation will proceed and interim products such as an interim classification, a database of all up to date sample locations with species composition summaries, and an interim quantitative classification will be available 13 months after the beginning of the project. If the fieldwork begins in late February of 2004, the fieldwork will be completed in summer 2005, and the map should be completed by December 31, 2005.

### **Products and Estimated Dates of Completion**



- Annual progress report, including include preliminary evaluation of project towards meeting initial objectives with recommendations (adaptive management). March 2005 (All dates herein assume a winter 2003/2004 start date).
- Fine-scale vegetation map GIS coverage of the Sierra Foothills Section, which will be archived and made available through WHDAB. Draft July 2005, final December 2005.
- Digital list of vegetation alliances and associations and crosswalks to other vegetation classifications as appropriate, including WHR. Preliminary available March 2005, Final December 2005.
- Keys and description of vegetation types to alliance and association level. Draft May 2005, final December 2005.
- Additions to the DFG Rapid Assessment database of all rapid assessment field samples. Cumulative and on-going.
- Additions to the CVIS database of all full relevé samples. Cumulative and on-going.
- Additions to the RA database of all rapid vegetation assessments. Cumulative and on-going.
- Additions to the CNDDDB of sensitive taxa occurrences. Cumulative and on-going.
- An assessment of map accuracy. Final assessment December 2005.
- A digital set of accuracy assessment plots in MS Access format. December 2005.
- The final product will be completed by January of 2006.
- Publication on detailed conservation assessment of the ecoregion based on map analysis and data collected.

### ***Collaborators***

DFG project leads will be Dr. Todd Keeler-Wolf and Diana Hickson, WHDAB and Melanie Gogol-Prokurat, HCPB.

DFG regional staff will be involved in landowner contact for access permission, field sampling, and accuracy assessment.

### ***Contractors:***

- Aerial Information Services (AIS) will provide air photo interpretation services to produce the vegetation GIS layer
- California Native Plant Society (CNPS) will provide approximately 1/3 to 1/2 of the necessary field crews, and provide assistance in classifying vegetation types and producing the vegetation GIS layer
- UC Davis Wildlife Health Center and Sacramento State Foundation or Hornet Foundation will provide between 1/2 and 2/3 of the field personnel for the project
- DFG WHDAB: Database storage and management and GIS support

### ***Other Agency Participants:***

Other landowning agencies in the Foothills region may provide field staff, land access, and aerial photography.



The USFS Remote Sensing Lab and the CDF FRAP will provide processed segmented satellite images for the entire area and will also provide their recently updated and produced digital vegetation maps for the foothills.

## ***Personnel Requirements and Funding from CDFG***

- Training of field crews for sampling techniques
- CDFG funding sources from RAP

## ***Issues to be Resolved***

- Obtaining existing aerial photographs from USFS/BLM
- Funding commitments outside of CDFG?
- Precise roles of Regional, headquarters, and contract staff in field data collection and data entry and processing.

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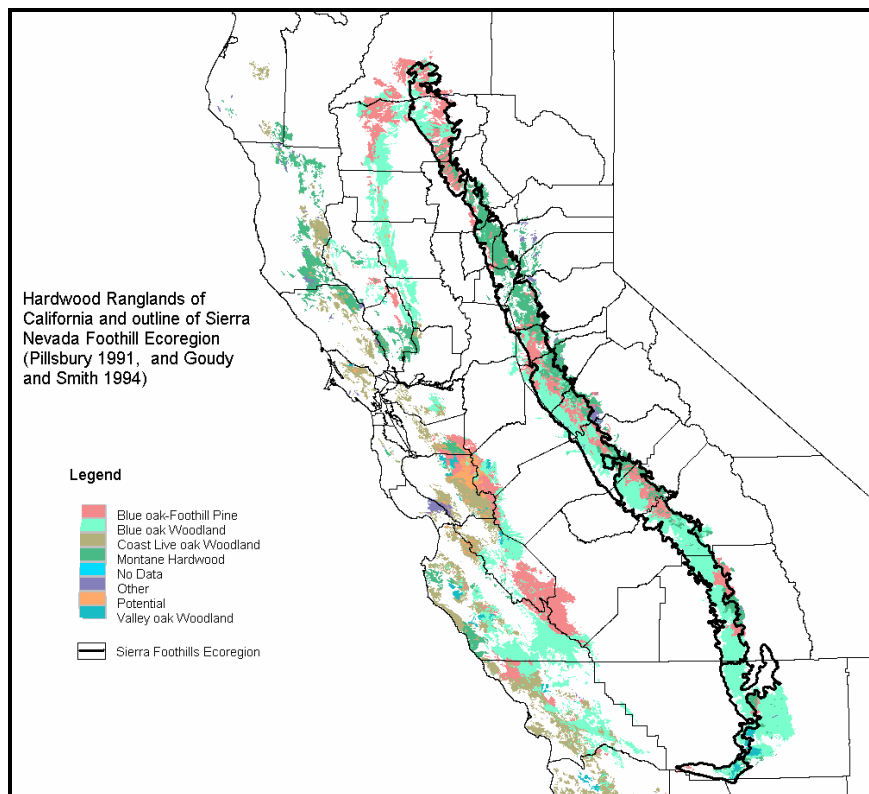


Figure 2. Map of Sierra Nevada foothill vegetation.