# CONSERVATION PLANNING BACKGROUND FOR THE REGION:

# *BERRYESSA – SNOW MOUNTAIN NATIONAL CONSERVATION AREA*

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# *Executive Summary*

This document is a planning report concerned primarily with identifying and describing approaches for conserving biological diversity in the region identified by Tuleyome as the *Berryessa – Snow Mountain National Conservation Area* (NCA). In the context adopted in this report, conservation means the long-term protection and facilitation of biological diversity, ranging from genetic variation among individuals through the range of variability among individual organisms to include the range of admixtures of species that occur on a landscape basis.

The proposed Berryessa – Snow Mountain NCA region incorporates gradients of biological richness as steep as any that may be found in California, as documented by the California Department of Fish and Game. The species richness in higher-elevation parts of the area is among the highest in California. The species richness in the region stems partly from the documented occurrences of plant species associated with serpentinitic substrates derived from the Coast Range Ophiolite in a number of locations in the NCA region. In addition, the region includes, in its highest elevations in the Mendocino National Forest, relict occurrences of plant species, more widespread in the region during the Pleistocene, with affinities for the dominant vegetation of the Klamath Mountains. A third major source of biological richness in the region results from the landscape's structural richness, which ranges from near sea level in the south to elevations above 7000 feet in the north, with a variety of exposures and aspects, over a region almost 100 miles long; this structural richness results in a diversity of habitat types throughout the region, which support a variety of plant and wildlife species.

The entire region has yet to be surveyed intensively for "sensitive" plant and wildlife species. Still, existing natural diversity database records indicate occurrences of at least 108 sensitive elements, appearing in 550 mapped occurrences (existing occurrences are identified in a supplementary report). Many elements are associated with serpentinitic substrates, others with relict vegetation occurrences, and still others with uncommon habitat elements (e.g., old-age forest stands).

Conservation planning generally includes three rather different, yet complementary, focuses, which reflect the overall trend of development of conservation biology:

- <u>Species-based planning</u>. One focus of biodiversity maintenance must remain the maintenance of uncommon species *per se*. In addition, this focus is embodied in a number of federal and state laws that affect all lands in the NCA area, but which specifically constrain the activities of federal land managing agencies, and consequently species-based planning must remain an element for the NCA. In a general sense, based on the occurrences of special-status species, the NCA region includes two high-priority conservation elements, one with abundant serpentinitic substrates and the other the high-elevation regions with remnant forests.
- <u>Habitat-based planning</u>. A second conservation planning focus addresses questions of the relative importance of different habitat types for a variety of species, since one focus of biodiversity maintenance is assuring that all native species are maintained in viable populations. Because of historical factors federal land managing agencies generally have requirements that include habitat-based planning. In the NCA region several important habitat types occur, including habitats that feature coniferous forests, oak woodlands, and riparian areas (areas associated with the transition from aquatic sites to upland).
- <u>Landscape-based planning</u>. Modern conservation planning builds upon the above categories to consider the importance of maintaining ecological processes throughout a region (i.e., a landscape) in order to maintain biological diversity in the region. This approach includes the identification (and

often the designation) of "reserve" areas and "linkages," and the "connectedness" of landscape elements is an important consideration for planning regionally.

These three focuses are interrelated and all should be incorporated into the conservation planning framework for the Berryessa – Snow Mountain region. The results that emerge when applying the different approaches to the region do not necessarily result in congruent identifications of importance for various elements in the landscape, or of the same degree of importance for any particular sub-region in the NCA area.

Several species-based conservation planning approaches have been applied in the Berryessa – Snow Mountain region, including the planning emphasized by the California Natural Diversity Database. These approaches have many champions, including conservationists interested in rare plants, birds, fish, or any of several other categories of "sensitive" species. In practical terms, species-based planning in the Berryessa – Snow Mountain region tends to emphasize the importance of serpentinitic substrates over most other habitat areas.

Habitat-based planning in the Berryessa – Snow Mountain region includes the management approaches used by federal and state management agencies, which is based on identifying associations between habitat types and the (numbers of) species that occur in them. Such approaches are facilitated with software-based applications that summarize the numbers of species having known associations with particular habitat types. Of the habitat types in the Berryessa – Snow Mountain region, the most significant appear to be oak-containing habitats, "riparian" habitats, and habitats dominated by conifers (Table ES-1). Because of the focus of this approach on total species numbers rather than numbers of "sensitive" species, habitat-based planning tends to assign conservation significance to different habitats in the region than does species-based planning.

**Table ES-1. Diversity-Habitat Associations in the Berryessa – Snow Mountain Region.**

| Group | Agricultural/Floodplain Basins [A] | Woodlands/Chaparral | Coniferous Forests |
|---|---|---|---|
| Native Plant Species | 719-838 | 1409 – 1705 [B] | 1409 – 1705 [B] |
| Vegetation Richness [C] | 26-35 | 36 - 53 | 54 - 82 |
| Amphibian Species | 4 - 6 | 7 -10 | 7 -10 |
| Reptile Species | 6 - 11 | 12 - 18 | 19 - 25 |
| Bird Species (Summer) | (91 – 108) [D] | 91 - 108 | 109 – 127 |
| Bird Species (Winter) | 144 - 187 | 118 - 143 | 91 - 117 |
| Mammal Species | 22 - 39 | 40 - 47 | 48 - 55 |

Notes
A Presumed to include species of riparian affinity.
B Mapping in the Atlas does not identify a diversity difference between woodland and forest areas in this region.
C Numbers of "Plant Alliances."
D Most breeding birds in agricultural regions are associated with remnants of natural habitat types, rather than with agricultural areas *per se*; see text.

Landscape-based conservation planning represents a further enhancement, because it recognizes that the spatial and functional relationships among landscape elements affect their value for conservation purposes. Landscape-based conservation planning generally includes elements of landscape ecology, because it has been demonstrated that the conservation values in a region are related to the size of the area protected, the general relationship between protected area and species richness in that region, and characteristics such as the contrast between protected areas and the remainder of the landscape (i.e., the "matrix"). Landscape-based planning typically includes landscape linkages to assure that species of concern are able to move within the landscape; this is an important element for planning in the Berryessa – Snow Mountain region owing to the likely effects of climate change in the region. The region currently includes extant landscape linkages that connect the Central Valley to the Interior Coast Range and the interior Klamath-Siskiyou Bioregion, and a primary benefit of the NCA will be that these existing linkages can be further strengthened in the region's planning. An early task for NCA management should be to document important biological and ecological resources in a fully developed conservation framework, an approach that can be developed using existing agency planning tools as well as special-purpose conservation modeling approaches.

At the present time landscape-based approaches are nearly universally adopted for conservation planning in California, primarily because this approach is comprehensive in its ability to address ecological factors influencing plant and wildlife populations. The approach is commonly enacted by designating "core reserves" that are established for the primary (or sole) purpose of maintaining ecological processes for conservationally important species. In the Berryessa – Snow Mountain region the reserves should include all special-purpose agency management areas with conservation or ecological focuses, such as Areas of Critical Environmental Concern (BLM) and Late Seral Reserves (USFS). Reserves are commonly interconnected by designated "corridors" or "linkages," and the reserves/linkages are commonly bounded by "buffer areas" of restricted use that separate the protected areas from a non-protected "matrix." In implementing this approach, federal management agencies will need to manage high-priority habitat areas for the protection of biological diversity, while still managing the remainder of the landscape appropriately to protect habitat values therein (Table ES-2).

**Table ES-2. Landscape-Level Conservation Plan Guidelines.** [A]

| **"Reserves/Linkages:"** |
|---|
| Prohibit new road construction or reconstruction of existing roads. |
| Close all pre-existing roads other than major highways; restore roadbeds to prior conditions. Reduce overall road density to be less than 0.5 miles road / square mile of Reserve. |
| Prohibit off-highway vehicles (including bicycles). |
| Limit or prohibit horses in Reserve areas (horses introduce exotic species). |
| Prohibit grazing or agricultural activities (they result in exotic species introductions). |
| Prohibit logging and any other commercial extraction of plants or biological materials. |
| Prohibit commercial extraction of other natural objects. |
| Prohibit mineral or energy leasing. |
| Restore degraded areas, particularly areas associated with sensitive species and those associated with aquatic ecosystem elements. |
| Eliminate invasive species. |
| Limit fire suppression; encourage controlled fire for restoration purposes. |
| Recreational activities such as hiking, primitive camping, nature study, environmental education, non-motorized restoration of degraded areas, and non-manipulative research are encouraged. |
| Eliminate inholdings. |
| **Multiple-Use Landscape/Buffer:** |
| Limit new road construction to those consistent with protecting Reserve environmental resource values. Reduce or maintain overall road density to be less than 1.0 miles road / square mile of multiple-use landscape. |
| Prohibit motorized off-high vehicles. |
| Protect environmentally important resources, particularly riparian areas, oak woodlands, and habitats for sensitive species. |

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|---|
| Vegetation manipulation, including grazing, logging, or other extractive activities, must be consistent with restoration and management goals for protecting Reserve environmental resource values.<br>Restore degraded areas, particularly areas associated with sensitive species and those associated with aquatic ecosystem elements.<br>Eliminate invasive species.<br>Manage fire suppression to be consistent with protecting Reserve environmental resource values.<br>Recreational activities, including hiking, low-impact camping, nature study, environmental education, non-motorized restoration of degraded areas, and non-manipulative research are encouraged.<br>Eliminate inholdings, or establish easement restraints over inholdings. |
| **"Matrix:"** |
| Require sustainable resource management approaches, including those for grazing and timberland management.<br>Manage environmentally important resources for conservation purposes, particularly riparian areas, oak woodlands, and habitats for sensitive species.<br>Restore degraded areas, particularly areas associated with sensitive species and those associated with aquatic ecosystem elements.<br>Control (eliminate if possible) invasive species. |

A Modified from Noss (1993).

A primary conservation concern in the Berryessa – Snow Mountain region is the potential effects on the region's biodiversity that will result from climate change. A coherent adaptive response to the effects of climate change has yet to be formulated in California. Projected impacts to ecological systems because of climate change include increased temperatures, more varied (and less predictable) precipitation, and increased fire frequencies and intensities. Based on ecological studies, an additional impact is clearly an increased invasion pressure from exotic (but not necessarily invasive) species.

The changes facing natural systems in California within this century are similar to (but perhaps more significant than) the changes that occurred in North America at the end of the Pleistocene glaciation. Ecological evidence about that period documents a dismantling of then-existing biological communities and a replacement assembly of functionally new communities of plants and animals. Projected effects for the current period of climate change include the assembly of "novel" ecosystems that do not necessarily resemble communities that currently exist (i.e., the development of "no-analog communities"). Evidence and scientific reasoning also indicate that many elements in these novel ecosystems will be exotic species that currently are adapted to human-modified parts of the California landscape.

The ecological changes that are likely to occur in the Berryessa – Snow Mountain region include the probable loss of important low-elevation community dominants, potentially including blue oak and valley oak. In addition, the vegetation that currently occurs at higher elevations in the northern part of the proposed NCA (which is ecologically and botanically significant) may be extirpated by changes associated with warming. The ecological dynamics associated with warming typically result in adaptive responses that cause species to move "poleward and upward;" while the oak species can be maintained at higher elevations north of their current distributions (probably in part as a consequence of strategic transplantation as a management response), the mountaintop species likely will be lost from the region.

From the perspective of biodiversity maintenance, the proposed Berryessa – Snow Mountain NCA represents a potential for assembling a coherent adaptive conservation response, given the orientation of the NCA area along a north-south axis, with the highest elevations more than 6000 feet higher than the elevations near the southern end. A unified management approach across this region, such as could be developed for a National Conservation Area, would help to assure that available adaptation options are acted upon. Some of these options may include active transplantation of desired species or life forms to suitable new locations in a climate-modified landscape, potentially including the transplantation into this region of desirable species that do not occur here now. Managing for ecosystem "resilience" in the climate-changed future is likely to involve providing an assurance that desired ecological functions (including providing habitat for wildlife and plant species) are maintained in the face of the likely dissolution of existing habitats, potentially by "designing" communities that include "redundant" species capable of "replacing" the functions of other species lost to the effects of changing climate.

Table ES-3 presents a summary of conservation planning considerations for the Berryessa – Snow Mountain region emphasizing concerns at species-, habitat-, and landscape-based levels, particularly as these concerns are affected by adaptation to the known or expected effects of climate change in this region.

**Table ES-3. Conservation Planning in the Berryessa – Snow Mountain region, tiered to address species-based, habitat-based, and landscape-based planning.**

| | |
|---|---|
| **A.** | **Species-Based Conservation Planning** |
| 1. | Initially, conduct field surveys to validate currently known distributions and densities of "sensitive" species in and adjacent to the NCA. Identify and document previously unrecorded occurrences of these species. Validate currently known occurrences of "special" habitat elements, including serpentinitic substrates, wetlands, and other habitat elements associated with "sensitive" species in and near the NCA. Identify previously unrecorded occurrences of these elements. |
| 2. | Among "sensitive" species in the NCA, assess species according to genetic importance for conservation purposes, including degree of relatedness among serpentine taxa, degree of differentiation of range-margin taxa from central populations, unique or very different adaptation complexes (e.g., insect-plant associations that differ from those elsewhere), and other genetically related conservation criteria. |
| 3. | Incorporate planning elements into NCA management that address "sensitive" species management under climate change, based on best available science, including elements required by federal or state laws and regulations (e.g., Endangered Species Act). Specifically incorporate genetic/evolutionary implications of actions or non-actions. |
| 4. | Monitor population status of "sensitive" species as they respond to climate change. Species with reduced but stable population sizes may not require direct intervention. For species appearing immanently endangered, develop and implement action plans to increase abundance, potentially including assisted migration to suitable habitat at other locations. |
| **B.** | **Habitat-Based Conservation Planning** |
| 1. | Initially, map existing habitat types in the NCA at least to the degree of classification used by the California Wildlife Habitat Relationships (CWHR) program or an equally effective habitat classification. If necessary, conduct field assessments that provide data to update uncertain assignments. Using the CWHR database or similar information, identify species richness expected in all of these habitats. |
| 2. | Implement a monitoring/assessment program that systematically, over time, samples habitats to verify use by wildlife. Identify important habitat functional elements, such as acorns/oaks, nesting cliffs, very large trees (old growth forest), significance for Neotropical migrant nesting, etc. |
| 3. | Incorporate into NCA management a program, based on best available science, to consider the dynamics of habitat changes, by area and by habitat value, which will result from climate change. Model the effects of changes in habitat area and habitat value on species distribution and population stability. Specifically consider "key" habitat types of highest value (e.g., riparian areas, oak-containing habitats, and coniferous forests). |
| 4. | Considering the dynamics of important habitat elements (e.g., blue oak, valley oak), develop strategies to address long-term changes in habitat conditions, potentially including assisted migration or active transplanting programs. Identify, using best available science, anticipated locations in NCA where transplanted elements would best thrive under changed climate conditions. |
| 5. | Identify "keystone" species in maintaining habitat values, and develop plans for maintaining the "resilience" of |

| | |
|---|---|
| | the habitats by "backing up" the functions provided by the keystone species (e.g., maintaining acorn production by assuring that additional native oak species are present in addition to keystone oak species) by introducing selected native species not currently present. |
| 6. | Develop elements for NCA management that address invasive species control or eradication. |
| **C** | **Landscape-Based Conservation Planning** |
| 1. | Establish a framework for a landscape-based conservation throughout the entire NCA based on existing conditions and information. All areas subject to existing administrative protections for conservation-related reasons, such as Late Seral Reserves, Research Natural Areas, and Areas of Critical Environmental Concern, should be included in this framework. Identify and map all species-rich locations in the NCA without respect to current administrative status; incorporate biologically significant locations not already in the conservation framework. |
| 2. | Establish a landscape-based modular reserve system that incorporates conservationally important areas in the NCA, with a system of "core reserves" and interconnecting "landscape linkages," with "buffers" that help to shield the conservation lands from adverse effects of activities in the rest of the landscape. Guidance for managing these lands should follow Table 4, except for "matrix" areas, which must be managed for increased internal habitat value as a functional response to climate change. Identify gaps in managed lands (e.g., private-land inholdings) that block or cut linkages; seek collaborative management or acquire lands to bridge/close gaps. Target degraded areas (e.g., logged areas or other incompatible land uses; landslides) for restoration of desired habitat conditions. |
| 3. | Incorporate "resilience" into NCA management by modeling the landscape changes that will occur because of climate change, based on best available science, particularly addressing the loss of "keystone" species throughout the landscape, and the potential increase in both fire frequency and severity. Based on the projections, identify potential fragmentation within core reserve and linkage elements, and develop methodology to repair the damage, possibly including introducing selected native species not currently present (i.e., identify functional roles and assure that native species are available to fill them). |
| 4. | Add "resilience" to the landscape by actively managing the landscape "matrix" to increase intrinsic habitat values within the matrix of lands not specifically designated as "core reserve," "corridor," or "buffer." With elements of these functions provided by the matrix, the integrity of the designated reserve system elements is augmented by a matrix that is "permeable" (i.e., not hostile) to mobile species, and the matrix also provides additional habitat values. The following actions, for example, increase the value of the matrix as habitat:<br>• Restore high-functioning ecological conditions to damaged/degraded/burned areas.<br>• Restore instream and riparian functions to aquatic features, while planning for future increases in peak flows and flood events; increase riparian "buffer zones" to be a least "two dominant tree-heights" in width.<br>• Include elements that increase the ecosystem functions provided by matrix lands for wildlife; e.g., incorporate oaks throughout the matrix, as well as establishing multi-hectare oak "nodes." |
| 5. | Increase landscape "resilience" by providing multiple designations of high-value "reserves," multiple "linkages," etc. The redundancy of landscape system elements will help the landscape system provide for conservation needs in the face of increased fire and other stressors. |
| 6. | Develop elements for NCA management that address invasive species control or eradication. |

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## 1.0 INTRODUCTION

This is a report about conservation planning in the region addressed by Tuleyome's proposed Berryessa – Snow Mountain National Conservation Area (NCA), particularly about conservation opportunities and constraints present in the area. As will be evident, the report is only secondarily concerned with occurrences of specific "sensitive elements" in the NCA region, although planning for the region will at some point have to consider the actual occurrences of plant and animal species (many of which are currently poorly documented owing to the lack of comprehensive biological and ecological studies in the region heretofore). The report is primarily concerned with framing a larger-scale perspective suitable to planning for conserving important biological and ecological resources in a major portion of the California landscape, particularly as that perspective incorporates the effects of changing climate.

"Conservation" in general parlance is understood to have two broad meanings. One conception is that conservation is the "wise use" of "natural resources," essentially a concern about how to produce "benefits" for some defined group of interested parties while fully exploiting the resources of interest. The other broad conception is that conservation is the protection of functional ecological integrity in a landscape, with a complete range of biological diversity present, from genetic elements through species to include landscape elements; this conception is allied with a "preservationist" motivation that seeks to maintain at least some "resources" inviolate or as protected from exploitation while being perpetuated indefinitely. It seems likely to me that these differing conceptualizations of "conservation" will both affect long-term planning in the Berryessa – Snow Mountain NCA, and that resolving the tension between the meanings (and their supporters) will be an important task in implementing an overall management plan for the area.

This report is primarily concerned with the latter conceptualization of "conservation," the idea that there are environmental resources that should be protected for intrinsic reasons. Further, this report is primarily concerned with the protection and perpetuation of biological diversity, the richness of species, genetic strains, plant and wildlife associations, biotic communities, and ecosystems that make up the living components of the natural heritage of all Americans, as this diversity occurs within and near the NCA. Other factors that could be addressed as elements of "conservation" in this sense include water quality *per se*, open space, recreational opportunity, and "heritage" or historical context, but these are topics for other reports.

Biodiversity protection, as a subject, has developed in the United States and in the international community largely since World War II, although the roots of the subject can be traced to work in the 1930s. Biodiversity protection is now a subject in which undergraduate and graduate degrees may be obtained through organized university curricula, and a number of useful texts exist. The general conservation subjects covered in this report are covered in greater detail in many of these texts. Nonetheless, I believe that it will be useful for a general comprehension of biodiversity conservation options in the Berryessa – Snow Mountain region to dig a little deeper into selected elements of the biology and ecology associated with biodiversity protection, as these relate specifically to region in which the NCA will exist.

One of the realities about the Berryessa – Snow Mountain region that quickly emerges from considerations like those in this report is that relatively little real information is available about many of the "places" within the region – there is a relative lack of knowledge about on-the-ground biological and ecological conditions in major parts of the NCA region. A lack of detailed knowledge is a significant hindrance to almost all types of conservation planning, and that's true for the NCA region. If one does not know what lives in various parts of the region, then one cannot really say what the most effective strategy might be for assuring the long-term conservation of those resources.

Another significant concern for conservation planning in the region (as with almost everywhere else) is composed of the potential effects on the region's biota and their ecology that will result from climate change. At the present time it's not possible to identify, with certainty, the effects that climate change will have on the biota of the region, although it's possible to project *potential* effects based on a general understanding of some of the effects of climate change on biota. It's also possible to identify some considerations for biodiversity conservation that might help to offset some of the impacts of climate change, and I do so in the final section of this report.

# 2.0 BIODIVERSITY CONSERVATION PLANNING APPROACHES FOR THE BERRYESSA – SNOW MOUNTAIN REGION

Conservation planning requires at least a broad-brush look at the specific biological and ecological values of concern in the area of interest. This information about real organisms and real landscapes must, however, be considered in relevant context, and conservation planning has evolved different approaches for identifying and considering relevant information. In this section I present summary information relating to three overlapping but nevertheless very different modes of conservation planning: (1) species-based, (2) habitat-based, and (3) landscape-based. In a conceptually (and historically) real sense these three modes represent a "clade" in planning for biodiversity protection, with species-based planning as a predecessor to the other modes and landscape-based planning more-or-less requiring both precursor modes. However, each subject area can function quite well as a separate focus of conservation interest, and all three modes are commonly used for various management purposes today.

*Species-based conservation planning* underlies various "listed-species" planning elements engaged by affected parties in order to meet the requirements of the federal Endangered Species Act, and in California the rather different California Endangered Species Act, as well as other approaches that are directed at particular species of wildlife and plants. Conservation planning in this mode is characteristically focused on the known or perceived needs of individual species, and other species are characteristically not addressed.

*Habitat-based conservation planning* is the basis for planning used by many federal land-managing agencies (e.g., the USDA Forest Service), owing in large part to the agencies' needs to address the management of the parcels of land that fall under the agencies' jurisdictions for a variety of purposes, only one of which is conservation. In this planning mode the focus of planning is most frequently (in my experience, at least) the incorporation of habitat needs for a variety of species (which may include various species of particular interest, but often not species "listed" under the ESA, which are treated separately), which may be grouped into categories that are thought to respond to habitat manipulations in similar ways. Typically the agencies assume formally (i.e., as an explicit part of the agencies' management approach) that the provision of habitat believed to provide for the needs of the wildlife and plant species will lead to the presence and ecological sustainability of those species. The overall planning focus in this mode is effectively (indicators of) the presence of all the species that occupy the landscape; sometimes agencies identify selected species to serve as "indicators" for the rest of the species, but the focus remains on all species collectively.

*Landscape-based conservation planning* is an innovation based on the recognition that habitat elements are affected by their relationships to each other, and that their conservation value depends on these interrelationships. That is, landscape-based conservation planning recognizes that ecosystem elements themselves interact, and that conserving ecosystem processes is an important element in conserving species and their habitats. An essential focus of this planning mode is on incorporating ecological processes into the planning framework. Because the processes are fundamentally tied to places in real landscapes, the achievement of landscape-based conservation plans is recognized by the identification and interrelationships of landscape elements that support the integrity of those ecological processes.

Specific landscape-based planning focuses frequently include the needs of "covered" species, especially to the degree that a covered species may require particular spatial relationships among habitat elements, but species *per se* are usually not the primary focus of landscape-based conservation plans. Landscape-based plans are more appropriately thought of as focused on maintaining ecological integrity, although they may explicitly adopt a focus on assuring the ecological integrity of one or more habitat types ("old-growth forests," oak woodlands); these plans focus on ecological processes and the representation of "minimum" ecosystem needs for "covered habitats."

These planning modes lead to differing considerations for conservation in the Berryessa – Snow Mountain region. All three modes are useful in understanding the conservation needs of the region, and ideally all three will play roles in developing conservation plans for the NCA (see, e.g., Schwartz 1999, Poiani et al 2000).

## 2.1 Background: Species-Based Conservation Planning

Because there are federal and state laws that address the conservation of identified species of plants, wildlife, and fish, and because these laws typically affect the operations of federal land management agencies, the initial perception that occurs to many people is that biodiversity conservation is primarily concerned with the protection or conservation of individual "sensitive" species. A dense regulatory apparatus has developed around this subject, and there's no question that species-based conservation will be an important element in the management of the NCA.

### 2.1.1 Information Sources

Conservation planning for any region must involve considerations of "species."[1] For historical reasons that are largely beyond the scope of this report, the legal framework for a great deal of the conservation planning work carried out in the United States is based on the general concept that certain species are "at risk" because of human activities.[2] This legal framework results in a particular focus on protecting those species and (for animals) their identified habitats. The primary vehicle for implementing this focus on federal lands is the federal Endangered Species Act (ESA; 16 USC §1531 *et seq*.), which constrains the activities of all federal land management agencies. In order to more easily implement the requirements of the ESA, federal management agencies generally incorporate its requirements into their operational manuals, so that managing the pubic lands inherently includes a focus on the needs of selected "sensitive" species (i.e., the species that are listed pursuant to federal law).

"Sensitive" species may be identified by one or more of a variety of additional criteria, including: (1) species that are listed under a state Endangered Species Act, such as the California Endangered Species Act (CESA; Fish & Game Code §2050 *et seq*.); (2) species that are listed or covered by one or more federal or state regulatory programs, such as the Migratory Bird Treaty Act (16 USC §701 *et seq*.) or the regulations adopted by individual federal land management agencies; and (3) species that are considered to be environmentally "at risk" by one or more non-profit conservation or professional organizations. This is not an all-inclusive listing of criteria that result in identifying such species, and the criteria are not necessarily interchangeable or always mutually compatible.

Sensitive species have therefore emerged as one of the primary indicators of significance in planning for biological diversity maintenance (but not the only indicator; see Section 3.0 below). Uncommon species may serve to indicate high habitat importance for "relictual" species, showing "hot spot" areas of high biological value (Stein and others 2000, CDFG 2003b). Uncommon species may also indicate an evolutionarily significant association with unusual habitat conditions, such as plant species evolved to tolerate ultramafic soils or reproduce within the hydrological constraints of vernal pool landscapes. Generally, uncommon species may be lost from a landscape fairly rapidly as a consequence of habitat

1 This report isn't about purely scientific or philosophical discussions, however fundamental they may be (although the report does consider some of the science underlying important conservation questions). In using the term "species" in this report I intend the term in a broad sense as it's used in biodiversity assessments and databases. This use includes taxonomic units recognized for conservation purposes that may not be recognized taxonomic "species," such as subspecies of plants that are recognized to be of conservation significance, or "evolutionarily significant units" (ESUs) of salmonids that have been recognized as important for addressing fishery conservation questions.

2 Wildlife and fishery management in the United States traditionally was focused on "harvesting" valuable "game" species. This traditional focus allocated most management decisions to state governments, which acted on behalf of their citizens, with the federal government's roles being primarily (1) to assure a balance and lack of discrimination among states in decisions about "harvesting" game species and (2) to regulate the "interstate commerce" in fishery- and wildlife-related commodities. A secondary federal role began to develop together with the establishment of land management responsibilities assigned to federal agencies, that role being to help manage public lands to meet habitat needs for wildlife that was "owned" by the states in which the federal lands occurred. The traditional "state ownership" doctrine was ended by the US Supreme Court in 1979 in *Hughes v. Oklahoma* (441 U.S. 322). Wildlife is now considered to be a "trust resource," with governments at all levels sharing a "trustee" role and acting on behalf of all citizens. See Bean and Rowland (1997) for additional information.

area reductions, habitat fragmentation, or other anthropogenic or natural processes. This is the essential reason why attention to "sensitive" plant and wildlife species is a valid conservation focus in many land use plans.

The practical identification of sensitive species occurrences is not without difficulties. Perhaps the most significant constraint is actually identifying the species, which are often inherently uncommon both geographically and in time, and identifications may require quite specialized knowledge. Aside from this difficulty, there is a well-known problem with "false negative" results: if a region that could host a sensitive species has not been searched relatively thoroughly during the appropriate seasons (or never searched), then the lack of evidence that the species is present is not a valid indication that the species is absent or that the region is not significant for that species.

Conservation agencies have developed approaches to overcome some of these uncertainties. Known occurrences of many uncommon species are included in the California Natural Diversity Data Base (CNDDB), a geographically based repository of sensitive species occurrence data maintained by the California Department of Fish & Game. The database is available as a computer software package, RareFind3 (CDFG 2003b), with regular online updating, which is widely used in environmental screening processes in California. The database consists of element occurrence information that has been reported to CDFG. An "element" is a sensitive species, or occasionally a sensitive habitat type.[3] An occurrence record is established when a reported occurrence is submitted to the CNDDB and accepted. Element occurrence records may be relatively general or quite location-specific.

A similar database has been developed for sensitive plant species, which is owned and maintained by the California Native Plant Society (CNPS).[4] There is good concordance between the CNPS database for sensitive plants and reported plant occurrence elements in the CNDDB. Both the CNPS database and the CNDDB are geo-referenced and the data may be used to identify element occurrences at least approximately (although occurrence data for some extremely sensitive species may be withheld).

The California Department of Fish and Game (CDFG) maintains a listing, available online, of wildlife "species of special concern," which constitutes a separate assessment of wildlife species sensitivity in California that is comparable to the CNPS database for plant species.[5] However, the "special concern" listing is not an occurrence database (although many element occurrences of "special concern" species are included in the CNDDB) and its use in site-specific conservation planning requires field assessments.

A variety of other indications of "special status" have evolved among members of the conservation community; a thorough explication of all of them is beyond the scope of this report. However, the elements of the "Partners in Flight" (PIF) program are worth noting, given that the PIF is a collaborative effort of many federal and state wildlife and conservation agencies, professional and amateur ornithological societies, and non-profit conservation organizations with a focus on birds. PIF was launched in 1990 in response to concerns about declines in the populations of many land bird species. The initial PIF focus was on Neotropical migrants, but the focus has broadened to include most landbirds

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3 The Sawyer and Keeler-Wolf (1995) manual incorporates sensitivity ratings for vegetation series from the unpublished "Holland" list. Generally, a vegetation series that is uncommon may be considered to be a "sensitive" element. This classification was subsequently revised and the successor is used by biologists to identify "sensitive" plant associations in California. See URL: http://www.dfg.ca.gov/biogeodata/vegcamp/natural_communities.asp (viewed November 2008).

4 See URL: http://www.cnps.org/cnps/rareplants/ (viewed November 2008).

5 See URL: http://www.dfg.ca.gov/wildlife/species/ssc/index.html (viewed November 2008).

and other species requiring terrestrial habitats. PIF has developed an overview landbird conservation plan for North America, which acts as a kind of "master plan" for bird conservation.[6]

In California the PIF overview has been developed further by California Partners in Flight (CalPIF), and the continental focus has been augmented and implemented by the development of a number of habitat-specific bird-conservation plans, including a *grasslands* plan (CalPIF 2000), a *chaparral* plan (CalPIF 2004, an *oak woodland* plan (CalPIF 2002a), a *coniferous forests* plan (CalPIF 2002b), and a *riparian habitat* plan (RHJV 2004). While these plans are written to identify conservation needs in a series of habitat types in California, the intrinsic focus of each plan is actually on bird species that occupy each of the habitats. In my opinion these bird habitat conservation plans are among the more significant species-based conservation planning documents applicable to California landscapes.

### 2.1.2 Population and Genetic Concerns for Species-Based Planning

In an essential sense all conservation planning is species-based, and the overarching goal of all species-based planning is the long-term viability of the species of concern. A vast literature has been compiled during the past three decades concerning the conditions that sustain the existence of these targets. Providing even a gross overview of this literature would greatly exceed the scope of this report. However, it's clearly necessary to take note of this work, since these results directly concern population-based conservation planning in the Berryessa – Snow Mountain region..

There are two essential threads that interweave with respect to the viability of species that are the subjects of conservation planning (see, e.g., Frankel and Soulé 1981, Soulé 1987, and Meffe and Carroll 1994): (1) *dynamic population concerns* in the strict sense, which are related to the numbers and spatial distribution of individuals that are available to maintain the existence of the population in space and time; and (2) *genetic constraints* associated with small populations, which may include inbreeding-related loss of fitness, a direct reduction in physiological capability owing to the accumulation and expression of deleterious genes, or a loss of adaptive traits resulting from a loss of genetic variability from the population that reduces its capability to respond to environmental variations. These are interrelated concerns, but their study is often concentrated in separate, rather specialized disciplines.

These concerns have become associated with the term "population viability assessment," which incorporates elements of both. There is a demographic element that is generally focused on identifying factors that limit the numbers of individuals, through focusing on predation, excessive mortality because of physical factors or disease, and other conditions that reduce population sizes. The genetic focus has come to be embodied in a concept known as "effective population size" ($N_e$), which relates to the numbers of reproductive individuals in the population through time. Some species have effective population sizes substantially less than the numbers of adult individuals present, owing to behavior characteristics of the species that increase their extinction risks at low absolute population levels (for example, reproduction dominated by behaviorally dominant members of one sex effectively reduces the number of individuals of that sex).

In the Berryessa – Snow Mountain region a number of the species of conservation concern are (nominally) uncommon plant species that occur in small localized populations. Each of the local populations is potentially exposed to increased extinction risk because of demographic effects (i.e., those related to small population size) or to random variations in the physical environment. Even when population sizes are large enough that "random" effects are unlikely to lead to localized extinction, the genetic effects of small population size remain a concern. Susan Harrison at UC Davis has worked extensively on these populations and her work should be consulted for specific relevance in the region.

6 See URL: http://www.partnersinflight.org/cont_plan/default.htm (viewed November 2008).

It should also be noted in passing that the context of small, localized populations that may periodically be extirpated but subsequently re-established through colonization from one or more of the other localized sub-units could support a particular kind of population biology known as a “metapopulation.” This term (originally attributed to Levins 1969) refers to a kind of distributed population that has regular extinction-recolonization dynamics among its constituent population sub-units. A more accurate understanding might be that there is a variety of population structures that involve elements of metapopulation dynamics (see Harrison and Taylor 1997), and that many of these dynamic contexts are associated with species of conservation concern.

### 2.1.3 Examples of Species-Based Planning in the NCA Region

California Natural Diversity Database. The element occurrences included in the California Natural Diversity Database constitute an initial survey of species-based conservation priorities for the Berryessa – Snow Mountain region. As background for this report I queried the database for sensitive element occurrences in 28 7.5-minute USGS quadrangles that include the federal lands and immediately adjoining private lands for the region between Putah Creek and Lake Berryessa on the south and the northern boundary of the Snow Mountain Wilderness on the north. The results (identified as Attachment B) are not included in this report owing to the length of the report, but have been provided to Tuleyome separately, and include 108 different elements in 550 (presumed extant) element occurrences. The element occurrences are summarized in Table 1, without detailed summaries of how often each element occurred or where the occurrences are located (see Attachment B for that information).

**Table 1. Summary of Element Occurrences Included in the California Natural Diversity Database for a 28-Quad region including the Berryessa – Snow Mountain Region.**

| Common Name | Scientific Name | ESA/CESA/ CDFG/CNPS [1] |
|---|---|---|
| **Plants** | | |
| Bent-flowered fiddleneck | *Amsinckia lunaris* | --/--/--/1B |
| Scabrid alpine tarplant | *Anisocarpus scabridus* | --/--/--/1B |
| Dimorphic snapdragon | *Antirrhinum subcordatum* | --/--/--/4 |
| Sonoma canescent manzanita | *Arctostaphylos canescens* ssp *sonomensis* | --/--/--/1B |
| Konocti manzanita | *Arctostaphylos manzanita* ssp *elegans* | --/--/--/1B |
| Jepson’s milk-vetch | *Astragalus rattanii* var *jepsonianus* | --/--/--/1B |
| Brittlescale | *Atriplex depressa* | --/--/--/1B |
| San Joaquin spearscale | *Atriplex joaquiniana* | --/--/--/1B |
| Big-scale balsamroot | *Balsamorhiza macrolepis* var *macrolepis* | --/--/--/1B |
| Scalloped moonwort | *Botrychium crenulatum* | --/--/--/2 |
| Narrow-anthered California brodiaea | *Brodiaea californica* var *leptandra* | --/--/--/1B |
| Indian Valley brodiaea | *Brodiaea coronaria* ssp *rosea* | --/CE/--/1B |
| Round-leaved filaree | *California macrophylla* | --/--/--/1B |
| Small-flowered calycadenia | *Calycadenia micrantha* | --/--/--/1B |
| Mt. Saint Helena morning-glory | *Calystegia collina* ssp *oxyphylla* | --/--/--/4 |
| Coast range bindweed | *Calystegia collina* ssp *tridactylosa* | --/--/--/1B |
| Coastal bluff morning-glory | *Calystegia purpurata* ssp *saxicola* | --/--/--/1B |

| Common Name | Scientific Name | ESA/CESA/ CDFG/CNPS [1] |
|---|---|---|
| Porcupine sedge | *Carex hystericina* | --/--/--/2 |
| Pink creamsacs | *Castilleja rubicundula* ssp *rubicundula* | --/--/--/1B |
| Rincon Ridge ceanothus | *Ceanothus confusus* | --/--/--/1B |
| Holly-leaved ceanothus | *Ceanothus purpureus* | --/--/--/1B |
| Pappose tarplant | *Centromadia parryi* ssp *parryi* | --/--/--/1B |
| Stony Creek spurge | *Chamaesyce ocellata* ssp *rattanii* | --/--/--/1B |
| Dwarf soaproot | *Chlorogalum pomeridianum* var *minus* | --/--/--/1B |
| Serpentine cryptantha | *Cryptantha clevelandii* var *dissita* | --/--/--/1B |
| Deep-scarred cryptantha | *Cryptantha excavata* | --/--/--/1B |
| Norris' beard moss | *Didymodon norrisii* | --/--/--/2 |
| Dwarf downingia | *Downingia pusilla* | --/--/--/2 |
| Snow Mountain willowherb | *Epilobium nivium* | --/--/--/1B |
| Brandegee's eriastrum | *Eriastrum brandegeeae* | --/--/--/1B |
| Tracy's eriastrum | *Eriastrum tracyi* | --/--/--/1B |
| Greene's narrow-leaved daisy | *Erigeron angustatus* | --/--/--/1B |
| Snow Mountain buckwheat | *Eriogonum nervulosum* | --/--/--/1B |
| Adobe-lily | *Fritillaria pluriflora* | --/--/--/1B |
| Boggs Lake hedge-hyssop | *Gratiola heterosepala* | --/CE/--/1B |
| Hall's harmonia | *Harmonia hallii* | --/--/--/1B |
| Glandular western flax | *Hesperolinon adenophyllum* | --/--/--/1B |
| Two-carpellate western flax | *Hesperolinon bicarpellatum* | --/--/--/1B |
| Brewer's western flax | *Hesperolinon breweri* | --/--/--/1B |
| Lake County western flax | *Hesperolinon didymocarpum* | --/CE/--/1B |
| Drymaria-like western flax | *Hesperolinon drymarioides* | --/--/--/1B |
| Napa western flax | *Hesperolinon* sp nov *"serpentinum"* | --/--/--/1B |
| Bolander's horkelia | *Horkelia bolanderi* | --/--/--/1B |
| Northern California black walnut | *Juglans hindsii* | --/--/--/1B |
| Burke's goldfields | *Lasthenia burkei* | FE/CE/--/1B |
| Contra Costa goldfields | *Lasthenia conjugens* | FE/--/--/1B |
| Colusa layia | *Layia septentrionalis* | --/--/--/1B |
| Legenere | *Legenere limosa* | --/--/--/1B |
| Jepson's leptosiphon | *Leptosiphon jepsonii* | --/--/--/1B |
| Red-flowered bird's-foot-trefoil | *Lotus rubriflorus* | --/--/--/1B |
| Anthony Peak lupine | *Lupinus antoninus* | --/--/--/1B |
| Milo Baker's lupine | *Lupinus milo-bakeri* | --/CT/--/1B |
| Cobb Mountain lupine | *Lupinus sericatus* | --/--/--/1B |
| Robust monardella | *Monardella villosa* ssp *globosa* | --/--/--/1B |
| Baker's navarretia | *Navarretia leucocephala* ssp *bakeri* | --/--/--/1B |

| Common Name | Scientific Name | ESA/CESA/ CDFG/CNPS [1] |
|---|---|---|
| Few-flowered navarretia | *Navarretia leucocephala* ssp *pauciflora* | FE/CE/--/1B |
| Many-flowered navarretia | *Navarretia leucocephala* ssp *plieantha* | FE/CE/--/1B |
| Marin County navarretia | *Navarretia rosulata* | --/--/--/1B |
| Slender orcutt grass | *Orcuttia tenuis* | FT/CT/--/1B |
| Sonoma beardtongue | *Penstemon newberryi* var *sonomensis* | --/--/--/1B |
| Eelgrass pondweed | *Potamogeton zosteriformis* | --/--/--/2 |
| Lake County stonecrop | *Sedella leiocarpa* | FE/CE/--/1B |
| Marin checkerbloom | *Sidalcea hickmanii* ssp *viridis* | --/--/--/1B |
| Marsh checkerbloom | *Sidalcea oregana* ssp *hydrophila* | --/--/--/1B |
| Red Mountain catchfly | *Silene campanulata* ssp *campanulata* | --/CE/--/4 |
| Freed's jewel-flower | *Streptanthus brachiatus* ssp *hoffmanii* | --/--/--/1B |
| Green jewel-flower | *Streptanthus breweri* var *hesperidis* | --/--/--/1B |
| individual subspecies | *Streptanthus morrisonii* | --/--/--/-- |
| Alpine crisp moss | *Tortella alpicola* | --/--/--/2 |
| **Invertebrates** | | |
| Valley elderberry longhorn beetle | *Desmocerus californicus dimorphus* | FT/--/--/-- |
| Molestan blister beetle | *Lytta molesta* | --/--/--/-- |
| San Francisco lacewing | *Nothochrysa californica* | --/--/--/-- |
| Wilbur Springs minute moss beetle | *Ochthebius recticulus* | --/--/--/-- |
| Wilber Springs shore fly | *Paracoenia calida* | --/--/--/-- |
| Wilbur Springs shorebug | *Saldula usingeri* | --/--/--/-- |
| Serpentine cypress wood-boring beetle | *Trachykele hartmani* | --/--/--/-- |
| Serpentine cypress long-horned beetle | *Vandykea tuberculata* | --/--/--/-- |
| **Fish** | | |
| Sacramento perch | *Archoplites interruptus* | --/--/SC/-- |
| Clear Lake hitch | *Lavinia exilicauda chi* | --/--/SC/-- |
| **Amphibians and Reptiles** | | |
| Foothill yellow-legged frog | *Rana boylii* | --/--/SC/-- |
| California red-legged frog | *Rana draytonii* | FT/--/SC/-- |
| Northwestern pond turtle | *Actinemys marmorata marmorata* | --/--/SC/-- |
| **Birds** | | |
| Cooper's Hawk | *Accipiter cooperi* | --/--/--/-- |
| Northern Goshawk | *Accipiter gentilis* | --/--/SC/-- |
| Tricolored Blackbird | *Agelaius tricolor* | --/--/SC/-- |
| Golden eagle | *Aquila chrysaetos* | --/--/--/-- |
| Burrowing owl | *Athene cunicularia* | --/--/SC/-- |
| Prairie Falcon | *Falco mexicanus* | --/--/--/-- |
| American Peregrine Falcon | *Falco peregrinus anatum* | FD/CE/--/-- |

| Common Name | Scientific Name | ESA/CESA/ CDFG/CNPS [1] |
|---|---|---|
| Bald Eagle | *Haliaeetus leucocephalus* | FD/CE/--/-- |
| Yellow-breasted Chat | *Icteria virens* | --/--/SC/-- |
| Bank Swallow | *Riparia riparia* | --/CT/--/-- |
| **Mammals** | | |
| Pallid bat | *Antrozous pallidus* | --/--/SC/-- |
| Townsend's big-eared bat | *Corynorhinus townsendii* | --/--/SC/-- |
| Silver-haired bat | *Lasionycteris noctivagans* | --/--/--/-- |
| Hoary bat | *Lasiurus cinereus* | --/--/--/-- |
| long-eared myotis | *Myotis evotis* | --/--/--/-- |
| Yuma myotis | *Myotis yumanensis* | --/--/--/-- |
| Humboldt marten | *Martes americana humboldtensis* | --/--/SC/-- |
| Pacific fisher | *Martes pennanti (pacifica) DPS* | FC/--/SC/-- |
| San Joaquin pocket mouse | *Perognathus inornatus inornatus* | --/--/--/-- |
| **Community Types** | | |
| Alkali Seep | | --/--/--/-- |
| Great Valley Mixed Riparian Forest | | --/--/--/-- |
| Northern Basalt Flow Vernal Pool | | --/--/--/-- |
| Northern Interior Cypress Forest | | --/--/--/-- |
| Northern Vernal Pool | | --/--/--/-- |
| Serpentine Bunchgrass | | --/--/--/-- |
| Wildflower Field | | --/--/--/-- |

Notes: **1** FE – Federal Endangered; FT – Federal Threatened; FC – Federal Candidate Species; FD – Federal Delisted; CE – California Endangered; CT – California Threatened; SC – DFG Special Concern Species; 1B – CNPS List 1B, "Rare, Threatened, or Endangered in California and Elsewhere;" 2 – CNPS List 2, "Rare, Threatened, or Endangered in California but More Common Elsewhere."

Federal ownership is indicated for 142 of the element occurrences, and these occurrences would presumably be subject to all conservation policies included within the NCA management direction.[7] However, the CNDDB also includes georeferenced maps of the element occurrences, and the pattern of occurrences in the resulting plot (not included in Attachment B) suggests fairly strongly that there are areas (including many areas of federal land within the proposed NCA) that have few or no occurrence records. Most likely this likely indicates a high rate of "false negatives." That is, for the Berryessa – Snow Mountain region there is reason to believe that sampling patterns for "heritage" species have not been particularly thorough, so that the observed occurrences of "heritage" species in the region as a whole may not reflect the actual distribution patterns or abundances of those species. As will be addressed more fully below, this is a primary concern in using "heritage" data as the major (or even the sole) basis for regional conservation planning, although this species-based focus is a required element in any such effort.

7 Lands owned by other governments account for 17 additional occurrences, while private ownership is indicated for 151 occurrences; the ownership status of the other 240 element occurrences is listed as "unknown."

Blue Ridge Berryessa Natural Area Conservation Partnership (BRBNACP). The Berryessa – Snow Mountain region currently exhibits a nominal example of comprehensive species-based conservation planning, presented by the BRBNACP.[8] As summarized in the following section of this report, the Berryessa – Snow Mountain region includes widespread occurrences of "ultramafic" substrates, which are associated with a number of "sensitive" plant species. The BRBNACP issued a "conservation framework" that includes a map of "biodiversity priorities," a portion of which is illustrated in Figure 1. In this "priorities" map the warmer colors (red and orange) represent areas a higher priority for biodiversity protection than do areas portrayed with cooler colors (greens and light blue).

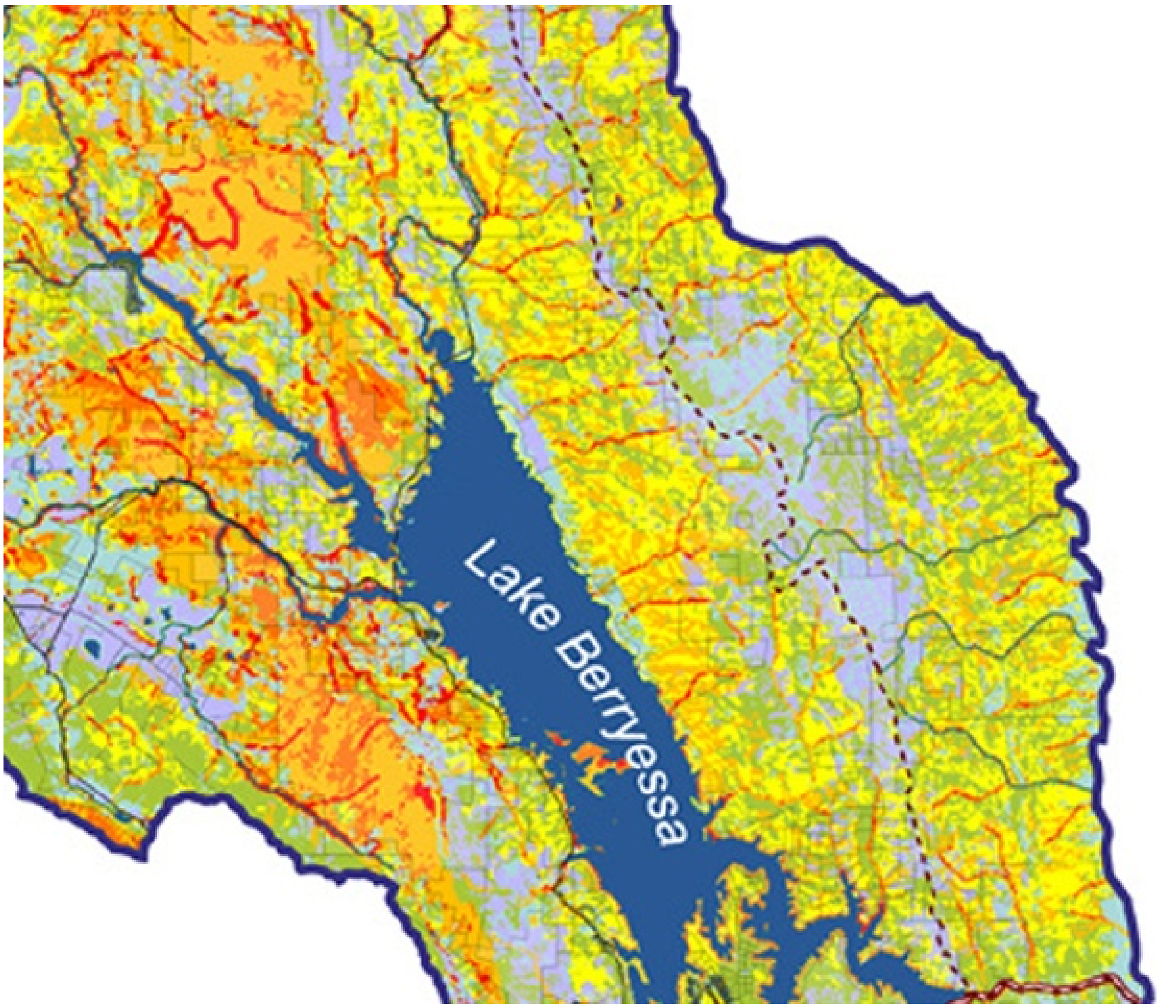


*Figure 1. Excerpt from the BRBNACP Conservation Priorities Map (Figure 5-9 of the BRBNACP Framework report). The excerpted area includes some of the highest priorities in the BRBNACP. The priorities were identified based on a combination of factors, particularly the occurrences of "listed" plant and wildlife species. In addition, the locations of both "high priority vegetation types" and serpentinitic soils were adopted as separate criteria from the*

8 The BRBNACP plan is nominally a regional conservation plan that should be included under the discussion in other sections of this report. However, the BRBNACP plan is structured so that regional habitat values are "down-weighted" in the plan's priority-ranking process while the distributions of sensitive plant species and ultramafic soil regions are emphasized. While this limits the utility of the BRBNACP plan as a regional conservation plan, it makes the plan a good example of a "region-scale" approach to conservation planning for sensitive plant species associated with ultramafic soils.

*occurrence of plants associated with those soils and vegetation types. Consequently this figure represents a conservation perspective that is substantially weighted for occurrences of "sensitive" plant species associated with serpentinitic soils. This is a valid conservation conclusion, and should be carried forward into conservation planning for the Berryessa – Snow Mountain NCA.*

The map includes many curvilinear features, distributed throughout the landscape, with high priority for biodiversity protection; these are streams with riparian habitat corridors (as mapped in the BRBNACP study). The regions mapped with green to light orange colors are generally oak-dominated habitats, which are thus rated in the BRBNACP conservation framework as having moderate importance for biodiversity protection.

The essential conservation priority feature illustrated in this map excerpt (shown by the orange colors) is the occurrence of ultramafic substrates of the Coast Range Ophiolite (see below), which are associated with a number of "sensitive" plant species. Because these species are relatively tightly linked to the occurrences of the appropriate geological and soil substrate, the priority-ranking process used in this planning effort rather effectively called out a subsection of the Berryessa – Snow Mountain region that has high priority for protecting a group of sensitive plant species. This identification of conservation significance for ultramafic/serpentinitic substrates owing to their association with several sensitive elements is, in my judgement, one valid statement of conservation priority within the NCA planning framework.

<u>Federal and State Endangered Species Act Planning</u>. The federal Endangered Species Act (ESA) and the California Endangered Species Act (CESA) require that listed species be protected, and the two acts compose one of the cornerstones of species-based conservation.[9] Both acts also address procedures for authorizing the taking of listed species. A complete summary of these procedures and various other requirements of these acts is well beyond the scope of this report, but it's relevant to note that significant differences exist between federal and state requirements, with the California act being far more protective of overall habitat than is the federal act. Nonetheless, the nature of the Berryessa – Snow Mountain NCA proposal (which only covers lands in public ownership) is not ideally structured for using the acts to achieve broad conservation goals.

*Federally Listed Species*. Sensitive species are listed under the ESA by a federal administrative process. Federal (and to a lesser extent state) agencies may be authorized to "take" federally listed species by way of an interagency consultation process. In carrying out the scope of the ESA, the responsible agencies [the US Fish and Wildlife Service (USFWS) for terrestrial and amphibious species and most non-marine fish, and the National Marine Fisheries Service (NMFS) for marine mammals and commercial marine fish] are required to "consult" (under Section 7) with other federal agencies that might "take" listed species in order to reduce potential impacts of federal actions so as not to "jeopardize" the listed species (pursuant to Section 9). The USFWS and NMFS may also identify (under Section 4) practices that can be implemented in agency management plans that are deemed not to jeopardize listed species; if those practices are incorporated into federal agency management plans the need for consultation is substantially reduced.[10]

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9 The federally and state-listed species include all those identified by the CNDDB on the basis of occurrences. Other listed species are likely to occur in the NCA planning area that are not represented by occurrence data at the present time.

10 The Bush administration adopted procedural rules for the ESA that further reduce the need for consultation, and it seems likely that the Obama administration will permanently rescind the Bush rules. The relevant point is that these federal agency procedures are not permanently set and can be affected by non-biological concerns.

When non-federal "applicants" propose actions on federal land that would "take" listed species the necessary action depends on whether the agency needs to "permit" the activity. If the federal management agency must issue an authorization, then the agency "consults" with the USFWS or NMFS and incorporates the results of the consultations into the issued permit. If there is no required federal permit, then the "applicants" must seek separate approval from the USFWS or NMFS; this uncommon situation invokes Section 10 of the ESA (as would the need for ESA approval for actions on private land) and requires the development of a "Habitat Conservation Plan" (HCP) under Section 10. The HCP must fully meet the requirements of the ESA for the "incidental taking" of listed species. Depending on the specific habitat needs of the covered species, the HCP may also incorporate substantial areas of habitat that benefit other (non-covered) species, but such a result is not a requirement of the ESA.

These contexts limit opportunities to use ESA-related conservation planning requirements to implement conservation goals within the NCA. Most actions on federal lands are dealt with through agency consultation processes, which are promulgated pursuant to the planning requirements of the management agencies and are constrained by myriad other agency management goals (see below). It should be noted, however, that federal lands are often included in "critical habitat" for listed species (if such habitat is designated), and federal lands typically play critical roles in the "recovery plans" adopted for listed species; both results do have important conservation consequences.

I'm not familiar with the specific ESA requirements for critical habitat, or any extant recovery plans, currently in effect for the federal lands in the proposed NCA. Most likely some ESA requirements exist (for example, it's likely that some elements of the Northwest Forest Plan apply within the part of Mendocino National Forest covered by the proposal), but they represent an opportunity to use the ESA to accomplish conservation goals within the NCA that should be incorporated into the NCA's ultimate management.

*State Listed Species*. The taking of listed species is prohibited under the CESA without authorization from the California Department of Fish and Game (CDFG). The Department may authorize (pursuant to Fish and Game Code Section 2081) taking covered species when the taking is "incidental" to otherwise lawful actions. Such authorization always involves "mitigation" to reduce the significance of the taking. Typically the Department also seeks to develop and implement longer-term conservation plans in association with such authorizations.

For federally owned land, meeting the requirements of the CESA involves interagency consultations with the CDFG (required by other federal laws), but the resulting conservation measures are generally best considered to be compromises. State agencies must, however, comply fully with the CESA, and larger-scale planning approaches that implement the CESA's intended habitat-based focus are possible for state-owned lands.

For private lands the CDFG will identify mitigation requirements for reducing the impacts of any "take" on covered species if any state or local agency approval is required. In most of the NCA region these requirements are addressed in individual permits. The preferred approach on private lands when large ownership areas or many covered species are involved is to develop habitat-based plans, in the form of Natural Community Conservation Plans (NCCPs), which require a habitat-based focus that is openly identified as being intended to protect "habitat systems" for covered species as well as non-covered species and ecosystem processes. However, because the NCA will not cover activities on privately owned land, it is unlikely that the context for applying the state's NCCP requirements will arise, and the conservation planning processes that will be available under the CESA most likely will involve negotiated agreements between federal (and possibly state) agencies and the CDFG.

Of the local government jurisdictions included in the region that includes the NCA proposal, only Yolo County and Solano County are engaged in developing NCCPs at this time, and the extent of federal land covered by these plans is quite limited. There's little reason to expect habitat-based conservation planning pursuant to the California ESA to be adopted as an overarching guideline by the federal (or even the state) agencies within the NCA boundary.

Agency Management Plans. Federal and state agencies generally operate in accordance with laws that require the development and implementation of management plans for the lands owned or controlled by the agencies (describing the details of adopted agency planning processes is beyond the scope of this report). The plans that result from these processes generally also address the requirements of a number of other laws (not the least of which will be the relevant endangered species act, in addition to laws, such as the federal Wilderness Act, that may have significant implications for protecting habitat needed by listed species).

The NCA proposal does, however, provide an opportunity to use agency planning requirements and processes to accomplish conservation goals on a broad scale. Following the implementation of an act establishing the NCA an overall management program for the NCA will be developed, which can provide explicit conservation planning direction to the agencies included in the NCA. This future direction is not limited either by current agency planning directions or by the sketchy conservation goals that are currently available for discussion in the region. Future NCA planning processes can help to establish coherent conservation planning policies throughout the federal and state lands in the NCA, although the specific elements of the future plans have yet to be established.

Bird Conservation Planning. Partners in Flight and CalPIF (and other groups interested in birdlife conservation) have identified lists of species that stand as indicators of status for other species. These "indicator" species are effectively a bridge between species that are the focus of conservation and habitats that are occupied by the "indicators" (see the following subsection). The Partners in Flight (PIF) program is unquestionably the most important bird conservation program in North America. The PIF agenda is framed on the general premise that migratory birds (which are formally protected by the Migratory Bird Treaty Act, a federal law that originally dates to 1918) require concerted attention from government agencies and private organizations to assure that their habitat needs are identified and considered. This focus results in large part from the fact that while the birds are protected by the Act, the habitats that the birds require are often not protected (although habitats such as many wetlands and habitats that occur on federal or other public lands may be protected by other federal or state laws). As a consequence of habitat loss the viability of populations or species can be affected. Thus the PIF goal is to identify species that could be affected by habitat loss or other kinds of "indirect" impacts throughout the United States, Canada, and (more recently) Mexico

As part of the PIF's work, a number of plans have been drafted that address the conservation status of most of the bird species in the United States as well as in various regions (cited previously). In California the conservation work of the PIF is mostly carried out by the California Partners in Flight (CalPIF) group, which is logistically based at the Point Reyes Bird Observatory but which includes many of the state and federal agencies and private organizations focused on birds in California.

The basic thrust of the PIF planning effort is to consider the current status of each species (including the protected status owing to current rarity), but also to consider the biological and ecological dynamics of the species to identify potential future conservation concerns. Thus Yellow-billed Magpie and Oak Titmouse become a conservation priority in the Central Valley because the habitats used by these species are under threat from development or other kinds of alteration or loss. In other words, the recommendations in the PIF and CalPIF plans are effectively conservation judgements about potential threats to the entire avifauna in California because of possible habitat losses, as well as a consideration of the "rarity" that is reflected on more formal listings. The information in the PIF and CalPIF plans cited above represents a judgement about the status of birds in the region that is based on the conservation science known to the participants. For example, the National Audubon Society (NAS) is an active PIF participant, and the NAS's published judgements about the conservation status of bird species and their habitat needs are virtually the same as those in the various PIF plans.[11]

The Yolo Audubon Society (YAS), in considering the needs for bird conservation in the region that includes Yolo County, identified a "Yolo County WatchList" of species that are believed on the basis of local knowledge to warrant conservation concern in the County, as noted in Table 2.

**Table 2. Yolo County Bird WatchList (from the Yolo Audubon Society).**

| YAS Status | Primary Habitat | Common Name | Taxonomic Name |
|---|---|---|---|
| Yellow | Wetland | Least Bittern | *Ixobrychus exilis* |
| Yellow | Grassland/Prairie | White-tailed Kite | *Elanus leucurus* |
| Red | Field Crops/Riparian | Swainson's Hawk | *Buteo swainsoni* |
| Yellow | Chaparral/Scrubland | Mountain Quail | *Oreortyx pictus* |
| Red | Winter Agriculture | Mountain Plover | *Charadrius montanus* |
| Yellow | Stream | Spotted Sandpiper | *Actitis macularia* |
| Red | Wet Pastures/Fields | Long-billed Curlew | *Numenius americanus* |
| Yellow | Riparian | Yellow-billed Cuckoo | *Coccyzus americanus* |
| Red | Grassland/Prairie | Short-eared Owl | *Asio flammeus* |
| Red | Grassland/Prairie | Burrowing Owl | *Athene cunicularia* |
| Yellow | Oak Woodland | Northern Pygmy-Owl | *Glaucidium gnoma* |
| Yellow | Oak Woodland | Acorn Woodpecker | *Melanerpes formicivorus* |
| Yellow | Riparian | Downy Woodpecker | *Picoides pubescens* |
| Yellow | Riparian | Willow Flycatcher | *Empidonax traillii* |
| Yellow | Oak Woodland | Western Wood-Pewee | *Contopus sordidulus* |
| Yellow | Grassland/Prairie | Loggerhead Shrike | *Lanius ludovicianus* |
| Yellow | Riparian | Bell's Vireo | *Vireo bellii(pusillus)* |
| Yellow | Oak Woodland | Hutton's Vireo | *Vireo huttoni* |
| Red | Field-edge Woodland | Yellow-billed Magpie | *Pica nuttalli* |
| Red | Grassland/Prairie | Horned Lark | *Eremophila alpestris (rubea)* |
| Red | Vertical Riverbanks | Bank Swallow | *Riparia riparia* |
| Red | Oak Woodland | Oak Titmouse | *Baeolophus inornatus* |
| Yellow | Oak Woodland | White-breasted Nuthatch | *Sitta carolinensis* |
| Yellow | Chaparral/Scrubland | Wrentit | *Chamaea fasciata* |
| Yellow | Oak Woodland | Western Bluebird | *Sialia mexicana* |
| Yellow | Chaparral/Scrubland | California Thrasher | *Toxostoma redivivum* |
| Yellow | Riparian | Yellow Warbler | *Dendroica petechia* |

11 See URL: http://audubon2.org/watchlist/viewWatchlist.jsp (viewed December 2008).

| YAS Status | Primary Habitat | Common Name | Taxonomic Name |
|---|---|---|---|
| Yellow | Riparian | Yellow-breasted Chat | *Icteria virens* |
| Yellow | Chaparral/Scrubland | Sage Sparrow | *Amphispiza belli* |
| Yellow | Grassland/Prairie | Grasshopper Sparrow | *Ammodramus savannarum* |
| Red | Wetland | Tricolored Blackbird | *Agelaius tricolor* |

The species identified in the Yolo County WatchList are included in one or more of the PIF and/or National Audubon Society lists of bird species of conservation concern. As on other "watchlists," "red" species are considered to warrant extraordinary conservation action. In some cases this status results from declining or reduced population size or demographic uncertainty, but in other cases this status results from known losses of the habitat needed by a species. "Yellow" species are generally somewhat less sensitive to stressors than are "red" species, and are considered by the YAS to indicate species that are particularly sensitive to prior or ongoing loss of their habitats in the Berryessa – Snow Mountain region.

The WatchList also includes a number of species that the YAS identified as having a high priority for habitat enhancement or restoration. In particular, the YAS Board concluded that restoration and/or enhancement of riparian and wetland areas should occur throughout the region, wherever reasonable opportunities for restoration and/or enhancement occur. As an example, the Least Bell's Vireo (*Vireo bellii pusillus*) was identified as a common breeding species throughout much of the Central Valley in the first half of the 20th Century. This species, which is closely linked to scrubby riparian habitats, declined and disappeared from the Central Valley by the mid-20th Century, resulting it its designation as "Endangered" under the federal Endangered Species Act. Owing to riparian habitat restorations in National Wildlife Refuge lands in Merced County this species has recently been recorded as a nesting species in the Central Valley for several years. The YAS concluded that similar results could be obtained through restoring riparian scrub habitats in the NCA region, and that this species can be "recovered" and "delisted" in the Central Valley and in California as a whole.

The species listed in Table 2 address PIF-based bird conservation concerns for a substantial part of the Berryessa – Snow Mountain region, since the list addresses species that are associated with streamside riparian, oak woodland, and chaparral habitats. Table 2 does not address bird species that occur in conifer-dominated forests or high-elevation habitats like alpine grassland or open chaparral; such species would be appropriate for monitoring habitat availability and status in the higher-elevation region near the northern end of the NCA. Based on personal experience with bird species in northwestern California, some candidate species that would address these concerns are identified in Table 2a.

**Table 2a. Potential Bird WatchList Candidates for Coniferous Forest Region.**

| BSM Status | Primary Habitat | Common Name | Taxonomic Name |
|---|---|---|---|
| Red | Old-growth Coniferous Forest | Northern Spotted Owl | *Strix occidentalis caurina* |
| Yellow | High-elevation Open Scrub | Common Poorwill | *Phalaenoptilus nuttallii* |
| Yellow | Rock Outcrop / Cliff | White-throated Swift | *Aeronautes saxatalis* |
| Yellow | Coniferous Forest | Pileated Woodpecker | *Dryocopus pileatus* |
| Red | Coniferous Forest | Olive-sided Flycatcher | *Contopus cooperi* |
| Yellow | Mixed Conifer/Chaparral | Townsend's Solitaire | *Myadestes townsendi* |

The “red-listed” Northern Spotted Owl may not be an appropriate WatchList species for the NCA, depending on the inclusion of Late Seral Reserves or other suitable habitat in the NCA. The second “red-listed” species, the Olive-sided Flycatcher, has declined markedly throughout its breeding range, although the reasons may be attributable in part to habitat loss in its wintering grounds in South America. The other species in Table 2a are relatively uncommon species that are associated with the primary habitat elements listed in Table 2a, and thus would be suitable species for monitoring the condition of the relevant habitat elements in the region. Quite possibly additional (or different) species should be included in the list to make it more useful for higher elevation and/or coniferous forest habitat conditions.

Plant Species Conservation Planning. The California Native Plant Society (CNPS) rare plant program uses a classification process that includes collective assignments of native species, subspecies, or varieties to one of several lists:[12]

- List **1B** “The plants of List 1B are rare throughout their range with the majority of them endemic to California. Most of the plants of List 1B have declined significantly over the last century. List 1B plants constitute the majority of the plants in CNPS’ Inventory with more than 1,000 plants assigned to this category of rarity.”
- List **2** “Except for being common beyond the boundaries of California, the plants of List 2 would have appeared on List 1B. From the federal perspective, plants common in other states or countries are not eligible for consideration under the provisions of the Endangered Species Act. Until 1979, a similar policy was followed in California. However, after the passage of the Native Plant Protection Act, plants were considered for protection without regard to their distribution outside the state.”
- List **3** “The plants that comprise List 3 are united by one common theme - we lack the necessary information to assign them to one of the other lists or to reject them. Nearly all of the plants remaining on List 3 are taxonomically problematic.”
- List **4** “The plants in this category are of limited distribution or infrequent throughout a broader area in California, and their vulnerability or susceptibility to threat appears relatively low at this time. While we cannot call these plants "rare" from a statewide perspective, they are uncommon enough that their status should be monitored regularly. Should the degree of endangerment or rarity of a List 4 plant change, we will transfer it to a more appropriate list.”

The process through which these assignments are made is described on the website identified above (and in the published Inventory). In essence, the CNPS inventory represents a determination by a “quasi-professional” scientific organization[13] about the taxa of plants occurring in California that should be considered “environmentally sensitive.”

The CNPS maintains an online inventory of sensitive plant species occurrence that is independent of the CNDDB, based on occurrence information compiled by CNPS members. This database[14] may be queried for existing occurrence records in a geographical context. For the purposes of this report, the CNPS

12 The California Native Plant Society also has developed other lists (such as List 1A, plant species that are extinct in California) that are not important for identifying species that are sensitive to management or development activities; these lists are not addressed in this comment. The quoted text is taken from the CNPS website (URL: http://www.cnps.org/cnps/rareplants/ranking.php; viewed March 2009).

13 Many CNPS volunteers are professional botanists and field ecologists, and the decision-making functions of the CNPS are conducted in a manner much like those of a professional society.

14 URL: http://cnps.web.aplus.net/cgi-bin/inv/inventory.cgi (viewed March 2009).

listing for the Berryessa – Snow Mountain region are functionally equivalent to the CNDDB listing in Table 1, and the listing is not repeated here.

## 2.2 Background: Habitat-Based Conservation Planning in the Berryessa – Snow Mountain Region

Uncommon or "rare" species are an important element of native biodiversity, and protecting these species and their habitats is an important element of a regional conservation strategy. "Heritage" data[15] do not comprehensively address several of the multiple causes for ecological "rarity," however, and therefore "heritage" data do not fully address the conservation status of all plant and wildlife species. As noted by Noss and Cooperrider (1994), "heritage" programs work through "successive approximations," which suppose that surveys are being conducted in various parts of the landscape over time, so that, eventually, the entire landscape will get adequate coverage. However, the adequacy of the sampling program in such cases is not assured, and many regions in California have not been surveyed adequately to apply this approach. The intermittent coverage of sensitive species in the USGS quadrangles that include most of the proposed Berryessa – Snow Mountain region suggests that the limitation of the "heritage program" approach described by Noss and Cooperrider is operating in this region.

Heritage programs are known to have inherent limitations for biodiversity or conservation planning; see Possingham et al (2002) for a brief discussion of several concerns that arise in this context. For example, plant species that are narrowly adapted to "rare habitats" (such as serpentinitic substrates) generally will find their way into "heritage" databases. While it's completely appropriate that such plant species be identified as "rare" under species-protection laws, that focus cannot adequately deal with important conservation elements that are not limited to small, mappable locations; these include large carnivores that require large home ranges, "minimum-area" species, and other conservation elements that require large habitat areas (Noss and Cooperrider 1994).[16] Further, there are conservation objectives regarding landscape connectivity that cannot be addressed except by adopting a landscape-based focus (see the following subsection).

A general approach has evolved among conservation planners for addressing questions such as these; the approach involves evaluating the occurrences of habitat presumed to be occupied by the species of interest. The element of "wildlife-habitat relationships" has existed in wildlife ecology for many decades (arguably this basic approach to wildlife population management originated with Aldo Leopold; see Leopold 1933) as the "habitat" needs of game species. The broader application of habitat-based considerations applied to conservation questions began as an earnest undertaking in the 1970s, as an apparent consequence of the growth of field ecology worldwide (particularly in the tropics) and a broadly based approach to environmental management in the United States (see, for example, Soulé and Wilcox 1980, Soulé 1986). The fundamental question that is addressed in this context is *whether the association between a given habitat type and sensitive elements of the biota causes the habitat type to assume an increased conservation significance because of its value to the biota*. This narrow question then becomes more generalized to become one seeking to identify the importance of *all* habitat types based upon their

15 Databases such as the California Natural Diversity Database arose from a segment of the conservation-planning spectrum known as "natural heritage programs," and the data in such databases is generally known as "heritage data." The standard criterion for including species in a "heritage" database is being listed under one or more federal or state laws, although additional indications of "rarity" are now widely employed, such as identification by the California Native Plant Society or other scientifically based conservation organizations.

16 Large carnivores may be uncommon because of positive metabolic scaling relationship between body size and home range size (Schoener 1968, Lindstedt et al. 1986, Haskell et al. 2002); populations of large individuals, especially carnivores, are typically not found at high densities in most landscapes, even though much of the landscape may be occupied by such species.

significance to the *entire* biota. That is, *will sufficient habitat be protected to assure the continued presence of the native biodiversity in the region?*

### 2.2.1 Habitat-based Planning related to Broad-scale Vegetation Patterns

Various factors that come under consideration for "heritage" listings are also relevant for considering regional species occurrence patterns based on habitat relationships. For example, the geology in the Berryessa – Snow Mountain region, and the relationship of vegetation to the geological substrate, is a primary conservation driver in this region. The relationship between the geology and the abundance of "serpentine taxa" is fundamentally a habitat-based conservation question.

The Coast Range Ophiolite is a tectonic feature of the NCA region (see Moores and Moores 2001; also see Harden 2004); because region's geology is fully addressed elsewhere it's not productive to repeat the story here. As is well known, ophiolites are derived from upper-mantle materials that are plastered onto stopped subduction trenches, and are rich in iron and manganese and poor in many cations that are present in greater abundance in more fertile substrates. These materials are geologically largely peridotite, and when enriched with water they become serpentinite; these substrates are associated with many plant species that do not occur or are less-common elsewhere. The flora of serpentinite has been a subject of botanical interest for decades (see the summary in Harrison 1997; also see Harrison and Inouye 2002). As noted above, this flora and its underlying serpentinitic substrate were the primary factors underlying the identification of conservation priorities by the BRBNACP, as reflected in Figure 1. Whatever else might be said about conservation in the region, the continued protection of the serpentinitic substrate and the flora associated with it remains a high conservation priority; wherever these substrates appear within the proposed NCA they should be recognized and managed for their ecological and conservation significance.

Habitat-based conservation considerations must also address questions about "rare" habitat types *per se*; that is, *are there habitats that are conservationally important because they are intrinsically uncommon* or otherwise significant?. The geofloristic history of the Berryessa – Snow Mountain region as a whole is not well characterized, although pieces of the history related to the Snow Mountain area have been considered by several authors, most directly by Heckard and Hickman (1984; a second paper by these authors, which I have not read, was published the following year). Geologically the Klamath Mountains province to the north is a piece of the North American continent that is significantly older than most of the Coast Range, and is generally identified as having already been present in approximately its present location at the time the Coast Range subduction zone began operating. The volcanic rocks of the Snow Mountain – Yolla Bolly massif are similar in age to the Klamath Mountains, and are thus much older than most of the northern Coast Range; the dynamics of the northern Coast Range's formation are not fully defined, unquestionably resulted from the action of the subduction zone, and are not particularly important from a current biodiversity conservation perspective.

As defined by Raven and Axelrod (1978), following Stebbins and Major (1965), the Klamath Mountains represent one of two centers of "relict" paleofloristic endemism/native plant diversity in California, resulting in significant part because of the province's retention of many plant lineages related to what Axelrod termed the "Arcto-Tertiary Geoflora." While the Klamath Mountains region's vegetation is dominated by "Arcto-Tertiary" conifer lineages, a few of the dominant species in the region's current vegetation [such as madrone (*Arbutus menziesii*)] are floristically related to vegetation centered in northern Mexico during the Tertiary. Abundant evidence supports a conclusion that vegetation patterns in North America and Europe were altered significantly by the Pleistocene glaciation (see the discussion later in this report regarding changes related to climate shifts). It is generally agreed, however, that the Klamath Mountains were too low and too close to the Pacific Ocean to support extensive Pleistocene glaciation (only small glaciers occurred in the higher elevations in the eastern part of the province), and the province apparently represented a "refugium" of endemism during the Pleistocene.

Heckard and Hickman (1984) identified the flora of the high-elevation mountain outcrops south of the Klamath Mountains (including Snow Mountain and St. John Mountain) as including an extension of the "old" flora of the Klamath Mountains, although the high-elevation species are presently absent from the intervening lower-elevation northern Coast Ranges. These authors generally endorsed the paleofloristic model described by Raven and Axelrod and several other regional authors (including Ledyard Stebbins, Jack Major, and Robert Whittaker, among others) that the Klamath Mountains represent a center of conifer endemism at least as old as the mid-Tertiary. However, it's evident that the Pleistocene represented a significant ecological and climatic filter for the regional flora, and the most plausible interpretation for the occurrence of Klamath Mountains-related flora on Snow Mountain is that these species were continuously distributed across the intervening lower-elevation region north of Snow Mountain at some time during the Pleistocene, the lower-elevation occurrences having been eradicated subsequently. From the perspective of biodiversity conservation, these mountain-loving plant species are indeed "relicts" of prior climate regimes. Because they occur as "outlying" populations potentially having genetic variation not present in more "central" populations, they warrant conservation consideration even though the taxa are not included on any lists of "sensitive" species (Leppig and White 2006). Moreover the "relict" plant associations are themselves "rare" in the Berryessa – Snow Mountain region; from a biodiversity-maintenance perspective these remnants of the region's Pleistocene flora are conservationally significant.

At lower elevations south of the Snow Mountain crest the Berryessa – Snow Mountain region undoubtedly experienced the kind of individualistic plant species movements that characterized post-Pleistocene dynamics elsewhere in North America. Moreover, it's very likely that similar dynamics occurred during previous Pleistocene interglacials (while pre-Pleistocene vegetation dynamics in the northern Coast Range are largely unknown it would be unrealistic not to expect vegetation to have responded to shifting climatic patterns). Therefore it should be presumed that there have been many opportunities for plant species to adapt to conditions within this region. However, as Raven and Axelrod (1978) noted, there is a decline in precipitation from north to south and from the coast inland, and as subsequently argued by Susan Harrison and numerous other plant ecologists, there is an overall pattern of plant species richness decline as the distance inland from the coast increases, and another decline from north to south. These broad ecological patterns have constrained or shaped the localized plant species richness within the Berryessa – Snow Mountain region, which developed locally on the basis of individual species tolerances for soil, moisture, and other ecological conditions. Still, given the topographic and edaphic complexity in the region there remains a potential for quite high localized adaptation and high variability and richness in vegetation types.

There is really no satisfactory account of the distribution of local "vegetation" in California. Previously several authors have addressed regional or national vegetation classifications that included California (e.g., Küchler 1977; Bailey 1994). Miles and Goudey (1997) provide a synopsis of regional vegetation; a summary excerpt from the online version, covering the Berryessa – Snow Mountain region, is attached to this report as Attachment 1. This report is a regional extension of the "ecoregion" approach developed by Bailey, is an extensive compilation of information by scientists working in California, and includes information on geology, soils, and water relationships in addition to the ecology of the vegetation *per se*. However, the summary does not include maps (which do not exist) of actual vegetation alliances that occur in the region.

A variety of mapping approaches (based primarily on remote sensing) have been advanced for California over the years, all of which have been criticized for one or more valid reasons; reviewing these efforts is beyond the scope of this report. The lack of an adequate compilation of California vegetation is an issue on which the California Department of Fish and Game and the California Native Plant Society have been working for some years. The Department has recommended a vegetation sampling and mapping approach that is based on the vegetation classification system developed by Sawyer and Keeler-Wolf (1995; an update of this Manual is pending).[17]

The CDFG classification and mapping work has not, so far, included portions of the Berryessa – Snow Mountain region; however, two existing classification and mapping efforts utilize methods that are quite close to those developed by the Department. The first is a vegetation map for Napa County (Thorne et al 2004). Owing to the application of the sampling methodology the Thorne study also included areas somewhat outside the boundaries of Napa County. The resulting vegetation map is available electronically, as are the underlying geodata. The second effort is a vegetation classification and mapping project carried out by Mendocino National Forest, which apparently largely conforms to the requirements of the CDFG classification and mapping protocol (I'm not personally familiar with this work). In other words, a substantial portion of the Berryessa – Snow Mountain NCA region already has been mapped using the current "standard" vegetation mapping protocol, and Tuleyome and collaborating organizations should complete the development of a georeferenced database for the NCA region at the earliest opportunity.

### 2.2.2 Habitat-based Planning Related to Wildlife

Complete and reasonably accurate vegetation maps range between being very useful to being essential for on-the-ground conservation planning. Landscape-based conservation plans need to be based on accurately understanding the regional vegetation/habitat patterns (see below). Arguably one of the most important uses of such information is that it represents the entry point into an assessment of potential habitat utility for wildlife species. A commonly framed conservation question addresses whether there are habitat types that are regionally important for wildlife, including questions about included habitat elements (e.g., nesting cliffs, oaks that produce acorns, and others related to specific features).

A standardized analytical assessment for wildlife habitat values is available in California, the Wildlife Habitat Relationships (CWHR) program, which is described in a report (Mayer and Laudenslayer 1988) available on the relevant CDFG website.[18] This approach is commonly implemented through a software application, also available from the same website. The software includes georeferenced range maps for each wildlife species, but the queries are based on identifying habitat types that occur on the ground in the area of interest.

In addition to being useful for species-based queries, the CWHR software also permits assessments of the broad utility of habitat types (which may also be undertaken in GIS by using the georeferenced habitat data). Queries of this type represent a form of habitat-based assessment that provides answers to questions of the form *what are the most significant habitat types in a region, indicated by providing habitat for the greatest number of species?*

The most immediate answer to such questions is a map of habitat values in a region, such as Figure 2. This figure, which shows the same region as Figure 1, displays the cumulative wildlife habitat utility of areas in the landscape in brighter colors (red scaling highest, to light green lowest). This figure resulted from the application of the CWHR database to a "habitat map" of the BRBNACP region. Plots such as

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17 The Department's work resulted in part from legislative direction (SB 85, 2007) to the Department to develop a statewide vegetation classification and mapping program. See URL: http://www.dfg.ca.gov/biogeodata/vegcamp/ (viewed December 2008).

18 See URL: http://www.dfg.ca.gov/biogeodata/cwhr/ (viewed December 2008).

Figure 2 are only feasible if there is some type of definable relationship between habitat types and wildlife species. It's quite apparent, however, that such a plot is only useful to the extent that the information about occurrences, composition, and/or structure of plant association/habitat used to enter the CWHR database is at least reasonably accurate.

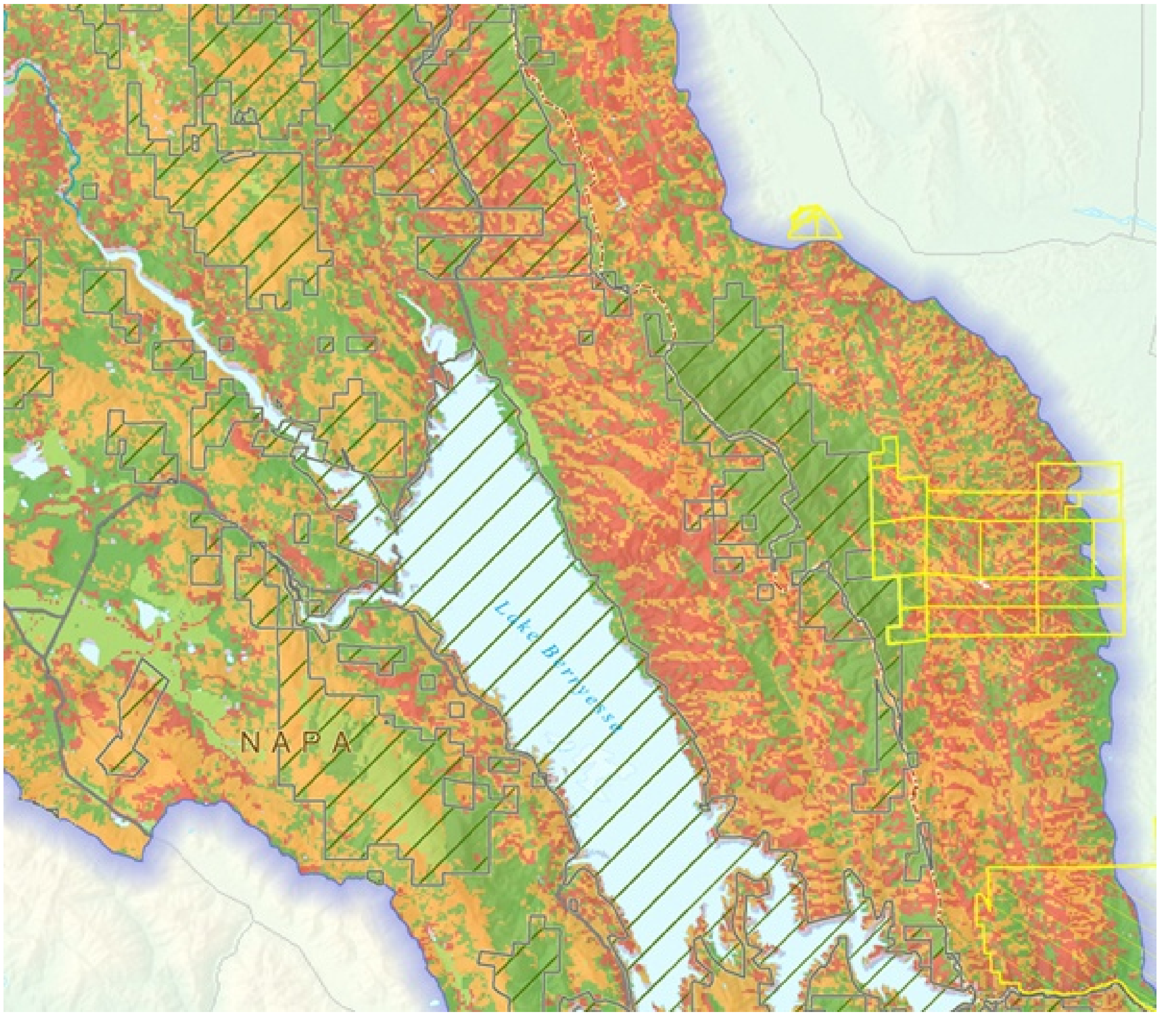


*Figure 2. A different version of conservation priorities in the BRBNACP results when the ranking is based on geographical data showing the numbers of species that find suitable habitat. The red and orange map symbols reflect high habitat importance for wildlife species (based largely on the GIS data included in the California Wildlife Habitat Relationships database); red areas in particular largely correspond with a combination of oak-dominated habitat areas and riparian areas. As with the result shown in Figure 1, this is a valid conservation planning result that should be carried forward into the planning for the Berryessa – Snow Mountain NCA.*

The specific results indicated in Figure 2 (which was also prepared for the BRBNACP, but which has not been published by the BRBNACP) can only be interpreted broadly here. As noted in the legend, generally the red (and likely most of the orange) areas in the figure appear to be habitats dominated by oak-containing alliances and/or by riparian alliances (I haven't personally reviewed the data on which the figure is based, but that interpretation is consistent with my previous exercises with CWHR).

Maps like Figure 2 constitute a basic input to the development of landscape-based conservation plans (see below). An essential need for such plans is an approach that maximizes the habitat values associated with protected areas; such planning must begin with at least an approximate knowledge of the kinds of information presented in Figure 2.

## 2.3 Background: Landscape-Based Conservation Planning

During the past two decades conservation planning has incorporated key elements of an area of ecological science known as *landscape ecology* (Forman and Godron 1986, Forman 1997). This discipline (together with the availability of computers that run powerful geographic information system software) has transformed conservation science by allowing conservation biologists to focus on ecosystem elements, processes, and functions at a landscape ("miles wide") scale. Conservation planners generally accept the proposition that *maintaining ecological processes in a landscape which have supported a range of species in the past offers the highest likelihood that the majority of species in that landscape will be maintained in the future* [see Meffe and Carroll (1994) and Noss et al. (1997) for additional considerations].

### 2.3.1 The Historical Ecological Framework for Landscape-Based Conservation Approaches

The concepts that comprise current conservation planning approaches, including landscape ecology, owe a great deal to ecological work carried out in the middle third of the Twentieth Century. A seminal publication during that period was a monograph called "the theory of island biogeography" (MacArthur and Wilson 1967), in which the operations of ecological processes on a landscape scale were interpreted to explain the numbers of species on islands, including habitat islands in a contrasting "sea" of non-habitat. The "theory" presented in the monograph really began many of the discussions that resulted in the majority of conservation science today; it's no accident that another of the seminal papers in the development of landscape-based conservation planning in the 1970s (Diamond 1975) originated with the "island biogeography" framework. Most importantly, the "island" framework generated discussions about "species-area relationships," which are portrayals of the numbers of species that occur in land areas of different sizes. Species-area relationships constitute a fundamental pattern in real landscapes, representing the ecological truism that *larger land areas contain more species*. This is such an important concept for conservation planning (and for ecology generally) that an illustration is appropriate [Figure 3; see Rosenzweig 1995 (on which the figure is based) for a relatively complete presentation of this science].

The first panel in Figure 3 shows an arithmetic plot of the numbers of bird species identified in field surveys (on the vertical axis) against land area (the horizontal axis) in increasingly larger samples of South America for four generalized habitat types. The observed results demonstrated that as the area sampled in each habitat increased from very small size to a very large area, the number of species identified in each habitat increased monotonically, rapidly at first and then more slowly as additional birds observed increasingly belonged to species that had already been recorded. Plots of this form are mathematically "power functions," represented in the form

$$S = cA^z,$$

where $S$ is the species number, $A$ is the sampled area, and both $c$ and $z$ are fitted constants (with the exponent $z$ <1). For analytical purposes the power function is invariably transformed logarithmically to a linearized form

$$log\ S = log\ c + z\ log\ A.$$

Transforming the data relationships in the first panel in Figure 3 yields the linearized relationships in the second panel; this is how most species-area relationships are presented.

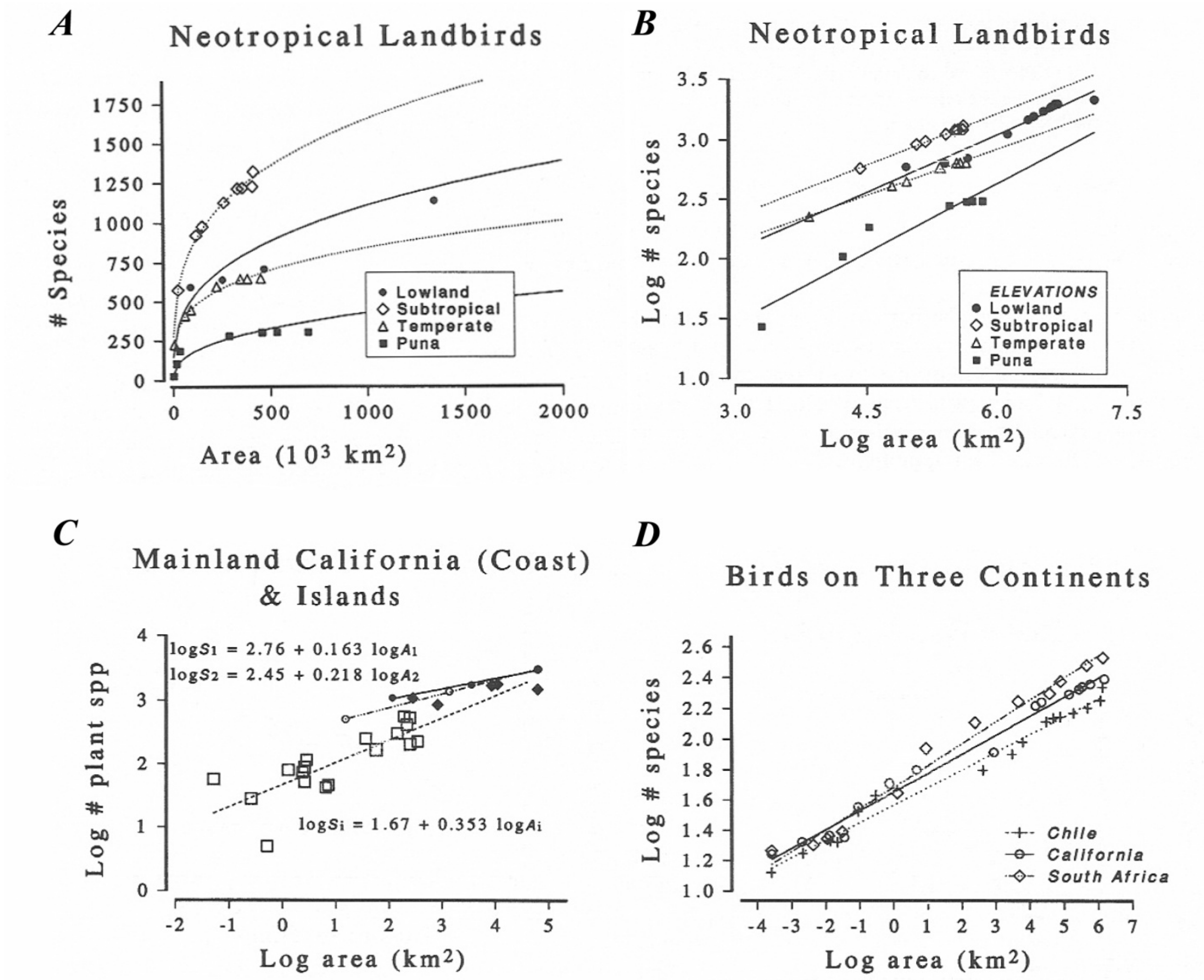


*Figure 3. Examples of species-area (S-A) relationships, which have been demonstrated empirically on every continent, for a variety of organism types. Panels A and C represent an increase in landbird species with area in South America, where panel B presents a logarithmically scaled plot of the same data presented arithmetically in panel A. Panel C shows log-scaled plots of the increase in plant species number with area for three regions in California. Panel D shows S-A relationships between the numbers of bird species and land area on three continents, demonstrating a (perhaps surprising) similarity of effect at continental scale for three continents. See Rosenzweig (1995) for additional information.*

The third panel in Figure 3 illustrates a California application of species-area relationships, with data on plant species richness and area sampled for three regions in coastal California, two from the mainland near San Francisco Bay and the third for the Channel Islands (see the figure legend for details).[19] Two

19 The meaning of these relationships, and particularly the significance of the exponent *z*, has been a subject of much scientific debate for more than 30 years. For example, Rosenzweig has concluded that "nested" data like the mainland studies in Figure 3 always add species more slowly, and therefore have lower z values, than do samples from "archipelagoes" in which each "island" represents a separate sample from a species pool. However, from a

“mainland” plots have shallower slopes than does the “island” plot, meaning that areas on the mainland added species at a slower rate as the sampled area increased than did the Channel Islands. Similar results have been obtained in other studies of this type.

The basic form of the relationship between species richness and landscape area is generally similar in most continental areas in the temperate zone everywhere on the planet (see the fourth panel in Figure 3), suggesting a fundamental or inherent relationship between the habitat richness in many temperate-zone land areas and the species richness that those land areas can support.

These plots represent empirical results, what the real world looks like, and in a region like the proposed Berryessa – Snow Mountain NCA it can be generally concluded that there will be more species retained as the area of a given habitat (e.g., serpentinitic substrates or oak woodlands) increases, although there will always be questions about details, both current and historical. It’s unknown, for example, whether the settlement of the North American landscape by Europeans changed the species-area relationships observed today, and it’s further uncertain how climate change will alter the relationships.

Ecological studies like those summarized in Figure 3 established a portrayal of biological diversity at multiple scales that is often encountered in conservation planning today. The descriptive concept of “α-diversity” refers the species richness observed within a relatively (small) homogeneous area [this and the other concepts described here are generally attributed to Robert Whittaker (see, e.g., Whittaker 1975), originally based in large part on his studies of the serpentine flora of the Siskiyou Mountains, although many other authors have helped to clarify these concepts over the years]. The results of these empirical studies indicate that as the area of the geographical region of interest increased, the total species richness in the region also increased; thus these observations in effect describe the same phenomena described in species-area relationships, looked at from a different perspective.

One reason for the increase in species richness has been observed to be that there is often an ecological and geographical replacement of a species in a given habitat (for example, grasslands on serpentinitic substrates) by another species, often a taxonomically close relative, in a different occurrence of the same habitat type. Thus two sites that represent occurrences of the same (or very similar) habitat may have similar α-diversity values, but the total species richness in both patches considered together is increased because there is an ecological replacement between the two occurrences. This augmentation in species richness has been termed “β-diversity,” although the term has also been defined in other ways in the ecological literature. The increase in regional species richness because of turnover is one element of biodiversity that has been identified as important in conservation contexts (see, e.g., Harrison 1997, Harrison and Inouye 2002); multiple representations of habitats for “heritage” species may be necessary to maintain the existing biodiversity in a given landscape. [Typically there is a further increase in regional biodiversity as the area sampled increases, which Whittaker called “γ-diversity,” resulting from the addition of different habitat types as the sampled area continues to increase.]

Discussions about many of these ecological “models” continue in current ecological literature, for the questions that they raise have fundamental importance to ecological science and the answers elucidated previously have not always been found to be complete. For example, “rarity” as a property of some species in a collection of species at a location (or in a region) is a kind of central question for “heritage program” conservation; i.e., the programs are inherently focused on “rare” species. For valid but not fully comprehended ecological reasons (Preston 1962a, 1962b; May 1999), the vast majority of species in the world are <u>not</u> “rare,” but some species inevitably fall into the low-density end of abundance distributions

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conservation perspective the “significance” of the mathematical constants is less important than the overall shape of the relationship.

for sites or regions.[20] This is not a trivial result, either ecologically or conservationally, because it means that the "rarity" of all species in the region are related to the total number of individuals, and that landscape or habitat changes that reduce the total capacity of a regional landscape to support individuals will inevitably shift the abundances of all species downward, and will force additional low-density species into a category of "rarity" that makes them conservationally significant. Hence one widely adopted guideline in conservation planning has become to "keep common species common" by maintaining the capability of the landscape to provide for viable populations of species (up to "all species") that occur in that landscape. Maintaining the capability of the regional landscape to sustain more individuals of the "common" species also increases the numbers of individuals in "rare" species.

The above paragraphs represent only a small sampling of the scientific concerns that underlie conservation planning today, and while delving into that science is (mostly) beyond the scope of this report, I trust that this brief digression has demonstrated both the historical scientific underpinning for and the logical sequence of conceptual development of landscape-based conservation planning today.

### 2.3.2 Applying Ecological Concepts to Develop a Landscape-Based Conservation Planning Framework

As noted above, "landscape-level" conservation planning addresses "landscape-scale" ecological processes.[21] Landscape ecology is concerned with the *spatial distribution of ecological elements* that have a conservation interest, as well as with the maintenance of *spatially based ecological processes* that support elements of conservation interest. Landscape-based planning addresses questions concerning the conservation of environmental resources that are only noticeable at scales larger than small, mappable occurrences, such as the use of landscapes by mountain lions or bears, or questions about the sub-population interactions of patchily distributed sensitive plant or butterfly species.

Developing a complete application of landscape ecology to conservation questions in the Berryessa – Snow Mountain region is beyond the scope of this report, but see Noss and Cooperrider (1994) for a masterful summary of the application of these principles to local conservation planning, together with discussion of practical concerns that will be associated with their implementation.

The basic approach in landscape-scale conservation planning today is a "network" of lands that are "managed" for conservation purposes. The central features of these conservation networks are "core areas," also known as "reserves," which are often areas with high value in protecting biodiversity; such areas might demonstrate locally high densities of a few sensitive species, or they might be areas having high densities of many (non-sensitive) species. The core reserve areas are often (but not always) "buffered" from adverse effects of activities occurring outside the reserve network by having additional areas adjacent to the reserves in which land uses may be limited; these areas are often identified in

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20 This ecological relationship apparently is also partly responsible, according to Lord May's (1999) thinking, for the "species-area relationship," discussed above, which also relates to the concepts of local and regional diversity discussed in this report. In short, questions important in conservation science are actually the same questions that are important in several areas of "ecological" science, and represent elements of fundamental understanding about how the natural world works.

21 A significant bridge between habitat-based conservation planning and landscape-based planning in the Pacific Northwest was the small volume about forest fragmentation written by Larry Harris (1984). This prescient consideration of the loss of "old-growth habitat" made use of the concepts developed by geographical ecologists considered above (and others), while looking forward to the landscape-based conservation approaches that are "standard" today. Harris's approach is no less relevant today than it was a quarter-century ago. The Harris volume appeared before the more comprehensive treatment of landscape ecology by Forman and Godron and stands (in my opinion) as a singular achievement in the development of landscape-based conservation science.

conservation plans as "multiple-use areas," or more directly as "buffer areas." The landscape conceptually also includes areas that are not specifically protected for biodiversity-maintenance purposes (although maintaining potential habitat utility in these areas remains important from a conservation perspective – see below); these areas are often identified as the "matrix" in which the conservation network is embedded. A widely known landscape-scale conservation model begins with "Multiple Use Modules," or MUMs (Noss and Harris 1986; Figure 4).

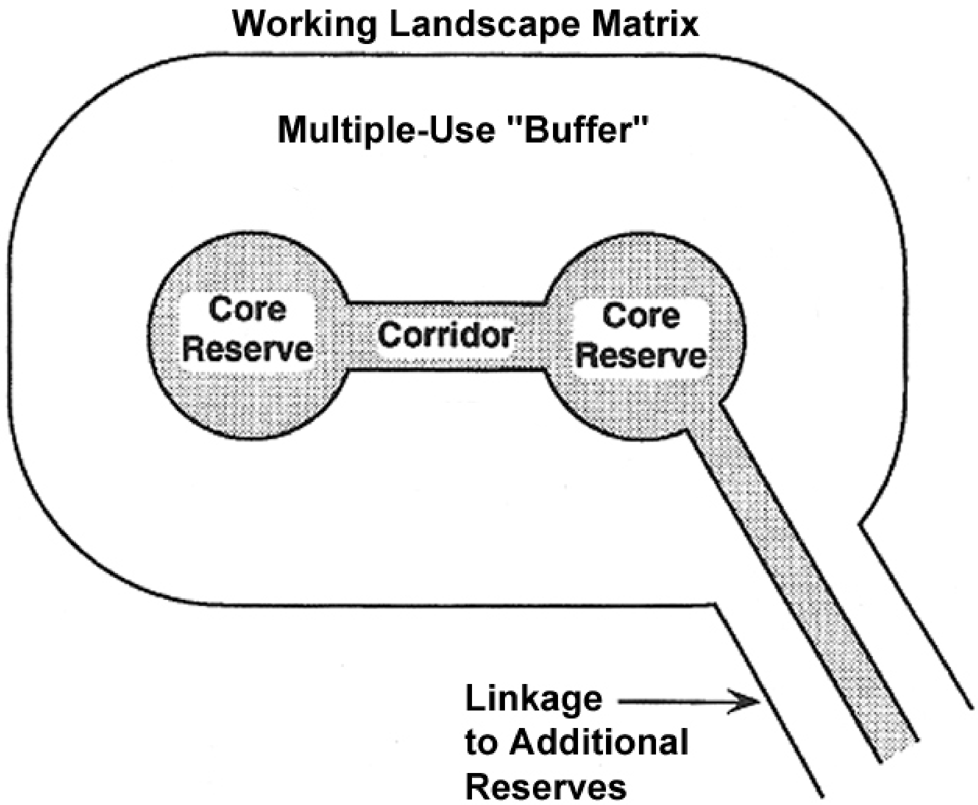


*Figure 4. The "Multiple Use Module" concept was pioneered by Reed Noss and Larry Harris for building conservation networks in landscapes that have areas with high conservation value in a "working landscape matrix." See Noss and Harris (1986), Noss (1992), and Noss and Cooperrider (1994) for additional information. [Based on Noss (1992)]*

Landscape-based approaches are "standard" in conservation planning, particularly in locations with well-informed public participants, such as Australia and the United States. Nearly all plans being prepared in California pursuant the State of California's CESA have adopted an "ecosystem" approach that relies on landscape-based planning to a greater extent than not. A variety of conceptual and applied software tools have been developed that address alternative reserve design approaches in various contexts. These tools help planners to conceptualize reserve systems that yield high conservation benefits with "optimal" investments of public money. The Natural Community Conservation Plans (NCCPs) under development in both Yolo and Solano counties make use of reserve-design software. Describing the content and development processes for these plans exceeds the scope of this report, although interested readers may contact the plan sponsors for information about these plans.

A valid question remains about the general attributes that should be sought for candidate “reserves” in a landscape-based conservation plan. Noss and Cooperrider (1994) offer the following “empirical generalizations for reserve design:”

“1. Species well distributed across their native range are less susceptible to extinction than are species confined to small portions of their range.

“2. Large blocks of habitat containing large populations of a target species are superior to small blocks of habitat containing small populations.

“3. Blocks of habitat close together are better than blocks far apart.

“4. Habitat in continuous blocks is better than fragmented habitat.

“5. Interconnected blocks of habitat are better than isolated blocks, and dispersing individuals travel more easily through habitat resembling that preferred by the species in question.

“6. Blocks of habitat that are roadless or otherwise inaccessible to humans are better than roaded and accessible habitat blocks.”

It may be argued that landscape-based conservation plans for the Berryessa – Snow Mountain region should follow these suggested empirical generalizations in establishing designated conservation “core areas.”

An important concept in the landscape-based approach is “connectivity,” which involves the ability of the landscape to support the movement of individuals of species of conservation interest. In the MUM example presented above connectivity is explicitly the reason for the “corridors” linking “core reserves.” Most conservation plans designate corridors or linkages as plan elements to assure that a minimal landscape connectivity can be established (although in many ways connectivity is more a function of matrix permeability than it is a function of discrete corridors or linkages; see below). Connectivity among reserve elements is important for maintaining genetic continuity among sub-populations that may occur in different reserves, or for promoting a “rescue” of a population segment that undergoes extirpation or near-extirpation (e.g., Brown and Kodric-Brown 1977). However, linkages may also be associated with adverse effects (e.g., because of enhanced disease transmission) as well as positive effects. Part of the importance of considering landscape linkages is that it leads to identifying natural connections across landscape elements.

A different conception of landscape connectivity has existed within conservation planning contexts almost since the discipline was established. In my opinion, owing to the effects on landscapes that are anticipated from climate change (see Section 4.0) this conceptualization requires serious consideration in planning for the Berryessa – Snow Mountain region. A branch of animal ecology that addresses the distribution of individuals in space and time includes various considerations (originally attributable largely to work published by SD Fretwell and HJ Lucas in the early 1970s) that in territorial species (e.g., many birds) at low population densities only “good” habitat is occupied, but that as population density increases subordinate individuals are forced into “less-good” habitats. From this synthetic result (and other work in this branch of ecology) a concept has been framed that in many territorial species there is a “floating” sub-population at or outside the margins of the “good” habitat.

This empirical result has led some scientists to postulate that many wildlife species are widely distributed in the environment at varying densities, higher (and with greater reproductive success) in “good” habitat, but still present at lower density (and with less reproductive success) in poorer-quality habitat for each species. This perception of the widespread distribution across a landscape of individuals at varying densities can be contrasted with the “island” model of distribution in which all individuals are confined to “islands” of suitable habitat and the intervening “ocean” of non-habitat is effectively empty.

The latter model (as I have attempted to demonstrate in this report) is one of the primary theoretical settings for the landscape-based planning framework in (to take the most obvious example) the Multiple Use Module described above. In the MUM the "matrix" is effectively viewed as non-habitat "ocean," with the core reserves as "islands" and corridors as "dry ground" that supports the movement of land-bound animals. The result of the planning exercise is entirely different when the "matrix" is conceived as habitat in which subordinate individuals (which are excluded from the "good" habitat) are able to "hang on," perhaps later to accede to a territory in the "good" habitat. There is ample evidence that many bird species use the environment in precisely this way, and this result presents certain implications for designing reserve systems for biodiversity conservation (see Wiens 1989 for a lucid explanation of this concept with respect to bird populations, and Wiens 1997 for an explicit presentation of the general conservation significance of this concept).

The conservation significance of the alternative framework is that a landscape may be variably "connected" by marginal habitat elements that are distributed throughout the "matrix." Evidence exists that this is true for many species, and the implication is that there is at least some "connectivity" for many wildlife species in the matrix of most natural habitats. The implication is that *the habitat value of the "matrix" for species of conservation significance can be enhanced by the intentional incorporation of habitat elements that benefit the species.* Various conceptualizations have been used for this effect, one of the most direct being that *enhancing the habitat quality in the matrix increases the "permeability" of the matrix for conservation target species, allowing them to "percolate" through the matrix between high-quality habitat patches in the designated "reserves," even if the matrix generally represents a population "sink" for the species*.

The two models of "connectedness" are not mutually exclusive, and each undoubtedly applies in some conservation contexts. There is little question that conservation plans for the Berryessa – Snow Mountain region need designated habitat reserves, and there is also little doubt that conservation planning must address the permeability of the landscape for all of the species that occupy it. Precisely what that planning framework should include is less clear, particularly because of the landscape effects that can be anticipated as a consequence of climate change (see Section 4.0).

Enacting landscape-based plans typically involves many decisions about the significance of particular landscape elements and trade-offs are often required that sacrifice one valuable site in favor of others, because in most real conservation contexts the cost of protecting the elements in a landscape-based plan that includes "reserves" exceeds the funding available. In addition, there is usually a "threat" that makes rapid execution important, and the acquisition of one important element may use up too much of the limited funding while a different important element may be lost before additional funding can be secured.

In the last two decades a modeling approach has been developed that addresses such dilemmas by applying geographic information system tools to real landscapes of conservation interest. For the most part describing this approach and its various current applications in detail exceeds the scope of this report. The essential "theory" of the approach is well explained in Margules and Pressy (2000). Essentially the concept is that conservation acquisitions made in order to enact a landscape-based plan represent a context of "optimization," and that a variety of existing approaches and management tools exist that will assist in making decisions rationally. Several models have been developed that are commonly applied in this context. Undoubtedly the most widely applied is MARXAN (Ball and Possingham 2000, Possingham et al 2000). Another model (which relies in part on elements of a predecessor to MARXAN) is the SITES model developed for the Nature Conservancy by Frank Davis and others at UC Santa Barbara.[22] Similar models have been developed by other research groups and by government agencies in other parts of the world.

22 See URL: http://www.biogeog.ucsb.edu/projects/tnc/overview.html (viewed February 2009).

The models offer consistent methodologies for screening landscapes to identify “irreplaceable” areas in a variety of conservation networks in the subject landscape. The models suggest alternative approaches to enacting these networks, which can help to “prioritize” acquisitions in the face of limited funding. The models always incorporate recognition of areas that are already protected, and have much in common with GAP assessments (see, e.g., Scott et al 1993).[23] The models functionally incorporate elements in the entire landscape, but require that the user be able to assign conservation significance to the elements; this assignment may be approximated by generalized assignments based on known habitat affinities, such as, for example, the regional distribution of oak woodlands, but the models cannot provide “on-the-ground” data that do not exist.

For practical reasons it is not realistic to apply these systematic conservation models to the Berryessa – Snow Mountain region at the present time. A primary reason is that there is no acquisition involved in the NCA establishment – the NCA only addresses land that is already owned by the public and additional priority-ranking will involve allocations to conservation purposes within this public land. In this context it should also be noted that federal land management agencies already have and use a variety of geographically based management models (for example, the model used by Mendocino National Forest is undoubtedly a version of SPECTRUM, the Forest Service’s land allocation system). It has been found (Csuti et al 1997) that linear programming models such as those used in federal land management programs often provide superior conservation planning results, and it’s likely that the implementation of the NCA will utilize these agency planning models for conservation planning purposes.

In the Berryessa – Snow Mountain region the well-documented locations of serpentinitic soils and their associated rare flora would be well-represented in these “systematic” conservation models, but the habitat-based (and largely uncharacterized) use of the region by many wildlife species would have to be addressed by approximations based on (for example) the CWHR database. In Section 3.0 I discuss elements needed in applying landscape-based planning in the region, recommending that thorough surveys be made that establish the geographical locations of conservationally significant elements. Such elements clearly include sensitive species such as those identified in Table 1. However, it’s also clear that understanding the importance to wildlife of the rest of the landscape, based on habitat use or habitat relationships, is important for assigning conservation value. In any event, it’s clear that applying structural conservation planning models to the Berryessa – Snow Mountain NCA region at the present time is not appropriate, although such applications likely will be useful following the NCA’s designation (probably in conjunction with use of the agencies’ planning models).

# 3.0 APPLYING LANDSCAPE-SCALE CONSERVATION PLANNING IN THE BERRYESSA – SNOW MOUNTAIN REGION

## 3.1 Biodiversity Patterns in the Landscape

An essential conservation consideration for the Berryessa – Snow Mountain region concerns current patterns of natural biological diversity in the landscape. In a general sense, *where are the natural highs and lows of species richness, or of habitat structural diversity, or of other measures of biological richness in the Berryessa – Snow Mountain region?* As indicated in the previous section these questions largely can’t be answered in detail at the present time. However, as also indicated previously an overall sketch of the regional biodiversity pattern can be created with existing assessments.

23 Also see the report prepared by the UC Santa Barbara Biogeography Laboratory of the California GAP Analysis project at URL: http://www.biogeog.ucsb.edu/projects/gap/gap_rep.html (viewed February 2009).

In 2003 the California Department of Fish and Game (CDFG) published a useful summary of biological diversity information for the State of California that illuminates the relative importance of various parts of the state for biodiversity (CDFG 2003a), based on an abstraction of data compiled by the Jepson Herbarium, the California Native Plant Society, the CDFG's Natural Diversity Data Base, and the Wildlife Habitat Relationships database regarding the geographical occurrences of plants and wildlife. Selected results for the Berryessa – Snow Mountain region are abstracted in Table 3.

**Table 3. Comparison of Biological Diversity Elements in the Berryessa – Snow Mountain Region.**

| Group | Agricultural/Floodplain Basins [A] | Woodlands/Chaparral | Coniferous Forests |
|---|---|---|---|
| Native Plant Species | 719-838 | 1409 – 1705 [B] | 1409 – 1705 [B] |
| Vegetation Richness [C] | 26-35 | 36 - 53 | 54 - 82 |
| Amphibian Species | 4 - 6 | 7 -10 | 7 -10 |
| Reptile Species | 6 - 11 | 12 - 18 | 19 - 25 |
| Bird Species (Summer) | (91 – 108) [D] | 91 - 108 | 109 – 127 |
| Bird Species (Winter) | 144 - 187 | 118 - 143 | 91 - 117 |
| Mammal Species | 22 - 39 | 40 - 47 | 48 - 55 |

Notes
A Presumed to include species of riparian affinity.
B Mapping in the Atlas does not identify a diversity difference between woodland and forest areas in this region.
C Numbers of "Plant Alliances."
D Most breeding birds in agricultural regions are associated with remnants of natural habitat types, rather than with agricultural areas *per se*; see text.

The results in Table 3 illustrate a gradient in species richness/biodiversity from relatively low richness in the highly modified agricultural landscape of the Central Valley lowlands, through increasingly rich landscape elements dominated by shrubs and deciduous trees in lower mountain elevations, into landscape elements dominated by conifers in the higher mountains northeast of Clear Lake. Associated with the ruggedness of the mountainous regions are increased opportunities for a variety of species to find "living space" by developing adaptations that differentiate them by substrate, temperature, moisture, plant growth form, and other ecological factors. The range of ecological variability in the Berryessa – Snow Mountain region appears to be quite remarkable, offering gradients in species richness that are as steep (in terms of total change in species richness over distance) as occur anywhere in California.

The patterns of species occurrence data were aggregated by CDFG according to the authors' interpretations of landscape-level biological processes, natural landforms, and biogeographic regions in California. It's noteworthy that the "Coniferous Forest" column entries in Table 3 for both "Native Plant Species" and "Vegetation Richness" are as high as any mapped in California. The taxonomic richness in the Berryessa – Snow Mountain region is substantially greater, across taxa, than is the richness in the agricultural landscape near the Sacramento River, where, except for breeding birds (considered further below), the observed taxonomic richness in the western mountains is two or three times the richness in the agricultural Central Valley.

There is a biologically coherent explanation for the Table 3 pattern. Two of the generally accepted relationships from the past 50 years of ecological studies indicate that species richness is positively correlated with the range of habitat conditions available and with habitat structural complexity (Mayer and Laudenslayer 1988; many others). The mountainous parts of the NCA region include a variety of habitat elements, including native grasslands, oak woodlands, chaparral, and coniferous forests. Oak woodlands are widely identified as being among the most important habitat types for wildlife in

California (see, for instance, CalPIF 2002a). The Berryessa – Snow Mountain region includes coniferous forests, adding habitat elements that are otherwise not present in the region (see CalPIF 2002b). The region also provides chaparral and grassland/prairie habitats that are important in preserving the state's native flora and fauna (CalPIF 2000, 2004). Finally, the Berryessa – Snow Mountain also provides a variety of riparian-related habitat elements (see RHJV 2004, discussed further below).

The mapped CDFG data for mammal occurrences indicate that the mountainous region includes a sub-region of lower relative species richness (40-47 species) in lower-elevation regions south of Clear Lake. The higher-elevation and more remote habitat regions north and northeast of Clear Lake are differentiated by having higher mammal species richness (48-55 species). This result is not unexpected, given that relatively sedentary mammals would be expected to find opportunities for increasing the numbers of ecological niches in the longer elevation gradients in the latter region. This relationship is confirmed in a separate CDFG map showing the richness of wide-ranging mammals: 7-9 species in the Central Valley, 10-12 species in the lower-elevation regions, and 13-15 species in the higher and more remote forested landscape near Snow Mountain.

The "agricultural landscape" in the Sacramento River Valley is not without important habitat values. These lands include mapped vernal pool complexes, for example, which are absent from the mountainous areas to the west. Wetland areas in the Sacramento Valley provide important habitat values for wintering waterfowl, shorebirds, and cranes, part of a regionally significant wintertime concentration area for wetland-related birds (CalFed 2000). However, many of the habitat values for birds present in the agricultural region are provided by remnants of native habitat types (e.g., riparian areas, remnant oaks) that have otherwise largely been removed from the agricultural landscape. Were nesting bird species in agricultural areas in Table 3 restricted to species that are confined to active agricultural areas, the breeding-season diversity would undoubtedly fall within the pattern observed in other taxa.

One important pattern identified by the CDFG that does not fit very well within the contrast set up in Table 3 is the pattern of native fish diversity associated with watercourses. The Sacramento River and the east-west oriented Cache Creek watershed were mapped by CDFG (2003a) as regionally important native fish habitats (with 15–21 species and 11–14 species, respectively). Moyle (1999; also see the regional habitat-based discussion in Moyle 1996) described the Cache Creek basin as "including most of the fish that inhabit Central California;" the basin lacks large impoundments between Clear Lake and the Sacramento Delta, which may have allowed many native fish populations in the basin to persist. Other tributary stream basins in the Central Valley do not appear to demonstrate a high diversity of native fish species. That is, the pattern of native fish species richness appears to be more a function of prior modification by humans than a reflection of natural processes.

Across landscape regions there are some habitat elements that continually emerge as significant for wildlife. As noted in the previous section, one of these elements is oak trees. For example, the California Partners in Flight Oak Woodlands Plan (CalPIF 2002a) includes the following summary regarding oak woodlands:

> "Oak woodlands have the richest wildlife species abundance of any habitat in California, with over 330 species of birds, mammals, reptiles, and amphibians depending on them at some stage in their life cycle (references omitted). Wilson and others (1991) suggest that California oak woodlands rank among the top three habitat types in North America for bird richness. Oak woodlands are able to sustain such abundant wildlife primarily because they produce acorns, a high quality and frequently copious food supply (references omitted). Oaks also provide important shelter in the form of cavities for nesting (references omitted)."

Similar habitat benefits for wildlife will result from having a range of oak trees and shrubs included in the NCA. For example, the frequent inclusion of black oak (*Q. kelloggii*) in conifer-dominated habitats increases the value of these habitats for a variety of wildlife species (Block et al 1994), a relationship expected to occur in mixed habitats in the Snow Mountain region now, and a pattern that is desirable for the region in the future.

A second "habitat type" that is nearly universally significant for wildlife species is the set of plant communities that are generally found near the "upland" margins of aquatic features. From biological and physical/hydrological perspectives, riparian areas function as elements of the aquatic ecosystems with which they are associated, rather than as separate habitat types (National Research Council 2002), but the identification of these areas as important for many wildlife species has probably permanently affected the common understanding of these areas.

Riparian habitat in the Central Valley is well established as a significant habitat for wildlife species of many varieties. The following summary is provided in the Riparian Habitat Joint Venture Plan (RHJV 2004):

> "More than 225 species of birds, mammals, reptiles, and amphibians depend on California's riparian habitats. Riparian ecosystems harbor the most diverse bird communities in the arid and semiarid portions of the western United States (references omitted). Riparian vegetation is critical to the quality of in-stream habitat and aids significantly in maintaining aquatic life by providing shade, food, and nutrients that form the basis of the food chain (references omitted). Riparian vegetation also supplies in-stream habitat when downed trees and willow mats scour pools and form logjams important for fish, amphibians, and aquatic insects. The National Research Council (2002) concluded that riparian areas perform a disproportionate number of biological and physical functions on a unit area basis and that the restoration of riparian function along America's waterbodies should be a national goal.
>
> "Riparian vegetation in California makes up less than 0.5% of the total land area, an estimated 145,000 hectares (reference omitted). Yet, studies of riparian habitats indicate that they are important to ecosystem integrity and function across landscapes (references omitted). Consequently, they may also be the most important habitat for landbird species in California (reference omitted). Despite its importance, riparian habitat has been decimated over the past 150 years. Today, depending on bioregion, riparian habitat covers 2% to 15% of its historic range in California (references omitted).
>
> "Due to their biological wealth and severe degradation, riparian areas are the most critical habitat for conservation of Neotropical migrants and resident birds in the West (references omitted). California's riparian habitat provides important breeding and over wintering grounds, migration stopover areas, and corridors for dispersal (references omitted). The loss of riparian habitats may be the most important cause of population decline among landbird species in western North America (reference omitted)."

The CDFG (2003a) map portraying riparian habitat areas within the Berryessa – Snow Mountain region includes narrow corridors along the Sacramento River, Putah Creek, and Cache Creek; the map also includes a few smaller areas of mapped riparian habitat along the eastern margins of the Coast Range. The map does not include other existing (i.e., known) narrow riparian corridors in this region. Taken as a whole, it's unknown whether existing mapping adequately captures the extent or the overall distribution of riparian habitat in the Berryessa – Snow Mountain region.

"Linkages" provided by corridors of "riparian habitat" along major streams are considered by many landscape ecologists to be among the most important elements in conservation plans. For example, a major USDA Forest Service study addressing wildlife habitat values in the Blue Mountains of northeastern Oregon (Thomas 1979) included the following conclusions: "riparian zones are the most critical wildlife habitats in the Blue Mountains;" "riparian zones are the most critical zones for multiple use planning in the Blue Mountains;" and "riparian habitat alterations will affect wildlife far more than indicated by the proportion of the total area." The Blue Mountains report noted that 285 of the 378 terrestrial wildlife species (75 percent) in the Blue Mountains either depended on riparian zones or used them more than other habitats.

The riparian elements of aquatic ecosystems have been established to be highly significant in arid regions of southwestern North America. The roles that these arid-land riparian areas play for resident and (especially) migratory birds are particularly well established (e.g., Skagen et al 1998, 2005). It seems inescapable that riparian areas will become ever more significant in the Berryessa – Snow Mountain region as the effects of climate change become more pronounced (see Section 4.0).

Finally, it should also be noted with respect to bird use of riparian habitats that there is a well-known change in use between the breeding season in spring and summer and use during the winter. Most of the "Neotropical migrants" that are present during the breeding season are absent in the winter, and a different complement of "winter migrant" bird species is encountered then (in addition to resident species that are present in all seasons). Studies in the Central Valley (e.g., Hehnke and Stone 1979, Motroni 1979, Gaines 1980) have indicated that the absolute numbers of wintering riparian birds may equal or even exceed the numbers present in the breeding season. The combination of this seasonal exchange in the avifaunal use of riparian habitats and the wintertime appearance of shorebirds and waterfowl in wetlands in the Central Valley appears likely to be the primary ecological reason for the "reversed" relative importance for wintering birds shown in Table 3 above.

## 3.2 Landscape Linkages in the Berryessa – Snow Mountain Region

At a 2000 conference in San Diego, CA, conservation biologists from around the state identified known or expected biological or conservation linkages in areas in which they worked.[24] An excerpt from the resulting statewide linkages map is shown in Figure 5. The general opinion among conservation biologists was (and remains) that Putah Creek and Cache Creek are important east-west landscape linkages. A north-south linkage corridor was identified along the Blue Ridge/Rocky Ridge crest, which represents a primary migratory pathway for Neotropical migrant birds as well as a dispersal corridor through relatively undisturbed habitat for resident wildlife species. An additional north-south linkage was identified in the lower foothills/terraces, at the margin of the Central Valley flatlands, although this "foothill corridor" is effectively just a portion of what might be designated the "Great Inner Coast Range Migration Corridor," as is a shorter corridor originally designated in northeastern Napa County (Figure 5).

The linkages illustrated in Figure 5 serve two broad purposes. First, the linkages were selected, in part, to interconnect relatively large areas of publicly owned land, such as the BLM lands in western Yolo County and those in eastern Lake County and western Colusa County. The second purpose was to illustrate and support migration routes among important wildland habitats regardless of ownership. The mountainous regions of western Solano, Yolo, and Colusa counties and eastern Napa and Lake counties were recognized as significant wildland habitats which also served to link similar habitats to the north and south in ecological relationships of hemispheric scope. Putah Creek and Cache Creek were recognized as important connections from the Coast Range to the Sacramento River corridor, and additional linkages were identified between the Sacramento River and the Sierra Nevada foothills (the east-west linkage in central Colusa County incorporates the visually prominent Sutter Buttes and the existing wildlife refuges to the north and west).

The corridors mapped in Figure 5 do not show the functional extension of the Inner Coast Range corridor northward and westward from Yolo County into eastern Lake County and western Colusa County. This is not an indication that the linkage was not considered important, but is a representation of the underlying dynamics of the people (I was one) who designated the regional linkages; federally owned lands were generally considered to be somewhat "linked" in any event and did not need designated corridors except

24 The resulting publication, with maps that can be downloaded as JPG files, is located at URL: http://www.calwild.org/linkages/index.html (viewed January 2009).

where there was significant pressure for logging or other activities that removed important ecological elements. In fact, however, the Inner Coast Range migration corridor should be shown explicitly, as is illustrated by the red arrows added to Figure 5. It is important to recognize, however, that this correction reflects existing conditions and is not a change in underlying ecological dynamics.

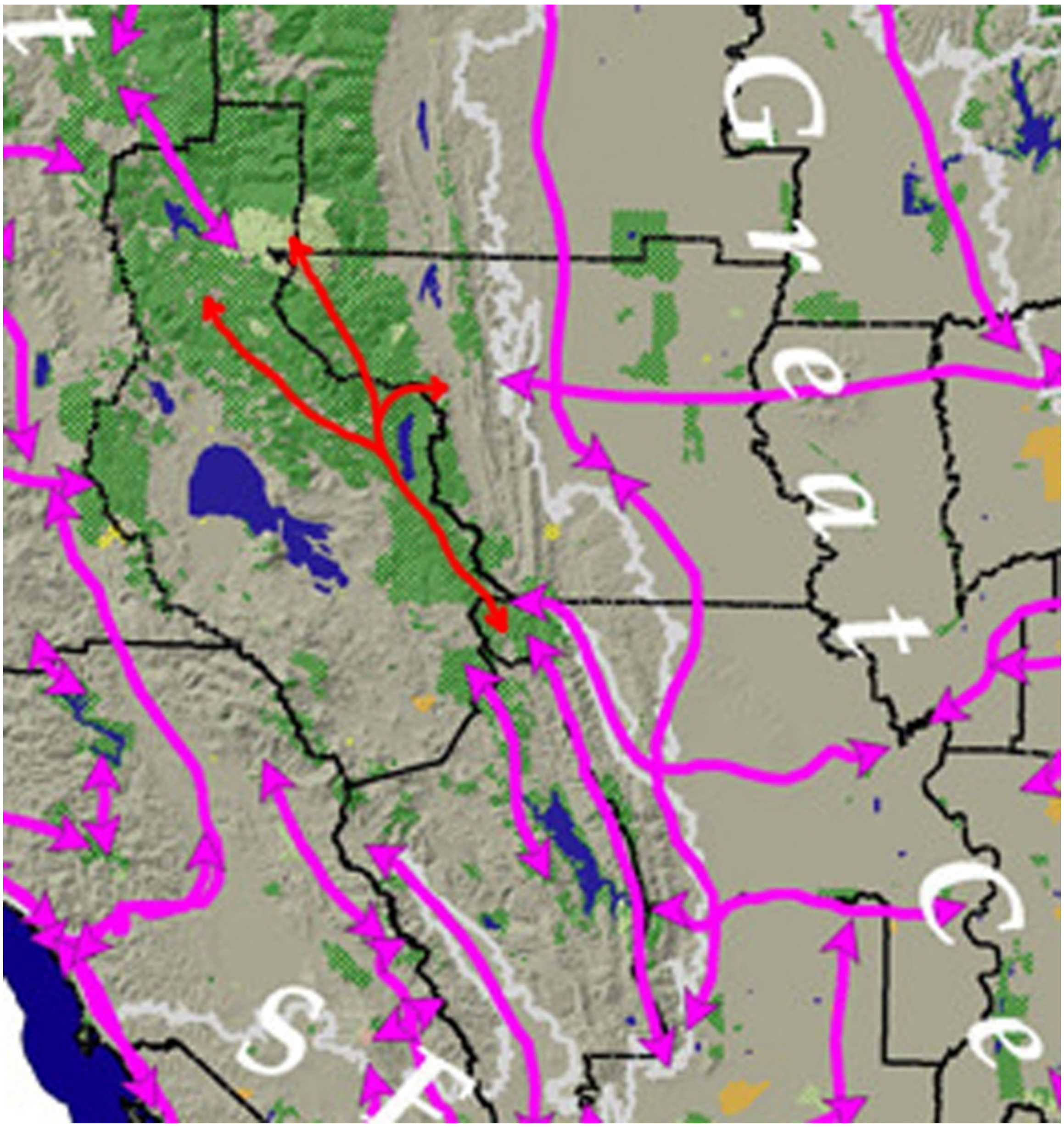


*Figure 5. Excerpt from the "Statewide Linkages Map," showing landscape-scale linkages (pink arrows) identified in and near the Berryessa – Snow Mountain region. The Snow Mountain Wilderness in upper left is shown in light green; Clear Lake at middle left and Lake Berryessa at lower center are in dark blue. The red arrow represents a linkage that was omitted from the maps published by the conference organizers; see text for discussion.*

Ecological conditions throughout the Berryessa – Snow Mountain region are not uniform across the landscape, and the variation in conditions on the ground is potentially significant for landscape-based conservation. Because the Berryessa – Snow Mountain NCA will only include publicly owned lands, ownership gaps in the public land maps also represent potential gaps in the corridors that are overlaid on the public ownerships. Particularly noteworthy gaps exist in public lands along the north side of Highway 20 in southern Colusa County and eastern Lake County. These gaps are partially closed by lands under conservation easement in Colusa County; additional attention should be directed to bridging these gaps.

As noted above, managing "corridors" as stand-alone, contrasting landscape elements is not a recommended conservation approach. A more desirable approach (particularly in the age of global climate change; see Section 4.0) is to incorporate corridor "functions" into the management of the landscape "matrix" as a whole, by assuring that known habitat elements that support migratory species are present throughout the entire landscape. The management coherence across federal lands that the NCA represents is an opportunity for an important conservation achievement across this region.

## 3.3 Landscape Level Conservation Planning for the Berryessa – Snow Mountain Region

A fundamental focus of the Berryessa – Snow Mountain NCA includes the desired result that the federal management agencies will address conservation needs of the NCA region as a whole. The large region included in the NCA is an appropriate scale at which landscape-based planning can be deployed effectively, and the size of the area available for implementing this approach is an important consideration. The minimum scale for landscape-level conservation plans is conceptually related to "the smallest area in which all of the processes that affect the landscape recur" with a frequency that maintains the elements; this is functionally the "minimum dynamic area" of Pickett and Thompson (1978) and Pickett and White (1985), which includes disturbance regimes (such as fire) as well as the landscape areas through which matter and energy flow (such as watersheds). Typically the area needed is much larger than the average disturbance patch; an appropriate focus of the landscape-scale conservation plan is to perpetuate the natural disturbance regime (Baker 1992), and the "minimum dynamic area" may be larger than (for example) the 40,000± acres that burned in the Rumsey fire in October 2004. Clearly areas much smaller than the Berryessa – Snow Mountain region will not be large enough to meet this criterion.

In landscape-level conservation planning, suitable management elements for the core reserves and linkages and the multiple-use buffer areas must be identified that accomplish the plan's goals, and often some consideration will need to be given, as well, to "matrix" areas near the buffers. Table 4 provides an example of a set of management guidelines (modified from Noss 1993) for a conceptual conservation plan that would be appropriate for the federally owned lands in the Berryessa – Snow Mountain region.

Identifying a specific landscape-based plan for these public lands greatly exceeds the scope of this report. Developing such a plan requires a collaborative effort among all of the managers, with a full commitment to protecting the conservationally important elements throughout the landscape, as well as a willingness to work collaboratively to restrict inappropriate management activities. However, it can be reckoned that all three federal agencies affected by the NCA will continue to have biologically rich "reserve" areas that will be incorporated into the "reserves" of a landscape-based conservation management plan. For example, the Mendocino National Forest has "late seral reserves," "research natural areas," and other forest legacy designations. The Bureau or Land management has "areas of critical environmental concern" with similar purposes. A landscape-based conservation plan for the region should incorporate all of these legacy resources into the protected "core reserve" and corridor areas, and management in the "reserves" should be focused primarily or solely on maintaining these resource values. Arguably the serpentinitic soils associated with the Coast Range Ophiolite should receive high consideration in siting reserve areas.

**Table 4. Landscape-Level Conservation Plan Guidelines.** [A]

| **"Reserves/Linkages:"** |
| --- |
| Prohibit new road construction or reconstruction of existing roads. |
| Close all pre-existing roads other than major highways; restore roadbeds to prior conditions. Reduce overall road density to be less than 0.5 miles road / square mile of Reserve. |
| Prohibit off-highway vehicles (including bicycles). |
| Limit or prohibit horses in Reserve areas (horses introduce exotic species). |
| Prohibit grazing or agricultural activities (they result in exotic species introductions). |
| Prohibit logging and any other commercial extraction of plants or biological materials. |
| Prohibit commercial extraction of other natural objects. |
| Prohibit mineral or energy leasing. |
| Restore degraded areas, particularly areas associated with sensitive species and those associated with aquatic ecosystem elements. |
| Eliminate invasive species. |
| Limit fire suppression; encourage controlled fire for restoration purposes. |
| Recreational activities such as hiking, primitive camping, nature study, environmental education, non-motorized restoration of degraded areas, and non-manipulative research are encouraged. |
| Eliminate inholdings. |
| **Multiple-Use Landscape/Buffer:** |
| Limit new road construction to those consistent with protecting Reserve environmental resource values. Reduce or maintain overall road density to be less than 1.0 miles road / square mile of multiple-use landscape. |
| Prohibit motorized off-high vehicles. |
| Protect environmentally important resources, particularly riparian areas, oak woodlands, and habitats for sensitive species. |
| Vegetation manipulation, including grazing, logging, or other extractive activities, must be consistent with restoration and management goals for protecting Reserve environmental resource values. |
| Restore degraded areas, particularly areas associated with sensitive species and those associated with aquatic ecosystem elements. |
| Eliminate invasive species. |
| Manage fire suppression to be consistent with protecting Reserve environmental resource values. |
| Recreational activities, including hiking, low-impact camping, nature study, environmental education, non-motorized restoration of degraded areas, and non-manipulative research are encouraged. |
| Eliminate inholdings, or establish easement restraints over inholdings. |
| **"Matrix:"** |
| Require sustainable resource management approaches, including those for grazing and timberland management. |
| Manage environmentally important resources for conservation purposes, particularly riparian areas, oak woodlands, and habitats for sensitive species. |
| Restore degraded areas, particularly areas associated with sensitive species and those associated with aquatic ecosystem elements. |
| Control (eliminate if possible) invasive species. |

A Modified from Noss (1993).

As previously noted, oak-containing habitats, forests, chaparral, and grasslands in the NCA all provide important habitat elements for wildlife and plant species. Under current climate and ecological conditions in the region these habitat types are roughly segregated geographically and elevationally (see Attachment A). Arguably a suitable conservation framework for the region will include appropriate representations for "reserve" purposes of all of these ecosystem elements. Riparian ecosystems are sensitive to the hydrological dynamics of the adjacent streams or rivers, because riparian habitat is functionally affected by inadequate streamflow (Winter and others 1998, NRC 2002). Therefore a landscape-based conservation plan for the NCA will also address watershed elements; it seems likely that the plan should also address hydrology associated with flood events, given the expectation that future events will exceed the magnitudes of those experienced heretofore.

Resource exploitation of the kinds that usually occur on federal lands (logging, grazing, mining, so forth) and other activities that damage conservation values (e.g., uncontrolled recreation) are very problematical for conservation reserves, and will need to be curtailed in conservationally significant areas. Selecting fire-management elements that are sensitive to the conservationally important values will be a major element in developing the plan. The details of how such a reserve and corridor system should be established is clearly part of a future effort that will follow the designation of the NCA.

There is, finally, a "new" overriding factor, not included in Table 4, which prevents specifying realistic landscape-based conservation planning for the Berryessa – Snow Mountain region as part of this report: the effects that will occur in this region because of climate change will alter the entire landscape and affect most of the important ecological factors in it. Developing a landscape-based conservation plan that addresses current conservation concerns may be technically and culturally arduous, but certainly solutions can be conceived. Developing a landscape-based conservation plan for ecological conditions that will occur in the Berryessa – Snow Mountain region in the climate-changed future may prove somewhat more difficult.

# 4.0 CONSERVATION CONSIDERATIONS FOR CLIMATE CHANGE IN THE BERRYESSA – SNOW MOUNTAIN REGION

> *"Paleoecologic data from the Pacific Northwest and elsewhere suggest that modern communities are loose associations composed of species independently adjusting their ranges to environmental changes on various time scales (references omitted). ... Periods of rapid environmental change in the past are generally characterized by increases in species richness, and analogs for these intervals are often modern ecotones between communities or vegetation types. ... Species with life histories suitable for frequent disturbance and stressed environments have fared well during periods of rapid climatic change (references omitted). ... A conservation strategy that seeks to preserve areas of high species richness in the face of future global warming fails to recognize the ephemeral nature of such associations to climate changes of similar magnitude in the Quaternary. Likewise, conservation efforts that emphasize the preservation of communities or vegetation types will probably be unsuccessful because future climate changes quite likely will dismantle the community or vegetation type of concern (references omitted). Present-day reserves will likely be the source area for many of the taxa that will comprise future communities. But these reserves will probably not be the final residence for the communities that form as taxa respond to increasing drought and warming (reference omitted)."*
>
> – Cathy Whitlock, *Northwest Environmental Journal* (1992)

Addressing potential effects of climate change on the biota in the region is a primary motivation underlying the Berryessa – Snow Mountain NCA proposal, and it's reasonable to ask how ecological science and conservation planning bear on this topic. A variety of evidence supports the conclusion that the planet's biota is responding to climate change.[25] For example, in a broad-scaled assessment based on

25 Because the Berryessa – Snow Mountain NCA is solely a terrestrial region, this report does not address the increasing evidence that marine ecosystems exhibit significant responses to global climate change.

143 published works (a meta-analysis) Root et al (2003) identified climate-related ecological shifts in a wide array of organisms ("from mollusks to mammals and from grasses to trees"). The Pew Report (Parmesan and Galbraith 2004) unequivocally documents climate-change-related biological changes that have already occurred, and similar results have been documented in other reviews and syntheses (e.g. Walther et al 2002; Parmesan 2006). The subject of potential effects on biota as a result of greenhouse gas-related climate change is an active research subject, however, and while many papers have appeared in recent years, definitive answers remain to be elucidated to a variety of questions about the biotic changes that will result from climate change.

To cite one subject (of many possible), consider the potential effects of changed local climate on the reproduction in migratory birds. In abstract it may be considered that migrants, which generally winter south of the United States or Europe, could be exposed to the effects of warming climate in several ways. One important effect would be a mistiming of arrival by the migrants, caused by a climate-advanced shift to earlier prey availability in nesting areas, leading to evolutionary pressure for advanced (earlier) migration, to the timing of nesting, or to other reproduction-related life-history traits.

- Such mistimed migration has been broadly documented for at least one European bird species (Visser et al 2004, Both et al 2006), where migrant Pied Flycatchers (*Ficedula hypoleuca*) now arrive after the (seasonally advanced) peak availability of the insect prey needed for nestlings, with observed reductions in flycatcher reproductive success.
- There is widespread evidence from both Europe and North America that populations of some resident bird species [e.g., the Great Titmouse (*Parus major*)] have demonstrated a shift toward earlier nesting, although other populations have not shifted nesting periods and have accordingly been adversely affected by climate change (Visser et al 1998).
- Many studies have documented phenological shifts in flowering times or bud burst in plants, which are indicators of adaptation to changing climate; these phenological changes are related to shifts in food availability for migratory birds. However, other studies have not documented significant phenological shifts in plant populations at higher elevations, and there is a potential that differential changes in seasonal plant phenology at low and high altitudes could affect altitudinal migrant bird species (Inouye et al 2000), although this effect has not been observed.
- Owing to adaptive behavioral plasticity many bird species already vary spring migration behavior in different years by responding differentially to migratory cues. There is evidence that some bird species are not migrating or nesting earlier despite seasonally advanced vegetative development in their nesting habitats (Marra et al 2005).
- Given a known general trend between nesting date and egg number, earlier nests would be expected to have larger clutches (i.e., more eggs). In a North America-wide survey based on data for Tree Swallow (*Tachycineta bicolor*) nests collected between 1959 and 1991, this species advanced nesting date by nine days, but did not show the altered life-history traits expected from the typical relationship between nesting date and clutch size (Winkler et al 2002).

While climate-change-related stressors are clearly acting on migratory birds and their habitats, and the observed results are mostly consistent with those expected, more research is required to characterize effects on bird migration and nesting behavior associated with climate-related ecological changes.

## 4.1 Ecological Effects that can be Anticipated in the Region Because of Global Climate Change

Generalized descriptions of some climate-change-related effects have appeared in the ecological literature (Walther et al 2002, Root et al 2003, Parmesan and Galbraith 2004, Parmesan 2006). Ecological range shifts have occurred in both plant and animal populations, generally "poleward and upward" as species migrate in response to warming temperatures. Many plant species exhibit phenological shifts toward earlier leaf appearance, flowering, and fruiting. As noted previously, migratory birds in many cases arrive earlier than in recent history.

The projected effects of climate change are, however, often not results of empirical studies; rather, they are potential effects of climate change based on climate models. Discussing climate models exceeds the scope of this report. It may be noted, however, that climate models differ in assumptions about greenhouse-gas emissions and other factors, so that different models, using differing assumptions about the future and the synergistic effects of atmospheric pollutants on climate variables, produce a range of possible future climate envelopes for California. It's my impression that there is a weak consensus on some effects that are anticipated to occur in California, and there are also significant uncertainties about other climate effects that may occur. In addition, translating the climate-model results into on-the-ground ecological conditions that affect natural communities also includes significant ecological uncertainty.

A general consensus among climate scientists and ecologists indicates that the future is most likely to present some version of the following:

- Future ambient conditions will be warmer. Average high and low temperatures will be warmer, and the range of temperatures expected at virtually all locations in California will be shifted upward. High temperature extremes will be hotter, perhaps significantly so (Battisti and Naylor 2009). However, while cool-season temperatures generally will be warmer, wintertime temperatures occasionally may be quite cool, because the climatic pattern will be more variable than previously.
- The pattern expected in California for storminess and rainfall is not predicted with high certainty by models of global climate. Generally there is a potential for the Berryessa – Snow Mountain region to experience less rainfall in the warmer future, but there is also a potential for increased rainfall in the future. It's unclear whether the rainfall will be less equitable (i.e., more extreme wet years and dry years with less similarity among years) in the future than currently. There is general consensus, however, that the atmosphere will receive increased moisture from the warmer Pacific Ocean, which is generally considered likely to lead to storms of increased intensity (that is, more rainfall in a given period of time), leading in turn to increased runoff and streamflow and to increased potentials for erosion and rainfall-induced land surface failures.
- A significant increase in fire frequency is generally expected (e.g., Lenihan et al 2006). The most common fire ignition source may be lightning associated with increased storminess. However, the increased aridity and higher temperatures, particularly in summer, will cause western forests (including those in the Berryessa – Snow Mountain region) to be more flammable. Because plant species respond to fires as a natural stressor, changed fire frequencies would be a probable "primary driver" of vegetation change in the region (Westerling et al 2006, Marlon et al 2009). Increased fire return frequencies (shorter intervals between fires) would likely result in shifting the dominant vegetation patterns in the region away from forests and woodlands to chaparral; it's possible that woody chaparral could be replaced by grasslands in much of the region.

In my judgement there is another significant ecological factor that must also be accommodated in conservation planning related to climate change in this region:

- Exotic species will become increasingly abundant throughout the region, and will be favored by the ecological shifts resulting from climate change. While most colonizations by exotic species are unlikely to result in significant disruptions of native communities, some species are likely to be invasive.[26] In my opinion there is an emerging scientific consensus that ecological conditions

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26 Invasive species are non-native species in any of a variety of taxa that occur in communities outside those of their origins and there cause ecological or economic harm. A white paper that addresses the definition of "invasive"

> that favor high diversity in native species also favor high diversity in exotic species, a result that is directly correlated with increasing abundances of exotic species in all native habitats through time (e.g., see Stohlgren et al 2001, 2003, and 2008 with respect to vegetation; see Stohlgren et al 2006 for evidence also relating to birds and fish). If any benefit results from high native species diversity in resisting colonizations by exotic species,[27] the effect seems likely to be overcome by the disruptions resulting from climate change.

The projected ecological effects of global climate change are generally based on "bioclimatic envelope" models. In these predictions, future biological and ecological conditions are simulated according to one or more climate models, and the simulated future conditions are then related to known physiological and ecological tolerances or environmental requirements of organisms. That is, a climate model is used to predict a range of future "climate conditions," which are then compared to the known physiological or ecological tolerances of various species of interest. When future climate conditions occur that are outside of the known range of conditions accepted by a given species, then that species is not expected to occur in the region following the change in climate. [Of course the converse is not true, and the fact that projected future conditions in a given region include the current bioclimate envelope of a species is not a guarantee that the species will occur in that region in the future.]

It's widely acknowledged that because global models use a fairly coarse cell grid for projecting future conditions owing to the computational requirements needed to run the massive models, better bioclimatic projects would result from "regionalized" models (see, e.g., Pearson and Dawson 2003) that would use finer grids and take cognizance of model factors that cannot be incorporated into global models. Some regionalized climate modeling has been conducted for California. For example, the projections for future bioclimate conditions relating to the continued presence of blue oak (*Quercus douglasii*) in the Berryessa – Snow Mountain region (Figure 6) raise significant concerns for conservation planning here. Generally both global and regionalized models project a "poleward and upward" shift, but the regionalized model predicts a change in suitable bioclimate conditions that is much greater than that projected by the global model.

The left panel in Figure 6 (see Kueppers et al 2005 for details) shows an anticipated range shift based on global climate models, indicating a likely abandonment of the low-elevation Coast Range foothills within the region by blue oak, although the global model projections indicate a high potential that blue oak will remain present at higher elevations throughout most of its present range in this region. The right panel in Figure 6 reflects the results of regional modeling (Kueppers et al 2005; also see Thorne et al 2006 for similar projections for the Sierra Nevada). In the (presumably more accurate) regionalized projection, the range of suitable conditions for blue oak in the Berryessa – Snow Mountain region is reduced dramatically, such that conditions suitable for blue oak [and also for valley oak (*Q. lobata*), not shown here] largely disappear from the region east of Clear Lake. The climate modeling work does not indicate what will replace blue oak as the dominant vegetation in the blue areas of Figure 6.

Bioclimate-envelope modeling predicts the future extent of ecological factors within which blue oaks currently live and reproduce. Changed conditions projected by the models do not necessarily mean that all of the currently extant blue oaks in the "blue" region in Figure 6 will disappear in the short term, and nonreproductive blue oak trees could continue to be present for as long as the trees survive (potentially

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is available at URL: http://www.invasivespeciesinfo.gov/docs/council/isacdef.pdf (viewed February 2009). See URL: http://invasivespecies.nbii.gov/ for general information about invasive species in the United States.

27 There is some evidence for this dynamic (e.g., Kennedy et al 2002). The potential that diverse native communities might repel colonizations by exotic species has been the subject of a recent scientific debate; in my opinion that debate has been resolved in favor of the conclusion that the evidence does not support the proposition.

several hundred years) as “living fossils” in areas that are mapped in blue in the figure. However, to the extent that the effects projected by the models are achieved by increased fires, for example, then the range shift could well be achieved by the removal of existing trees in a relatively short period. Such short-term changes in vegetation boundaries associated with climate variables have been recorded (Allen and Breshears 1998), who state:

> “(W)e propose that the unprecedentedly rapid climate changes expected in coming decades will produce rapid and extensive contractions in the geographic distributions of long-lived woody species and shifts in associated ecotones such as the one we document. These shifts are very likely to occur globally because semiarid forests and woodlands and their associated ecotones are widespread and considered to be among the most sensitive to changes in climate.”

It’s likely, in other words, that shifts in dominant vegetation in response to climate change could occur relatively abruptly.

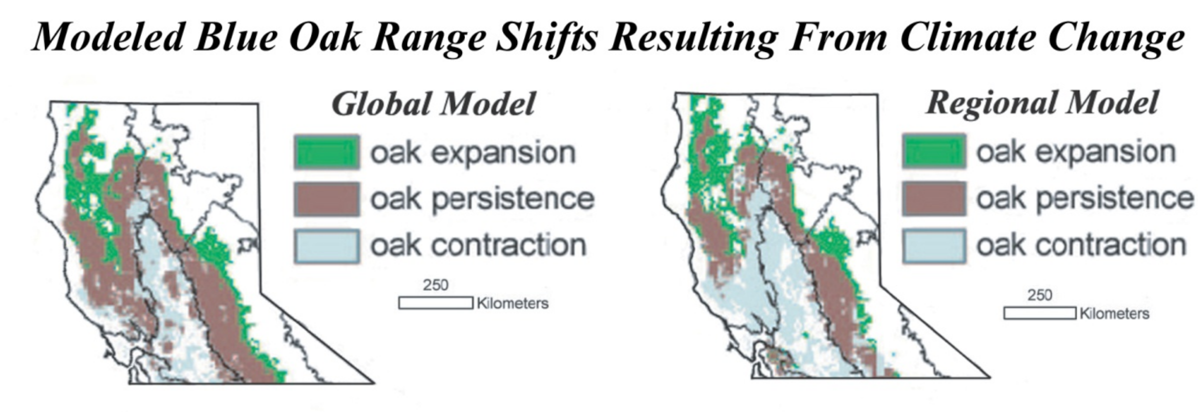


*Figure 6. Bioclimate-envelope modeling results for oaks in northern California. Left panel represents typical results from modeling using “global” models such as those used by the International Panel on Climate Change (IPCC). The right panel was simulated by regionalized climate modeling (Kueppers et al 2005), and indicates a reduction in the likely future occurrence of oaks (including valley oak as well as blue oak) in the Berryessa – Snow Mountain region.*

Similar bioclimate simulations have been developed for shifts in California “vegetation” (not individual species) that may result from climate change, particularly for vegetation that is commercially important (i.e., forests). For example, the California Energy Commission commissioned studies for an environmental review process carried out within the past decade that looked at a number of commercially significant vegetation shifts (including altered agricultural patterns). The supporting study that considered forest vegetation in northwestern California (Lenihan et al 2006) identified a likely decrease in coniferous forests (forests predominantly or solely composed of conifers) and an increase in “mixed evergreen” forestlands dominated by a mixture of conifers and broadleaved evergreen tree species.

A major shift in the vegetation patterns that occur on the landscape within the Berryessa – Snow Mountain region will have potentially important effects on the NCA’s conservation achievements. A major loss of oak woodland habitats, such as is suggested by the Kueppers et al (2005) model results, represents a significant alteration in wildlife habitat values. While there’s no certainty as to which might replace the oak woodlands, the most likely candidate plant alliances would be dominated by shrubby chaparral species (providing that future fire frequencies permit the occurrence of woody vegetation) or grasses. Assuming a conversion of woodland to chaparral, the effect on wildlife habitat utility is essentially to turn a majority of the red areas in Figure 2 into shades of green.

Such a result would occur because of changes in habitat type, to which wildlife species respond as a "proximate" evolutionary factor.[28] Individual wildlife organisms would also be exposed to direct selection by climate-related environmental factors, such as short-term high temperatures that may exceed the physiological tolerances of individuals. These "ultimate" factors are known to be altering the elevational distributions of wildlife species in mountains, forcing some of the "upward" adjustments described by scientists. For example, recent work in the Sierra Nevada (Moritz et al 2008) has documented increases in the elevation range limits of small mammals, compared to the elevational limits described by scientists less than a century ago. Such a direct effect on elevation range limits can be expected within the Berryessa – Snow Mountain region as well. The geography of the region may limit an *in situ* upward range adjustment by many wildlife and plant species, however, in much of the southern and central parts of the region, because the inner Coast Range may simply not be high enough.

The dynamics of the ecological range shifts widely contemplated by ecologists (which are the dynamics captured by models such as those underlying Figure 6) anticipate a geographical range translation as a consequence of "migratory" shifts. For wildlife, this dynamic typically presumes a physical movement, either a "colonization" of a formerly unoccupied area by individuals from an adjacent occupied range, or a settlement by migrating individuals into a formerly unoccupied area as part of a typical migration pattern. Since the "new" habitat will already be occupied by different species, the result in either case is a "new" wildlife species association, although it would be expected that some of the "old" residents would disappear in time because the changed conditions no longer meet their ecological requirements. Existing studies support this model (e.g., Brown et al 1997).

The dynamic is fundamentally different for plants, and essentially involves the establishment of new individuals from seeds or spores, characteristically at the "leading edge" of a shifting ecotone with a higher-elevation alliance, while the "trailing edge" of the population dies out (as described by Allen and Breshears 1998). This dynamic is within the ecological capability of plant species only if the movement rate required to "track" changing ecological conditions is less than the maximum rate of "range migration" possible for a species; the ability of species to "follow" changing ecological conditions is a great unknown about climate-change response. Furthermore, human land uses (residential, commercial, or recreational development, or conversion to vineyards/agriculture) may reduce landscape connectivity and block potential "migration" routes.

For the most part the proposed NCA region appears to present few inherent obstructions to climate-related movements of species, although there is a need for a careful assessment of the potential for migration blockages in the NCA landscape. There is one context, however, where migration cannot preserve existing biodiversity. This is at the upper end of the elevation gradient, at the highest elevations in the northern part of the region. Some species (particularly plants, but also invertebrates and fungi that are closely associated with the plants) that occupy the highest elevations on Snow Mountain and St John's Mountain will not be able to migrate to nonexistent higher elevations; nor will they be able to migrate poleward, because the lands to the north are lower and are unlikely to provide suitable ecological conditions, particularly as the effects of global climate change modify those lower elevation areas. Thus many of the species derived from the relict Klamath Mountains flora may disappear from the Berryessa – Snow Mountain region, an ecological result that has negative supra-regional conservation implications (see, e.g., Leppig and White 2006). However, the availability of the higher-elevation landscape around Snow Mountain for the "upper end" of *future* ecological gradients in the region remains an important conservation consideration for the NCA.

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28 In evolutionary terms, "proximate" factors are indirectly related to major evolutionary pressures (for example, the conformation of the woodland habitat occupied by wildlife), whereas "ultimate" factors are those that directly change the fitness of organisms (for example, the quantity or quality of acorns or oak galls or other food actually produced by oak trees).

The quotation from Cathy Whitlock that opened this section occurs in a summary of vegetation changes in western Washington at the end of the Pleistocene, referring to the same broad-scale events that severed the connections between currently outlying populations of some alpine plant species in the Snow Mountain region from larger populations in the Klamath Mountains. There should be no confusion that the biotic changes occurred in association with short periods of rapid climate shifts.

Still, longer-term genetic adjustments apparently did occur in the plant (particularly tree) species populations in the region, and the genetics of the populations could well have affected the responses of the species to changing climate, although these results provide little basis for concluding anything other than that the pace of future climate changes will most likely exceed the abilities of the species to make biotic adjustments. As summarized, for example, by Petit et al (2008):

> "The role of adaptive responses to climatic change has rarely been considered in interpreting Quaternary paleoecological records, because the perception that evolution occurs more slowly than climatic change (reference omitted). … Although local evolutionary responses to climate change are likely to have occurred with high frequency, there is no evidence for change in the absolute climate tolerances of species (reference omitted). Thus, future extinctions of tree species in response to climate change are probable, especially if their geographic distribution or climatic range is already highly restricted. ... Europe lost at least 89 tree genera during the climatic transitions of the Late Tertiary to the Quaternary (reference omitted). ... (A) 320,000-year history of vegetation and climate in Hungary showed that species extinctions clustered near times of high climate variability (reference omitted). This interpretation is consistent with the case of a now-extinct North American spruce, *Picea critchfieldii*, which was abundant during the Last Glacial Maximum but vanished during the last deglaciation, at a time of rapid climate change (reference omitted)."

It's clear that more information will be required in order to understand fully the ecological dynamics that are associated with climate-related changes. For example, in one intermediate-length study (Suttle et al 2008) carried out in forestlands in northern Mendocino County (at the approximate latitude of Snow Mountain), initial results suggested that ecological responses by producers and two levels of consumers in a grassland ecosystem would be easily interpreted as consistent with the changes predicted from climate-warming studies. However, by the end of the experimental period the initial result had been reversed, which led the authors to conclude:

> "(U)nder any scenario of future climate change, prediction of ecological effects will require understanding the web of interactions that mediate species- through ecosystem-level responses (reference omitted). To date, forecasts of range shifts and extinction probabilities are based largely on species-climate envelope models (references omitted). These models are powerful initial tools with which to explore consequences of alternative climate scenarios, but they cannot forecast lagged impacts of altered higher-order interactions that will govern the trajectories of ecosystems under sustained climatic change. Nonlinearities are expected from the assembly of new combinations of species brought together by climate-induced range shifts, but these can also arise from environmental effects on the strength and direction of interspecific interactions without any change in species composition (references omitted)."

It's important to be constrained by real evidence in discussions about climate change, particularly with respect to ecological patterns, which are notoriously complex. There is, nonetheless, an abundance of evidence that confirms ecological changes in response to changing climate factors. For example, in one long-term monitoring study of tree mortality patterns in relatively undisturbed landscapes throughout the western United States a group of senior research ecologists established beyond question that the absolute rates of mortality in individual trees of multiple species, multiple ages, and multiple sizes have increased during the past several decades (van Mantgem et al 2009). The areas studied by these authors were all in undisturbed "old age" forests, and the authors concluded that the most likely factors producing this West-wide increase in tree mortality were "regional warming and consequent drought stress." The effects of climate change on native communities are likely to be extreme, and there's clearly no need to wait until all of the relevant ecological dynamics can be fully explained to begin considering the conservation implications of the change.

## 4.2 Plant and Wildlife Communities in the Region are Likely to be Reconstituted by the Effects of Climate Change

A fundamental ecological dynamic related to climate change emerged from paleobiogeographic studies of plant and animal distributions during and after the Pleistocene. The dynamic is related to fundamental ecological principles about the nature of ecological "communities" in space and time; the essence of the principles is that species "respond" independently of one another to changing ecological circumstances.[29] Consistent with these general principles, what the studies demonstrated was that during and after the Pleistocene, plant and animal species responded to changing climate in an "individualistic" fashion.

In general, late-Pleistocene and Holocene climate varied in conditions important for plants, particularly temperature and moisture availability, and plant species responded according to the ecological preferences or tolerances of individuals (a readable summary of findings for the Pacific Northwest, based primarily on pollen records, is available in Whitlock 1992). Pleistocene climate patterns affected all of North America (and Eurasia as well) by compressing the vegetation of the continent into unglaciated areas south (or to the sides) of the ice front or below the termini of mountain glaciers. Regional distributions of individuals of various species fluctuated geographically throughout the Pleistocene in accordance with regional fluctuations in temperature and moisture; as a consequence, vegetation in western North America during the Pleistocene included plant associations unlike associations present today, and the associations were not constant through time.

In association with the Holocene retreat of the glaciers and the ameliorating climate conditions, individual adaptations led each species to track the changing ecological conditions independently (Whitlock 1992, Davis and Shaw 2001), colonizing new habitat as it became available and suitable. Plant species that formerly co-occurred extensively migrated out of glacial "refugia" at different rates, and "new" plant communities came into existence based upon co-occupancy of the same geographic area by species that did not previously co-occur (van Devender and Spaulding 1979, van Devender 1986). Virtually the same pattern of "individualistic" responses was identified in the Holocene fossil records of small mammals (Graham 1986, Graham et al 1996); species that co-occurred during the Pleistocene shifted to ranges that are now hundreds to thousands of miles apart, and "new" small-mammal communities were created.

The Holocene changes are a template for what should be expected during the next century or two as a consequence of global climate change. This is an important point that needs to be understood in contemplating actions that may be taken to conserve biodiversity in responding to climate change. One set of authors (Williams and Jackson 2007; also see the commentary by Fox 2007) has coined a term for the "new" species associations that will result from the climate-related shuffling of species: "*no-analog communities*;" while the term is new, the concept is well established in ecological science.

The essential dynamics of this perception are portrayed in Figure 7, redrawn from a paper by a different set of authors (Seastedt et al 2008) who identify the result of the shuffling as changes at the ecosystem

29 The contrasting, and invalid, perspective is that groups of species belong to "associations" or "communities" that respond to changing ecological circumstances as coherent "superorganisms." In fact, groups of species do respond to changing ecological circumstances in similar ways and may tend to co-respond in ways that keep them together in space and time, but they do so only by chance. This difference in perspective was a fundamental issue in the development of ecology in the first half of the Twentieth Century. For both theoretical and empirical reasons the "superorganism" model of ecological communities was rejected by practicing ecologists in the middle of the century (see, e.g., Whittaker 1975), but it remains a common perception of many non-ecologists.

level: "*novel systems*." This dynamic is based on the conceptualization that biotic conditions alone or environmental conditions alone may change (under short-term stress), and that species in the landscape the system as a whole can return to pre-disturbance conditions as stressors abate. This conceptualization is straight out of the sort of "community ecology" that developed in the United States in the last quarter of the Twentieth Century, the idea that properties of the interacting species group will help to stabilize the interactions among the species (see, e.g., Pimm 1991). The new perception portrayed in Figure 7 is, however, that the system can be moved by climate change into a new adaptive landscape, one from which it likely cannot be returned to the state that existed prior to the disturbance.

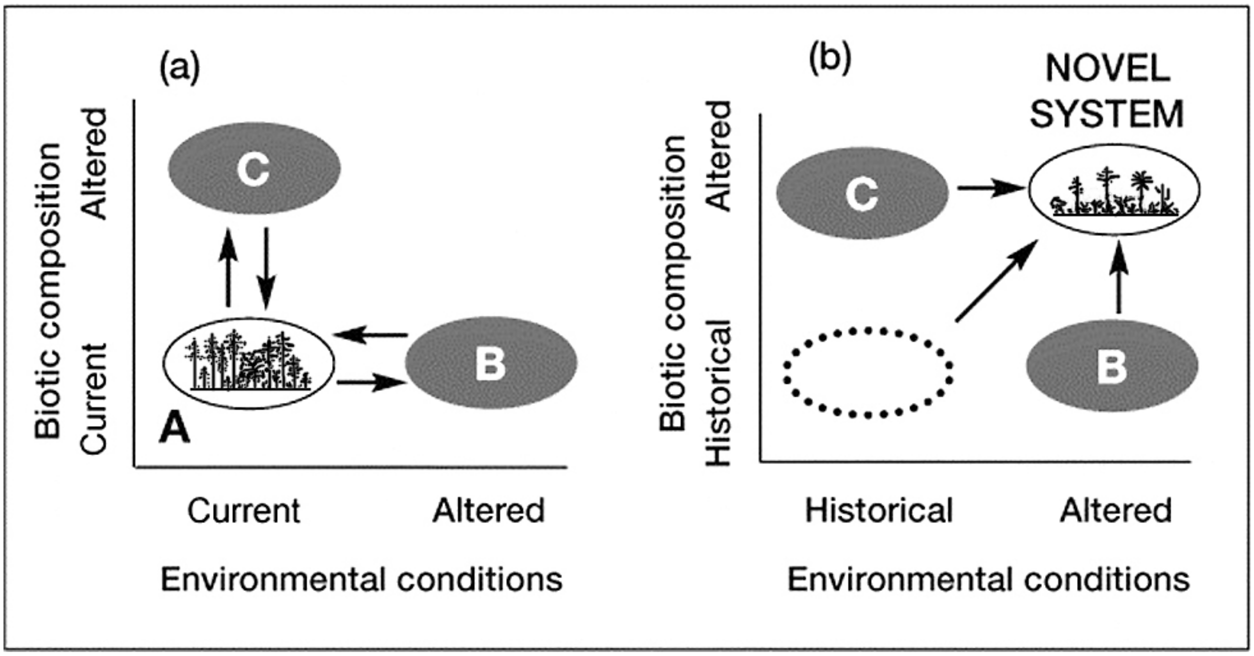


*Figure 7. Schematic diagram (redrawn from Seastedt et al 2008) indicating the probable development of "novel" ecosystems as a consequence of altered climate. While the biological composition of a community at a given place on the Earth's surface may be altered (e.g., as by fire or flood) in the current climate regime, the expected response would be a return to pre-disturbance conditions. In the future the environment is expected to depart from the historical regime, a change that will either lead or be accompanied by long-term changes in the composition and dynamics of the biological communities on the landscape. The expected result of these long-term changes is the development of "new" biotic communities that are adapted to the "new" environmental conditions.*

It seems likely that some (perhaps a large part) of the diversity that will occur in the climate-altered future will be constituted by species that are not native to communities in the Berryessa – Snow Mountain region today. The "rich-get-richer" dynamic (e.g., Stohlgren et al 2006) generally indicates that areas of high native species diversity also accumulate high exotic species diversity through time. One of the general effects of global climate change that has been consistently predicted (e.g., by Parmesan 2006) is an increase in the importance of exotic species in future communities. This result also raises an immediate concern about the fraction of those species that will be "invasive" rather than merely exotic, given the ability of invasive species to dominate communities. At the present time there are too few data to address this concern, but the significance of the impacts of invasive species already widely known in the United States suggests that even if only a small fraction of the exotics are invasive that future biodiversity could be affected significantly.

These are important considerations in identifying potential responses to the ecological changes that will occur. The State of California has embarked upon a planning effort to address climate-change impacts on biodiversity, which includes a recommended approach for responding to climate change.[30] One of the guidelines identified in initial discussion documents is that the state's response should address the "resilience" of biotic communities. In the 1980s "resilience" was defined by ecologists as a property of ecological systems which referred to the ability of an ecological system to return to its pre-disturbance state following a perturbation (Pimm 1982, 1991). The term "resilience" is used similarly in discussions about climate change to indicate an ability to adapt to climate-related stressors (e.g., Parmesan and Galbraith 2004). However, based on the results of numerous paleobiogeographic studies (and ecological principles in general) it seems highly improbable that existing ecosystems will return to their "pre-warming" states under any conceivable circumstances, and the term appears to be effectively meaningless in this context.[31]

Studies of existing ecosystems do not provide definitive answers to questions about future conditions, although they do point in directions that should be useful. For example, questions about assuring "ecological services" of various sorts do occur in conservation planning (e.g., Daily 1997, Kremen and Ostfeld 2005). One answer to questions about enhancing the "resilience" of stressed ecosystems is to increase "functional redundancy," referring to having multiple species in ecosystems to carry out various ecological tasks (Naeem 1998, Peterson et al 1998; also see Luck et al 2003 with respect to the potential functional benefits for redundancy associated with multiple populations of each species). In the most general sense, therefore, retaining high levels of diversity in future ecosystems emerges as an important conservation goal for maintaining ecosystems services.

Increased warmth, increased (in some areas) moisture, and increased carbon dioxide ($CO_2$) concentrations are all factors that favor increased plant growth. Increased plant growth potential could favor denser populations of existing species. It could also favor more individuals of a variety of species, which could be drawn mostly from native sources, equally from native and exotic sources, or mostly from exotic sources. Evidence exists that while enhancing plant growth factors tends to increase species numbers, the species that are favored in these circumstances are exotic species, including invasive species. For example Woodward and Kelly (2008) conclude:

> "In summary, although the results may appear to contradict earlier projections, with increasing diversity forestalling some endemic extinctions, this is not the most important conclusion to be drawn. ... The demonstrated association between $CO_2$ enrichment and enhanced diversity capacity per unit area is likely to create "holes" in the carrying capacity of any particular area. The temporal correlation between $CO_2$ concentration and cumulative numbers of invasive species indicates that those holes will be filled by those species best able to respond rapidly to this opportunity – weeds."

Another important implication for biodiversity conservation is that the composition of "reserve" and "corridor" elements in the landscape will follow the same dynamics that the rest of the landscape will follow. This means that the species composition of these "conservation set-asides" is no more likely to escape the climate-induced dissolution of biotic communities than are other parts of the landscape. The implication is that existing communities, or even many of the species, targeted by reserve designations may (or will, more likely) no longer be served by conservation networks established under present

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30 The Public Review Discussion Draft of the Adaptation Strategy document was posted online 03 August 2009; see URL: http://www.climatechange.ca.gov/adaptation/ (viewed August 2009).

31 The Pew Climate Center has included "resilience" in a glossary in a manner that has led to the widespread use of the term as a criterion for planning responses to climate change, apparently now referring to the ability of biotic communities to continue providing desired ecological services even as the climate change-induced dynamics progress.

ecological and climatic conditions. A resolution for this dilemma that has a high probability of addressing future needs of targeted rare species without substantial manipulation by landscape managers does not suggest itself, and it appears to me that a very high level of "hands-on" engagement will be required to address the future conservation of these targeted species in the changing landscape.

A second consequence is that the ability of reserve and corridor allocations created under pre-climate-change assumptions likely will no longer provide the "connectedness" that reserve design strategies seek to promote. While the legal, geographically established coordinates of the reserves and corridors will remain, their ecological content will not necessarily serve future conservation needs on account of the changes described above, possibly (probably) leading to the sorts of landscape fragmentation effects that reserve systems are intended to prevent.

As a consequence of these changes, it's a fair question whether it's worth considering systems of protected lands at all. In my judgement the answer is clearly "yes," because these management approaches allow for the allocation of lands to conservation purposes within the management frameworks of federal, state, and local agencies (and sometimes for private landowners as well), and the existence of protected landscape elements is an advance in both a conservation planning sense and in terms of adapting to climate change. Moreover, it may be that specific landscape locations that foster high native species diversity under current conditions will retain at least some of the same desirable characteristics under a changed climate, suggesting that "core reserves" and "linkages" designated now may also be higher-diversity areas (though with different species) under the changed climate.

The regionalized distribution of future biodiversity is a topic of active research interest for scientists in many parts of the world, and there are numerous ways of looking into the crystal ball. The modeling efforts of Kueppers at al (2005), cited above, constitute one way of addressing this question. Other projections also exist. A recent synthesis (Loarie et al 2008) of evidence about prospective changes in the diversity of native species in California included the following:

> "The results of this study present a dilemma for conservation planning in the face of climate change. Future diversity will likely peak along the coast and to the north of its present concentrations. These areas are sensible priorities for conservation. Some areas of high diversity, however, will be comprised of species expanding their ranges, and these species may not represent important targets for conservation efforts. Areas that are projected to harbor species with shrinking ranges, on average, include many mountainous areas scattered across the study area. We identify these areas as refugia that may disproportionately contain the most ''threatened'' species. These ''future refugia'' present valuable opportunities as conservation targets. They may protect significant components of biodiversity into the next century. The number of species projected to survive in these refugia depends critically on the ability to disperse, highlighting the importance of landscape connectivity and potential restoration in the face of increasing urbanization, land use change, and disturbance."

The summary statement by Loarie and colleagues seems to point directly to elements included in the Berryessa – Snow Mountain NCA region, particularly the areas dominated by serpentinitic substrates and the high-elevation "refugia" for species being pressed upward and poleward by warming climate. However, active management is likely to be required to assure that the region achieves as much in conserving California's biodiversity as may be possible.

## 4.3 Possible Adaptive Responses to Climate Change in the Berryessa – Snow Mountain Area

There is presently no widely agreed-upon adaptive response strategy for responding to the biological and ecological changes that will result in California (or elsewhere) from climate change. As noted previously the State of California is considering elements that should be included in such a response, based on the legislative direction included in AB 32 (the California Global Warming Solutions Act of 2006). The Public Review Discussion Draft of the Adaptation Strategy was posted online in August 2009, and includes a draft strategy for responding to climate-induced biodiversity effects.[32] The elements discussed in the Draft Strategy are consistent with (if less comprehensive than) the recommendation is this report.

Popular literature (and to a lesser extent the scientific literature) already contains a great deal of discussion about responding to climate change, and some of this discussion includes recommendations for biodiversity concerns.[33] In general the discussion features many elements found in the "ecological restoration" literature. This is unsurprising, since a primary recommendation for responding to climate change is to restore damaged ecosystem elements that would otherwise exacerbate habitat loss as a climate-change response. Restoring damaged ecosystem elements is certainly a valid conservation recommendation in any event, and it will certainly assist in allowing species to adapt to climate change-related impacts of several kinds.

One climate-change response element that has been widely discussed in non-technical literature (see, e.g., Smith and Gow 2008) is some form of species transplantation in order to address loss of existing habitat. Because one universally acknowledged effect of climate change is that it shifts suitable habitat upslope, toward the nearer pole, or both, an obvious response to this shift would be to capture/dig up individuals of the affected species and move them to places where the future climate is expected to be within the preferred zone again. This simple solution raises some serious conservation questions:

- Who decides which species are appropriate candidates for such intervention? Biblically Noah took two individuals of every species, but in the real world there are too many species for that approach to be feasible, so some kind of "triage" or prioritization seems necessary. What criteria have been established for this? Will commercial significance be a primary consideration, so that (for example) harvested conifer species receive highest priority? If not, what will be the decisive criteria?

  In my opinion there should be a conservation priority assigned to "keystone" species that are scientifically or culturally established as conservation targets. I would definitely place both valley oak (*Quercus lobata*) and blue oak (*Q. douglasii*) high on a list of priority species for transplantation in the Berryessa – Snow Mountain region, because these two species are likely to be key elements in habitats that society will want in the region in the future. I return to this point below.
- Who decides where "future" ecological conditions will be satisfactory for the transplants (i.e., who has the authority to select the target area and then execute the transplant)? The issue isn't about picking specific locations so much as it is about assuring that the decision-maker has an underlying understanding about how the transplantation of a given species to a specific site is an adaptive response to climate change, and can discuss how a given transplant location will fit into the future conservation picture. At present there's little indication that predicting future conditions throughout a large area like the Berryessa – Snow Mountain region has progressed sufficiently that identifying target locations for, say, valley oak would be more than a wild guess, with no particular likelihood for meeting future conservation goals either for the species or for the ecosystem.
- Who will assure that the individual organisms selected for transplanting are "representative" of the species or are otherwise the "best" individuals to transplant? The act of transplanting only a few

32 See URL: http://www.climatechange.ca.gov/adaptation/ (viewed August 2009).

33 This report does not address greenhouse gas reduction or offset approaches as a biodiversity protection strategy. The volumes of greenhouse gases already in the atmosphere and the "inertia" of the atmosphere/climate system mean that impacts on the planetary biota cannot be avoided. While successfully addressing greenhouse gas emissions and/or sequestering carbon may help to reduce future impacts, little that happens to reduce future greenhouse gas emissions can limit biodiversity impacts that are "forced" by current and near-term future atmospheric greenhouse gas concentrations.

individuals will create an inherent genetic bottleneck (and a subsequent founder effect) for the transplanted population unless the transplanted individuals are carefully selected to represent the full range of genetic variability present in the target species. Such a study is no mean undertaking (see, e.g., Grivet et al 2008 and Sork et al 2008 with respect to valley oak genetics and conservation).

- Who will verify that the transplants will produce no adverse genetic impacts on resident species, introduce no pathogens, or create no other impacts in previously "safe" locations? In ecosystem terms transplanting a desired native species into an area in which it currently does not occur is functionally not very different than planting horticultural varieties of South African or Australian species; the possible effects of the transplants on the existing communities are largely unknown (although a fair argument can be made that such considerations are effectively irrelevant because existing communities are already destined to be dismembered by climate change).

  In my opinion this is a primary consideration in species-based conservation planning for the region. If the conservation focus includes maintaining a group of related rare plant taxa, such as species found in various pockets of serpentinitic soils in the Berryessa – Snow Mountain region, then one real effect of such transplants could be to swamp genetic differentiation of closely related sister taxa in the target zone. Clearly it is only worth the conservation risk that this effect might occur if it's clear that the transplanted species would be extirpated in the source zone(s) by climate change impacts.

All of the concerns summarized in the above list (and others) have been identified previously in the ecological restoration and/or conservation literature. Transplanting species is clearly not free of ecological risks, and responding to climate change's impacts needs to include an assurance that effects like these have considered. The urgency of responding to climate change does not free us of the obligation to address these concerns.

The basic theme of this report has been that conservation biology has a kind of "tiered structure," with several (interrelated) levels or focuses, which are associated with the historical development of the field. There are thus relevant subsets of conservation concern for the Berryessa – Snow Mountain region, namely those related to species, habitats, and landscape-based conservation. In my opinion a useful response to climate change for each of the three sorts of concerns differs enough that each warrants a separate planning approach, one that addresses the conservation issues that underlie the concern to start with. Responding to climate-change concerns for a listed species would not necessarily produce the same management response as would addressing the landscape-based conservation concerns for a regional biota. Some elements of these three categories of response that I believe to be relevant for conservation planning in the Berryessa – Snow Mountain region are included in Table 5.

**Table 5. Considerations for addressing conservation concerns in the Berryessa – Snow Mountain region, tiered to address species-based, habitat-based, and landscape-based planning.**

| **A.** | **Species-Based Conservation Planning** |
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| 5. | Initially, conduct field surveys to validate currently known distributions and densities of "sensitive" species in and adjacent to the NCA. Identify and document previously unrecorded occurrences of these species. Validate currently known occurrences of "special" habitat elements, including serpentinitic substrates, wetlands, and other habitat elements associated with "sensitive" species in and near the NCA. Identify previously unrecorded occurrences of these elements. |
| 6. | Among "sensitive" species in the NCA, assess species according to genetic importance for conservation purposes, including degree of relatedness among serpentine taxa, degree of differentiation of range-margin taxa from central populations, unique or very different adaptation complexes (e.g., insect-plant associations that differ from those elsewhere), and other genetically related conservation criteria. |
| 7. | Incorporate planning elements into NCA management that address "sensitive" species management under climate change, based on best available science, including elements required by federal or state laws and regulations (e.g., Endangered Species Act). Specifically incorporate genetic/evolutionary implications of |

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| | actions or non-actions. |
| 8. | Monitor population status of "sensitive" species as they respond to climate change. Species with reduced but stable population sizes may not require direct intervention. For species appearing immanently endangered, develop and implement action plans to increase abundance, potentially including assisted migration to suitable habitat at other locations. |
| **B.** | **Habitat-Based Conservation Planning** |
| 7. | Initially, map existing habitat types in the NCA at least to the degree of classification used by the California Wildlife Habitat Relationships (CWHR) program or an equally effective habitat classification. If necessary, conduct field assessments that provide data to update uncertain assignments. Using the CWHR database or similar information, identify species richness expected in all of these habitats. |
| 8. | Implement a monitoring/assessment program that systematically, over time, samples habitats to verify use by wildlife. Identify important habitat functional elements, such as acorns/oaks, nesting cliffs, very large trees (old growth forest), significance for Neotropical migrant nesting, etc. |
| 9. | Incorporate into NCA management a program, based on best available science, to consider the dynamics of habitat changes, by area and by habitat value, which will result from climate change. Model the effects of changes in habitat area and habitat value on species distribution and population stability. Specifically consider "key" habitat types of highest value (e.g., riparian areas, oak-containing habitats, and coniferous forests). |
| 10. | Considering the dynamics of important habitat elements (e.g., blue oak, valley oak), develop strategies to address long-term changes in habitat conditions, potentially including assisted migration or active transplanting programs. Identify, using best available science, anticipated locations in NCA where transplanted elements would best thrive under changed climate conditions. |
| 11. | Identify "keystone" species in maintaining habitat values, and develop plans for maintaining the "resilience" of the habitats by "backing up" the functions provided by the keystone species (e.g., maintaining acorn production by assuring that additional native oak species are present in addition to keystone oak species) by introducing selected native species not currently present. |
| 12. | Develop elements for NCA management that address invasive species control or eradication. |
| **C** | **Landscape-Based Conservation Planning** |
| 7. | Establish a framework for a landscape-based conservation throughout the entire NCA based on existing conditions and information. All areas subject to existing administrative protections for conservation-related reasons, such as Late Seral Reserves, Research Natural Areas, and Areas of Critical Environmental Concern, should be included in this framework. Identify and map all species-rich locations in the NCA without respect to current administrative status; incorporate biologically significant locations not already in the conservation framework. |
| 8. | Establish a landscape-based modular reserve system that incorporates conservationally important areas in the NCA, with a system of "core reserves" and interconnecting "landscape linkages," with "buffers" that help to shield the conservation lands from adverse effects of activities in the rest of the landscape. Guidance for managing these lands should follow Table 4, except for "matrix" areas, which must be managed for increased internal habitat value as a functional response to climate change. Identify gaps in managed lands (e.g., private-land inholdings) that block or cut linkages; seek collaborative management or acquire lands to bridge/close gaps. Target degraded areas (e.g., logged areas or other incompatible land uses; landslides) for restoration of desired habitat conditions. |
| 9. | Incorporate "resilience" into NCA management by modeling the landscape changes that will occur because of climate change, based on best available science, particularly addressing the loss of "keystone" species throughout the landscape, and the potential increase in both fire frequency and severity. Based on the projections, identify potential fragmentation within core reserve and linkage elements, and develop methodology to repair the damage, possibly including introducing selected native species not currently present (i.e., identify functional roles and assure that native species are available to fill them). |
| 10. | Add "resilience" to the landscape by actively managing the landscape "matrix" to increase intrinsic habitat values within the matrix of lands not specifically designated as "core reserve," "corridor," or "buffer." With elements of these functions provided by the matrix, the integrity of the designated reserve system elements is |

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| augmented by a matrix that is "permeable" (i.e., not hostile) to mobile species, and the matrix also provides additional habitat values. The following actions, for example, increase the value of the matrix as habitat:<br>• Restore high-functioning ecological conditions to damaged/degraded/burned areas.<br>• Restore instream and riparian functions to aquatic features, while planning for future increases in peak flows and flood events; increase riparian "buffer zones" to be a least "two dominant tree-heights" in width.<br>• Include elements that increase the ecosystem functions provided by matrix lands for wildlife; e.g., incorporate oaks throughout the matrix, as well as establishing multi-hectare oak "nodes." |
| 11. Increase landscape "resilience" by providing multiple designations of high-value "reserves," multiple "linkages," etc. The redundancy of landscape system elements will help the landscape system provide for conservation needs in the face of increased fire and other stressors. |
| 12. Develop elements for NCA management that address invasive species control or eradication. |

Table 5 represents a rough outline of a multi-tiered biodiversity conservation strategy for climate-change effects in the Berryessa – Snow Mountain region. The essence of the Table 5 strategy is that there are appropriate differences in approach for the different conservation concerns that have been discussed in this report. The approach needed for maintaining listed serpentinitic soil-related plants is fundamentally different from one needed to address populations of large-bodied, wide-ranging mammals, or the needs of species for relatively undisturbed ("old-growth") habitat conditions, but a conservation response to climate change requires that both approaches be addressed.

Carrying out the multi-tiered approach recommended in Table 5 will not be a trivial exercise, and will reflect a need for a real commitment to conservation by the land managers in the NCA (a commitment that is likely to be incompatible with commodity-based management emphasizing board feet or animal-unit months). Nonetheless, it seems likely that anything less than such a commitment will not lead to a response adequate to deal with the impacts on the biota that will result from climate change.

Some fundamental realities will likely direct our collective response in this region. One primary reality is that the ecological communities that are present in the NCA region today bear only a "statistical resemblance" to communities that will occur in the region in the future. There are two reasons for this, previously identified. The first is that existing communities will be "dismantled" by climate change, and "no-analog" communities will be assembled; a reassembly of existing species associations will only occur by chance. The second is that the ecological changes will favor the colonization of the region by species adapted for disturbed conditions, and these species will be a significant part of future communities in the region.

These changes have more significant implications. If it will not be possible to define "resilience" in the communities in this region as a return to the pre-disturbance state (and it will not), then "resilience" has to be defined otherwise. It seems most useful to define *successful adaptation to climate change* as *the development or strengthening of the ability of the "novel" ecological communities to continue to provide the "functions" for which the communities are currently valued*. Among these desired functions is the ability to maintain species' populations and ecosystem processes that are conservationally significant. However, there's no inherent reason why, for example, the "novel" communities have to be composed solely of native plant species to accomplish this goal, and the inevitable inclusion of cosmopolitan species does not automatically mean that conservation goals will not be, or are not being, met.

A corollary consideration is that some element of "design" could be appropriate for these future "novel" ecosystems. There's no inherent reason why the desired future communities need to be composed primarily of species that occur in the Central Valley today, and a rational argument can be framed that transplanting desert species into this region may be an appropriate anticipatory response to the impacts of climate change. In my opinion there really is little alternative to addressing the need for some "managed colonization" into the region; species can be chosen for transplantation into the region to assure that necessary or desired elements continue to be provided in the future.

I recommend relatively early screening for and transplantation of both blue oak and valley oak into appropriate locations in the Berryessa – Snow Mountain region. Early transplantation will allow individuals to use more-favorable near-future climatic conditions to attain sizes that help to secure their survival as climate conditions deteriorate. Such transplants "jump-start" the colonization of these native species and assure the availability of habitat elements needed by or favorable for wildlife species that will occupy the region in the future. Also, following Naeem (1998), an element of the adaptation strategy should be to assure "redundancy" among ecosystem elements that are keys to the desired ecological services we hope to see in the future. The addition of blue oak and valley oak to existing black (*Q. kelloggii*) occurrences in the region will help to assure that ecosystem and habitat functions currently provided by oaks will continue to be provided.

With respect to exotic species, it's unlikely that their colonization can be prevented. As a policy, only native species should be transplanted into the region, but it will clearly be a waste of time to try to eradicate all of the many exotic species that colonize the region on their own (Stohlgren et al 2008). However, management plans for the NCA need to include a strong commitment to aggressively manage *invasive species*, those having a capacity to dominate, take over, and disrupt ecosystems.

Reliance on a landscape-based "reserve-and-corridor" conservation system in the Berryessa – Snow Mountain for the achievement of all regional conservation goals is likely to prove problematical in the face of the regional changes resulting from changing climate (as previously noted, the establishment of dedicated conservation elements in the landscape is valuable in any event and should be implemented). Table 5 includes recommendations that address the loss of conservation function caused by changing habitat conditions. In my judgement, item C.4 will prove to be essential to the successful adaptation of a landscape-based conservation approach in a world responding to changing climate (see Section 2.3.2 above for additional considerations). Methods to implement this recommendation to *restore/enhance habitat utility in "matrix" lands* should be considered in all conservation planning underway now, including the management programs of the Forest Service, the Bureau of Land Management, and the Bureau of Reclamation, the land use planning efforts of all counties in the Berryessa – Snow Mountain region, other forms of comprehensive resources planning such as Integrated Regional Water Management Plans, and all conservation planning efforts in the region, including the Yolo Natural Heritage Program NCCP/HCP project and similar efforts now underway or to be developed in the future.

The overall geographical orientation of, and the arrangement of geographical features within, the NCA region appears to be nearly ideal to allow the regional biota to respond effectively to changing climate. The region is oriented longitudinally north-south, and the highest land elements in the region are at the northern end of a "corridor" covering more than a full degree of latitude and more than 6000 vertical feet of elevation difference. Substantial topographic irregularity within the region helps to provide a variety of localized ecological conditions. The part of the region occupied by people is relatively small, there are no dense urban or suburban pockets, and the "breaks" in landscape continuity because of highways and other major human-use corridors that cross the landscape are relatively minor. These beneficial geographical attributes should all help the region to respond effectively to climate change's impacts.

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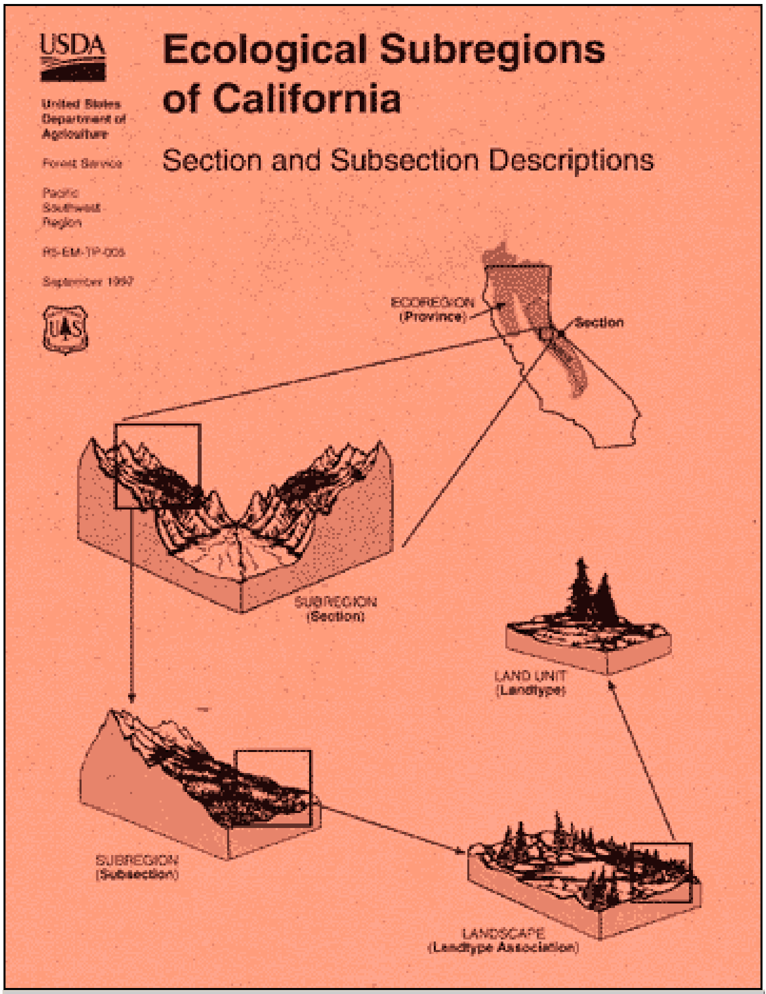
# ATTACHMENT A

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## PREFACE

This document contains the biophysical descriptions of the sections and subsections as depicted on the map "Ecological Units of California," (Goudey and Smith, 1994). This represents a subdivision of the ecological units shown on the map "Ecoregions and Subregions of the United States," (Bailey, et al., 1994), and described in "Ecological Subregions of the United States: Section Descriptions," (McNab and Avers, 1994). The basis for these maps and documents is the National Hierarchical Framework of Ecological Units (ECOMAP, 1993). This framework provides a standardized method for classifying, mapping, and describing ecological units at various geographic planning and analysis scales in the United States.

This text, which supplements the map by describing the delineated section and subsection ecological units, is the product of collaboration and teamwork by contributors from the Forest Service and other federal agencies in California, State agencies, universities and individuals. Because this document presents information on a wide range of environmental, biological, and cultural characteristics of ecosystems at the subregion scale, many contributors were involved in its development. Each contributor drew upon personal knowledge of environmental relationships and mapping principles and obtained help from other resource specialists to develop these map units and descriptions.

This text should be viewed as a continually evolving and refined draft of our ability to recognize and describe ecosystems at the subregion scale. Because this is the first edition and it was prepared by many persons in a short time, this text undoubtedly contains errors and perhaps omits pertinent information.

Also, because our current knowledge of ecosystems is evolving, new relationships will be discovered continually. The Forest Service and Natural Resources Conservation Service are committed to management based on ecological principles and intends to update the subsection map and this text as required. Users are invited to report corrections to this document and present new knowledge applicable to the subsection level in the national hierarchy. Comments and suggestions should be forwarded to:

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## INTRODUCTION

The USDA Forest Service adopted a policy of ecosystem management on June 4, 1992, that applied to national forests, grasslands and research programs. By July, an Ecological Classification and Mapping Task Team (ECOMAP) was formed in the Washington Office to develop a consistent approach to ecosystem classification and mapping at multiple geographic scales. This was identified by the Chief of the Forest Service as a critical first step in providing field units with an essential tool and scientific basis to plan for and implement ecosystem management. Soon afterwards a subgroup of ECOMAP was formed with representatives from all Forest Service Regions, two Research Stations, the USDA Natural Resources Conservation Service, and The Nature Conservancy. They met in September in Lincoln, NE, to begin development of a land classification system. The structure of the National Hierarchical

Framework of Ecological Units (Table 1) was formulated at this meeting and was adopted by the Forest Service on November 5, 1993 (ECOMAP, 1993).

**Table 1 - The Forest Service National Hierarchical Framework of Ecological Units**

| Planning and Analysis Scale | Ecological Units | Purpose, Objectives and General Use | General Size Range |
|---|---|---|---|
| **Ecoregion** | | | |
| ***Global*** | Domain | Broad applicability for modeling and sampling, strategic planning and assessment and international planning. | Millions to tens of thousands of square miles |
| ***Continental*** | Division | | |
| ***Regional*** | Province | | |
| **Subregion** | Section | Strategic, multi-forest, statewide, and multi agency analysis and assessment | Thousands to tens of square miles |
| | Subsection | | |
| **Landscape** | Landtype association | Forest, area-wide planning and watershed analysis | Thousands to tens of square miles |
| **Land unit** | Landtype | Project and management area planning and analysis | Hundreds to less than 10 acres |
| | Landtype phase | | |

Briefly, as described by ECOMAP (1993), the Framework "...is a regionalization, classification, and mapping system for stratifying the Earth into progressively smaller areas of increasingly uniform ecological potentials. Ecological types are classified and ecological units are mapped based on associations of those biotic and environmental factors that directly affect or indirectly express energy, moisture, and nutrient gradients which regulate the structure and function of ecosystems. These factors include climate, physiography, water, soils, air, hydrology, and potential natural communities."

In November 1992, the subgroup began the process of producing a national map of ecological units at the section level of the subregion planning and analysis scale. During the process of delineating Sections, ecoregion boundaries were revised. The map "Ecoregions and Subregions of the United States" was compiled by December 1993 and printed in June 1994 (Bailey and others 1994). The Section map unit descriptions in this text were produced after the map was compiled. A new, revised ecoregion map was also printed in June 1994. Bailey's publication (Bailey, 1980), which describes the Domains, Divisions, and Provinces of the United States is being revised (Bailey, in prep.).

Work began in 1993 by the Forest Service and other agencies to subdivide sections into subsections, the next lower level in the hierarchy. The 1:1 million scale map "Ecological Units of California, Subsections" was published in August 1994. In addition, maps are being developed at landscape and land unit scales on national forests and other selected areas in California to provide detailed information for project implementation. Thus, delineation and description of ecosystems at all levels in the hierarchy are components of an ongoing process that will result in a series of maps and explanatory texts to meet planning and analysis objectives (Figure 1). Each map and each descriptive text documents our current knowledge and provides a basis for study and communication among natural resource managers and planners.

## HIERARCHY OF ECOREGIONS AT A RANGE OF SCALES

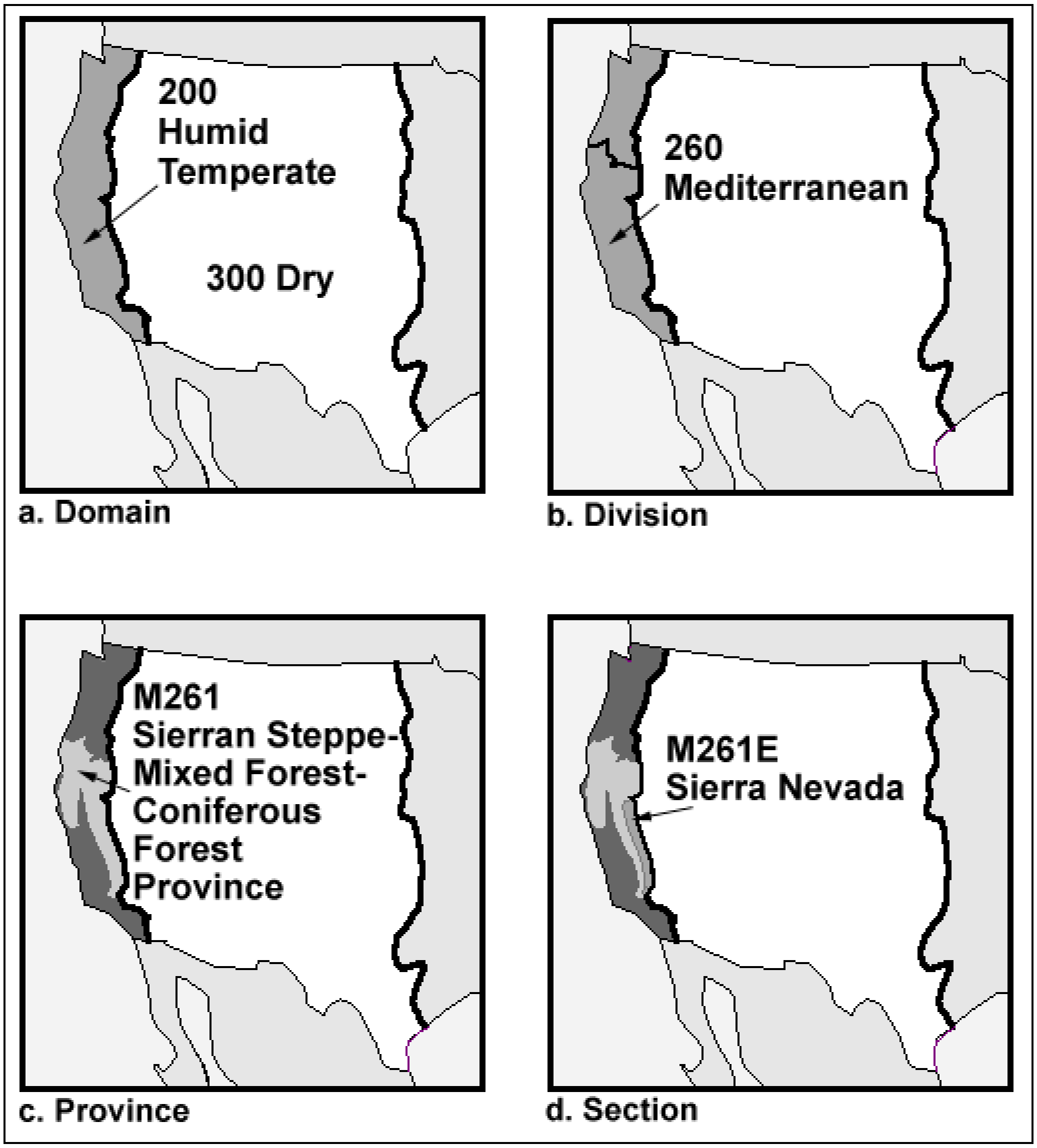


**Figure 1 -** The upper four levels of ecological units in the Forest Service National Hierarchical Framework consists of Domain, Division, Province, and Section. Selected ecological units of the Humid Temperate Domain, in the western United States, are progressively revealed to the Section level to illustrate the hierarchical structure, the identification system, and relative sizes of map units at the ecoregion and subregion planning and analysis scales (Hierarchy of ecoregions at a range of scales, Bailey, 1994). In summary, the National Hierarchical Framework provides a scientific basis for regionalization of ecosystems into successively smaller, more homogeneous units. At the Section level, these units allow managers, planners, and scientists in the Forest Service, and in cooperation with other agencies, to study management problems on a multiforest and statewide basis; organize data collected during broad-scale resource inventories; and interpret these data among regions.

## Maps

During 1993, three interdisciplinary teams representing northern, central and southern California drafted subsection boundaries on 1:250,000 scale base maps. Map units were formed using various combinations of line determinants from 1:250,000 scale geology, general soils, topography and vegetation maps, LANDSAT imagery and local personal knowledge. Some information from other map scales was also used. Representatives of the Forest Service and Natural Resources Conservation Service edited the maps for statewide consistency and meeting guidelines. These representatives also met with their counterparts in Nevada to coordinate the development of common ecological units along the California and Nevada state line. This coordination resulted in refinement of the Mono (341D) and Southeastern Great Basin (341F) section boundaries and the identification of subsections within these sections. The Mono section was extended farther to the north and the Southeastern Great Basin section was extended into California. These section boundaries also coincide with Natural Resources Conservation Service major land resource areas (MLRA). Section line refinement from subsection mapping will be reflected in the next update of Ecoregions and Subregions of the United States (Bailey and others, 1994).

A 1:1 million scale map, “Ecological Units of California, Subsections” was compiled from the 1:250,000 scale maps described above and published in 1994 (Goudey and Smith, 1994). This map, and the 1:250,000 scale subsection maps are available in paper or digital form, from:

Regional Forester
USDA Forest Service
1323 Club Drive
Vallejo, CA 94592
Attention Geometronics.

## Map Unit Descriptions - Sections

This text is organized following the national hierarchical framework of ecological units. Sections, the highest hierarchical level at the subregion scale (Figure 2), are the basis for chapters. Each chapter begins with a description of the section, followed by descriptions of the subsections which occur in that section. Each section is described by the predominant environmental and biological features used in its delineation, along with other pertinent or characteristic factors. These descriptions are not intended to be detailed, but rather to present enough information to describe the salient features of the units. This information provides the user with a brief description of environmental features that characterize sections for broad planning and assessment and are useful for comparing landscape characteristics among sections. The section map unit descriptions contained in this document have been revised with information brought forward from subsequent description of subsections. Consequently, these section descriptions are considered to be updates to those contained in “Ecological Subregions of the United States: Section Descriptions” (McNab and Avers, 1994).

The content of each section map unit description element is described below.

**Introductory paragraph**. A brief description of the section and its location. The Major Land resource Area (MLRA) which mostly coincides with the section is also listed.

**Geomorphology**. Geomorphology is the classification, description, nature, origin, and development of present landforms. This element describes the predominant landforms in the section. In some cases, the geomorphic processes involved in forming the characteristic landforms is also described. The geomorphic province in which the section occurs is listed.

**Lithology**. Lithology is the description of rocks on the basis of such physical characteristics as manner of origin, composition, and texture. The predominant general lithologies and relative age that occurs in the section is listed.

**Soil Taxa**. Soils are characterized by orders that typify the map unit. Soil moisture and temperature regimes are included to help characterize map units. Soil Taxonomy (Soil Survey Staff, 1992) is the basis for soil classification.

**Vegetation**. The first paragraph lists the predominant or typifying potential natural community series found in the section. The series are described in *A Manual of California Vegetation* (Sawyer and Keeler-Wolf, 1995). Potential natural community is defined in Appendix C. It is not intended to list all series found within the section, but rather to list those that are common, typical or unique to the section. The series are listed in general order of extent. In some cases, where a number of similar series occur, a descriptive lifeform name is used, for example, mixed chaparral shrublands or sedge meadow communities.

Series that are found throughout the section, but are not restricted to, or extensive in any one subsection are listed alphabetically in the second paragraph. These series may be potential natural communities, or dominated by existing vegetation or exotic plants. These series may be potential natural communities, or they may be dominated by existing vegetation or exotic plants. The series are described in *A Manual of California Vegetation* (Sawyer and Keeler-Wolf, 1995).

**Fauna**. Characteristic mammals, birds, reptiles, and amphibians of the map unit are named. Some historic, common, and characteristic species are usually listed. Threatened species are provided for some sections.

**Climate**. Prevailing climate is characterized in terms of mean annual precipitation in inches and mean annual temperature in degrees Fahrenheit. Seasonality of precipitation and relative amount that occurs as snow may also be presented. The growing season is defined as the mean annual range of days between the last spring and first fall minimum temperatures above 32 degrees Fahrenheit.

**Surface Water Characteristics**. Relative occurrence and distinguishing characteristics of rivers, streams, lakes, and wetlands are presented. Some major rivers may be identified.

**Disturbance Regimes**. This element lists the natural factors and forces that significantly influence ecosystem dynamics within a planning period.

**Land Use**. This element identifies the predominant changes to natural vegetative communities caused by human uses of land and water resources.

**Cultural Ecology**. Examples demonstrate how the historical relationship between humans and the natural environment has resulted in modified landscapes.

## Map Unit Descriptions - Subsections

Each chapter begins with a description of the section, followed by descriptions of the subsections which occur in that section. Each subsection is described by the predominant environmental and biological features used in its delineation, along with other pertinent or characteristic factors. These descriptions are not intended to be detailed, but rather to present enough information to describe the salient features of the units. This information provides the user with a brief description of environmental features that characterize subsections for broad planning and assessment and are useful for comparing landscape characteristics among subsections.

Many potential uses exist for the descriptions of ecosystems presented in this text. Perhaps the most important use is to provide a means for comparison and contrast of environmental conditions among sections or subsections as a basis for region-wide assessment and monitoring programs. Material in this text will provide a common basis for communication and coordination among public agencies and groups at the international, national, state, and local levels of planning and evaluation. Researchers, land managers, and other users of research findings will have a common basis for suggesting limits of applicability of results from experimental studies. Another potential use of information in this document will be to provide a uniform basis for planning areas of coordinated work, especially among a wide range of resource disciplines. When used with related ecosystem maps and companion texts at various scales, information in this document can be used to illustrate the nested relationship of ecosystems, ranging from global to local levels. A single resource classification, such as a geology, soils or a existing vegetation map, may not satisfy all user needs, but an ecological classification can provide greater integrated information.

Some subsection description elements differ from those used in section descriptions. The content of each subsection map unit description element is described below.

**Introductory paragraph**. A brief description of the subsection and its location. The Major Land Resource Area (MLRA) subunits which mostly coincide with the subsection are also listed.

**Lithology and Stratigraphy**. Predominant kind, arrangement, age and characteristics of rocks and formations that typify the subsection.

**Geomorphology**. A description of common landforms and landshapes that occur within the subsection. Adjective terms are used to reflect general slope gradients of major landforms. Terms used to indicate slope groups and approximate gradient ranges, are: nearly level (0-3%), very gently to moderately sloping (3-15%), moderately steep (15-30%), steep (30-70%), and very steep (> 60%). The elevation range within the subsection is given in feet above mean sea level. Major geomorphic processes active in the subsection that resulted in formation of the characteristic landforms are given.

**Soils**. Soils are mostly identified at the subgroup level according to the list of soil series available at the time (National Resources Conservation Service, 1995). Higher categories are sometimes used to reflect important broad soil characteristics. Most of the soil series were classified before the current *Keys to Soil Taxonomy* (1994 and 1996) was published, which contained significant changes in the classes of Vertisols and Aridisols. It was beyond the scope of this project to present a consistent statewide reclassification of the soil series in these orders at this time. These and other changes in Soil Taxonomy will be included in future revisions of this document. There are small areas of poorly and very poorly drained soils in many of the subsections. These areas may be wetlands that are small, but are locally important. Soil drainage classes, soil moisture and temperature regimes, and sometimes other soil characteristics are given to help characterize the soils. Where certain soil taxa or soil characteristics occur within the subsection is often described.

**Vegetation**. The first paragraph lists the predominant or typifying potential natural community series found in the subsection. The series are described in *A Manual of California Vegetation* (Sawyer and Keeler-Wolf, 1995). Potential natural community is defined in Appendix C. Series dominated by exotic plants are listed when they are extensive and stable. It is not intended to list all series found within the subsection, but rather to list those that are common, typical or unique to the subsection. The series are listed in general order of extent. In some cases, where a number of similar series occur, a descriptive lifeform name is used, for example, mixed chaparral shrublands or sedge meadow communities.
Series that are commonly found in the subsection are listed alphabetically by lifeform in the second paragraph. These series may be potential natural communities, or they may be dominated by existing vegetation or exotic plants. The series are described in *A Manual of California Vegetation* (Sawyer and

Keeler-Wolf, 1995). Some series listed in subsections 261Aj, 261Bb, M262Ae and M262Bb are not yet described in the Manual of California Vegetation. For descriptions of these series contact:

Forest Supervisor
Los Padres National Forest
6144 Calle Real
Goleta, CA 93117

**Climate**. Prevailing climate is characterized in terms of mean annual precipitation in inches and mean annual temperature in degrees Fahrenheit. Seasonality of precipitation, the relative amount that occurs as snow, or other climatic factors may also be presented. The mean freeze-free period is the approximate number of days between the last spring and first fall minimum temperatures that are above 32 degrees Fahrenheit.

**Surface Water**. Relative surface water runoff, and the occurrence and distinguishing characteristics of rivers, streams, lakes, and wetlands are presented.

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## SECTION M261B
### NORTHERN CALIFORNIA COAST RANGES

This section is the interior part of the northern California Coast Ranges mountains, north of the Carquinez Straight. Marine air modifies winter and summer temperatures, but the section is inland from the coast far enough that oceanic effects are greatly diminished. The northern part is in MLRA 5 and the southern part in MLRAs 14 and 15.

**Geomorphology**. Parallel ranges, folded, faulted and metamorphosed strata; rounded crests of subequal height. Coast Ranges Geomorphic province.

**Lithology**. Late Mesozoic eugeosynclinal rocks of the Franciscan Formation, Mesozoic ultramafic rocks, and Cenozoic volcanic rocks.

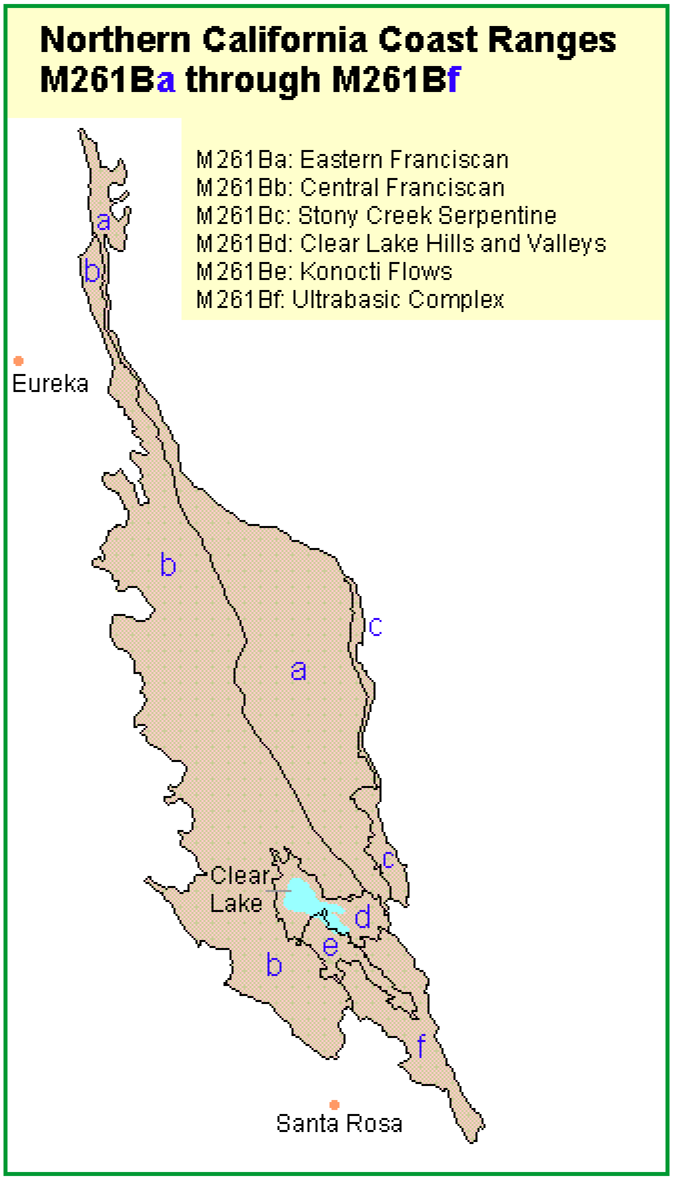
**Soil Taxa**. Alfisols, Entisols, Inceptisols and Mollisols in combination with frigid, mesic or thermic soil temperature regimes and a xeric soil moisture regime.

**Vegetation**. Predominant potential natural communities include the Douglas-fir - tanoak series, Blue oak series, Oregon white oak series, Chamise series, Purple needlegrass series, Mixed conifer series and White fir series.

The following series are found throughout the section and are not restricted to or extensive in any subsection. Series dominated by exotic plants are not listed under subsections unless they are extensive and stable.

*Series dominated by exotic plants:* Cheatgrass series, Kentucky bluegrass series and Tamarisk series.
*Series that can occur in all subsections, but are not extensive:* Bulrush series, Bulrush - cattail series, California oatgrass, Cattail series, Creeping ryegrass series, Duckweed series, Idaho fescue series, Mosquito fern series, Nodding needlegrass series, One-sided bluegrass series, Pondweeds with floating leaves series, Pondweeds with submerged leaves series, Quillwort series, Sedge series, Spikerush series, Tufted hairgrass series and Yellow pond-lily series.
*Series restricted to riparian settings:* Arroyo willow series, Black cottonwood series, Black willow series, Fremont cottonwood series, Mixed willow series, Mulefat series, Narrowleaf willow series, Pacific willow series, Red willow series and White alder series.

*Disturbance series of short-lived vegetation:* Blue blossom series, Coyote bush series, Deerbrush series, Eastwood manzanita series and Wedgeleaf ceanothus series.




**Fauna**. Mammals include black-tailed deer, black bear, mountain lion, coyote, bobcat and ringtail. Roosevelt elk, marten and fisher occur in the northern part of the section. Tule elk and mule deer occur in the southern part. Birds include eagles, hawks, owls, herons and osprey. Species of concern include marbled murrelet and northern spotted owl in the northern part.

**Elevation**. 300 to 8100 feet.

**Precipitation**. 25 to 120 inches.

**Temperature**. 35° to 60° F.

**Growing Season**. 80 - 250 days.

**Surface Water Characteristics**. Many rapid or moderately rapid rivers and streams in deeply incised canyons with weak bedrock channels flowing westerly to the Pacific Ocean.

**Disturbance Regimes**.

*Fire:* Historic occurrence has changed from frequent, low, moderate and high intensity surface fires to infrequent, high intensity ground or stand replacing fires.
*Seismic Activity:* Seismically active area with strong shaking and ground rupture.
*Climate:* Wide fluctuations in precipitation and temperature for periods of years result in significant or catastrophic changes in biological communities.

**Land Use**. Composition and successional sequence of some communities has changed because of plant and animal species introduced between the mid 1800's and early 1900's related to mining, grazing, forestry and recreational activities.

**Cultural Ecology**. Humans have been utilizing the area for about 10,000 years; the Northern Coast Ranges are the type location for the early, Borax Lake, Paleoindian component. Humans have been an integral part of Coast Range ecology for some 2,000 to 3,000 years. The diversity of Northwest California ethnographic cultures is the most complex in the United States, reflecting diverse prehistoric and historic uses, practices, and human adaptations. Contemporary attitudes and beliefs are dichotomized between emphasis on amenity/newcomer and commodity/long-time resident values, with all overlain by a rural lifestyle. The economy is relatively diverse - government employment, the timber industry, recreation, and agriculture.

**Subsections**. The Northern California Coast Ranges section is divided into 6 subsections.

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## Subsection M261Bd
## Clear Lake Hills and Valleys

This subsection is a relatively low part of the Northern Coast Ranges that is surrounded by mountains. Most of the Franciscan rocks in this basin have been covered by late Tertiary sedimentary and volcanic rocks. The volcanics are not included in this subsection. Clear Lake, the largest natural lake in the Coast Ranges, occupies much of this subsection. The subsection has a hot and subhumid climate. MLRA 14d.

**Lithology and Stratigraphy**. This subsection contains Jurassic and Cretaceous Franciscan rocks of the Central and Eastern Belts, nonmarine Plio-Pleistocene sediments, and Quaternary alluvium.

**Geomorphology**. This subsection is in a structural low, or graben, in the northern California Coast Range mountains. It contains moderately steep hills, highly dissected Plio-Pleistocene sediments, and nearly level to gently sloping Quaternary alluvial fans, terraces, and basin-fill. The elevation range is about 1300 feet to 2000 feet. Fluvial erosion and fluvial and lacustrine deposition in the basin bottom are the main geomorphic processes. Mass wasting is a minor process, except on ravine sideslopes in the highly dissected Plio-Pleistocene sediments.

**Soils**. Soils of Franciscan terrain are mostly Lithic Xerochrepts and Mollic Haploxeralfs. Those of gentle to moderately steep slopes that predominate in dissected Plio-Pleistocene sedimentary terrain are mostly Mollic Haploxeralfs. Fluventic and Cumulic Haploxerolls, Aeric Fluvaquents, Fluventic Haplaquolls, and Pelloxererts are common in alluvial fan and basin-fill deposits, and Ultic Palexeralfs on terraces. The hill and terrace soils are generally leached free of carbonates, but calcium carbonates and salts accumulate in basin-fill. Soil temperature regimes are thermic. Soil moisture regimes are xeric, except for some soils with aquic moisture regimes in alluvium around Clear Lake.

**Vegetation**. The predominant natural plant community is Blue oak series. Needlegrass grasslands, Valley oak series, Riparian habitats, and Emergent aquatic communities are common on alluvium and basin-fill around Clear Lake.

***Characteristic series by lifeform include:***
*Grasslands:* California annual grassland series.
*Shrublands:* Chamise series, Chamise - wedgeleaf ceanothus series, Scrub oak series.
*Forests and woodlands:* Blue oak series, California buckeye series, Foothill pine series, Interior live oak series, Knobcone pine series, Valley oak series.

**Climate**. The mean annual precipitation is about 20 to 40 inches. Most of the precipitation is rain, but some is snow. Mean annual temperature is about 50° to 56° F. The mean freeze-free period is about 150 to 200 days.

**Surface Water**. Runoff from hills and the Plio-Pleistocene sedimentary terrain is rapid and all but the larger streams are dry through most of the summer. Runoff is stored in and around Clear Lake and the lake level rises when runoff from the surrounding hills and mountains is more rapid than drainage from the Lake. There is some hydrothermal activity and accumulation of minerals from it, as in and around Borax Lake.

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## Subsection M261Bf
### Ultrabasic Complex

The distinctive feature of this subsection is a complex pattern of Mesozoic sedimentary, metasedimentary, metavolcanic, and ultramafic rocks. It has a hot, subhumid to humid climate. MLRA 15d.

**Lithology and Stratigraphy**. This subsection contains Jurassic and Cretaceous Franciscan rocks of the Central and Eastern Belts, including much ultramafic rock, and Cretaceous sedimentary rocks of the Great Valley Sequence. There are large areas of late Quaternary alluvium in Coyote, Long, and Pope Valleys, but they are only minor parts of the subsection.

**Geomorphology**. This is a subsection of north-northwest to northwest trending mountains that generally have rounded summits and steep sides. Most of the canyons are narrow, but some have broad alluvial plains. The elevation range is from about 300 feet up to 3196 feet on Brushy Skyhigh. Mass wasting by flow and sliding, and fluvial erosion are the main geomorphic processes.

**Soils**. The soils are mostly serpentinitic Lithic Argixerolls and Haploxerolls and nonserpentinitic Dystric Lithic Xerochrepts and Typic and Mollic Haploxeralfs. The soils are generally leached free of carbonates. Soil temperature regimes are mostly thermic, but are mesic on some north-facing slopes and at higher elevation. Soil moisture regimes are xeric. There are no extensive surfaces old enough to have Palexeralfs.

**Vegetation**. The predominant natural plant communities are Leather oak series on serpentinitic soils, Chamise series on shallow nonserpentinitic soils, Mixed conifer series on deep soils with mesic temperature regimes, and Blue oak series on other soils. There is Coast live oak series on many north-facing slopes.

***Characteristic series by lifeform include:***
*Grasslands:* California annual grassland series.
*Shrublands:* Chamise series, Chamise - wedgeleaf ceanothus series, Leather oak series, Scrub oak series, Whiteleaf manzanita series.
*Forests and woodlands:* Birchleaf mountain-mahogany series, Blue oak series, California bay series, Coast live oak series, Foothill pine series, Interior live oak series, Knobcone pine series, McNab cypress series, Sargent cypress series.

**Climate**. Mean annual precipitation is about 30 to 60 inches. Most of the precipitation is rain at lower and snow at higher elevation. Mean annual temperature is about 50° to 60° F. The mean freeze-free period is in the range from 150 to 250 days.

**Surface Water**. Runoff is rapid and all but the larger streams are dry through most of the summer. Natural lakes are absent.

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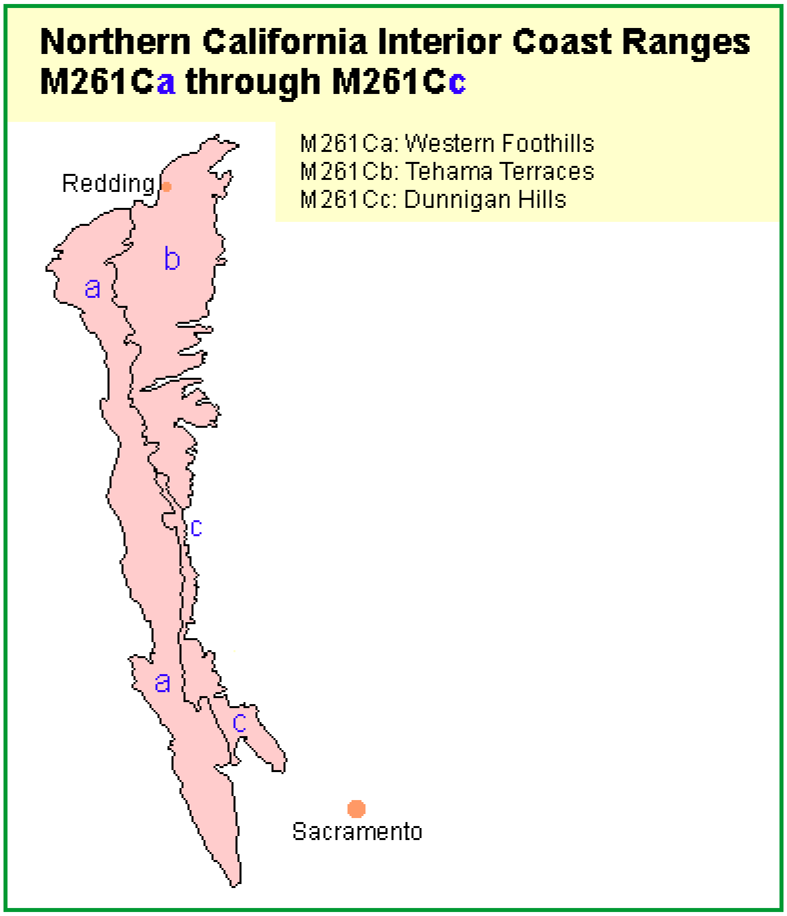
## SECTION M261C
### NORTHERN CALIFORNIA INTERIOR COAST RANGES

This section is the southeastern edge of the northern California Coast Ranges mountains, south of Cache Creek, and hills and terraces along the west side and north end of the Sacramento Valley. It is in MLRAs 15 and 17.

**Geomorphology**. Parallel ranges, folded, faulted and metamorphosed strata; rounded crests of subequal height. Coast Ranges Geomorphic province.

**Lithology**. Late Mesozoic shelf and slope sedimentary deposits.

**Soil Taxa**. Alfisols, Inceptisols, Mollisols and Vertisols in combination with thermic soil temperature regime and xeric soil moisture regime.




**Vegetation**. Predominant potential natural communities include the Blue Oak series, Chamise series, Purple needlegrass series and Foothill pine series.

The following series are found throughout the section and are not restricted to or extensive in any subsection. Series dominated by exotic plants are not listed under subsections unless they are extensive and stable.

*Series dominated by exotic plants:* Cheatgrass series, Eucalyptus series, Tamarisk series.
*Series that can occur in all subsections, but are not extensive:* Bulrush series, Bulrush - cattail series, Cattail series, Creeping ryegrass series, Duckweed series, Mosquito fern series, Nodding needlegrass series, One-sided bluegrass series, Pondweeds with floating leaves series, Pondweeds with submerged leaves series, Purple needlegrass series. Saltgrass series, Sedge series, Spikerush series.
*Series restricted to riparian settings:* Arroyo willow series, Black willow series, Buttonbush series, Fremont cottonwood series, Mixed willow series, Mulefat series, Narrowleaf willow series, Pacific willow series, Red willow series, White alder series.

**Fauna**. Mammals include mule deer, black-tailed deer, coyotes, ground squirrels, cottontails, jack rabbits and kangaroo rats. Birds include turkey vultures, eagles, hawks, owls, quail, mourning dove, mockingbird, scrub jay, western meadow lark, finches and sparrows.

**Elevation**. 200 to 3000 feet.

**Precipitation**. 15 to 40 inches.

**Temperature**. 55° to 62° F.

**Growing Season**. 150 to 250 days.

**Surface Water Characteristics**. Many rapid perennial or intermittent streams in deeply incised canyons with weak bedrock channels flowing easterly to the Sacramento River. Reservoirs for irrigation water and flood control are common.

**Disturbance Regimes**.

*Fire:* Fires are low, moderate and high intensity surface or stand replacing fires.

**Land Use**. Composition and successional sequence of some communities has changed because of plant and animal species introduced between the mid 1800's and early 1900's related to grazing and agriculture.

**Cultural Ecology**. Humans have been utilizing the interior Coast Range foothills for 8,000 to 9,000 years, and have been an integral part of the ecology for 3,000 to 5,000 years. Historically, ranching and agriculture provided the primary Euroamerican livelihood. Contemporary attitudes and beliefs are dichotomized between emphasis on amenity/newcomer and commodity/long-time resident values, with all overlain by a rural lifestyle. Contemporary economic pursuits include government employment, agriculture, and recreation.

**Subsections**. The Northern California Interior Coast Ranges section is divided into 3 subsections.

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## Subsection M261Ca
## Western Foothills

This subsection includes Blue Ridge in the northern California Coast Ranges and steep hills east of Blue Ridge and east of the Stony Creek fault. It extends north to the Klamath Mountains. The climate is hot and subhumid. MLRAs 15d and 15e.

**Lithology and Stratigraphy**. This subsection contains Jurassic and Cretaceous marine sedimentary rocks of the Great Valley Sequence. They are mostly sandstone, shale, and conglomerate that are tilted monoclinally eastward toward the center of the Great Valley.

**Geomorphology**. Blue Ridge, in the southeast margin of the northern California Coast Ranges mountains, trends north-northwest. The steep hills east of the mountains are elongated parallel to the edge of the Great Valley. They resemble hogbacks along the west edge of the Valley, but do not have such distinct forms at the north end of the Valley. The elevation range is from about 300 feet up to 3057 feet on Berryessa Peak. Mass wasting and fluvial erosion are the main geomorphic processes.

**Soils**. The soils are mostly Lithic Xerochrepts, Typic Haploxeralfs, Xerolls, and Chromoxererts. The soils are generally, but not all, leached free of carbonates. Few surfaces are old enough, because of active erosion, to have Palexeralfs. Soil temperature regimes are predominantly thermic. Soil moisture regimes are xeric.

**Vegetation**. The predominant natural plant communities include Chamise series and Blue oak series. Chamise series is most prevalent on steep slopes with shallow or rocky soils. Needlegrass grasslands predominate on some Vertisols.

***Characteristic series by lifeform include:***
*Grasslands:* California annual grassland series.
*Shrublands:* Chamise series, Chamise - wedgeleaf ceanothus series, Scrub oak series, Wedgeleaf ceanothus series, Whiteleaf manzanita series.
*Forests and woodlands:* Birchleaf mountain-mahogany series, Blue oak series, California buckeye series, Foothill pine series, Interior live oak series.

**Climate**. The mean annual precipitation is about 25 to 40 inches; most of it is rain. Mean annual temperature is about 55° to 62° F. The mean freeze-free period is from 150 to 250 days.

**Surface Water**. Runoff is rapid and all but the larger streams are dry through most of the summer. There are no natural lakes, but there are a few reservoirs.

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## Subsection M261Cc
## Dunnigan Hills

This subsection comprises Dunnigan Hills and the low hills that extend northerly along the western edge of the Sacramento Valley to just north of Nye Creek. MLRAs 15e and 17e.

**Lithology and Stratigraphy**. This subsection contains predominantly nonmarine Pliocene mudstones, sandstones and conglomerates that are only slightly consolidated rocks. There are small areas of Pleistocene nonmarine deposits.

**Geomorphology**. Pliocene and Quaternary fluvial surfaces are highly dissected by streams draining toward the Sacramento River. Drainage patterns are dendritic, branching from streams that drain toward the Sacramento River. The Dunnigan Hills are almost completely dissected, leaving very little of the Pliocene depositional surface. They are well rounded hills with moderately steep to steep sides. The elevation range is about 200 to 1500 feet. Fluvial erosion is the main geomorphic process; mass wasting is important on moderately steep slopes with Vertisols and on steep slopes.

**Soils**. The soils are mostly Entic and Typic Chromoxererts. Palexeralfs predominate on undissected terrace surfaces. Other common soils are Lithic and Calcixerollic Xerochrepts, Haploxeralfs, and Argixerolls. Calcium carbonate accumulations are common in subsoils. Soil temperature regimes are thermic and soil moisture regimes are xeric.

**Vegetation**. The predominant natural plant communities are Needlegrass grasslands. Blue oak series is present, but not common, on soils other than Vertisols.

***Characteristic series by lifeform include:***
*Grasslands:* California annual grassland series.
*Forests and woodlands:* Blue oak series.

**Climate**. The mean annual precipitation is about 15 to 25 inches; most of it is rain. Mean annual temperature is about 60° to 62° F. The mean freeze-free period is from 200 to 250 days.

**Surface Water**. Runoff is rapid and all but the larger streams are dry through most of the summer. There are no natural lakes in the area.

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## SECTION 262A
## GREAT VALLEY

This section contains the alluvial plains of the Sacramento and San Joaquin Valleys. Summers are hot and dry and winters are mild. Oceanic influence on climate is slight in the middle of the Great Valley, which receives some marine air through the Carquinez Straits, but becomes negligible at the north and south ends of the Valley. MLRAs 15 and 17.

**Geomorphology**. Low fluviatile plain. Great Valley geomorphic province.

**Lithology**. Cenozoic nonmarine sedimentary rocks and alluvial deposits.

**Soil Taxa**. Alfisols, Aridisols, Entisols, Histisols, Inceptisols, Mollisols and Vertisols in combination with a thermic soil temperature regime and xeric, aquic or aridic soil moisture regimes.

**Vegetation**. Predominant potential natural communities include Purple needlegrass series, Valley oak series, vernal pools and wetland communities, blue oak series, allscale series and saltgrass series.

The following series are found throughout the section and are not restricted to or extensive in any subsection. Series dominated by exotic plants are not listed under subsections unless they are extensive and stable.

> *Series dominated by exotic plants:* California annual grassland series, Cheatgrass series, Common reed series, Eucalyptus series, Introduced perennial grassland series, Kentucky bluegrass series and Tamarisk series.
> *Series that can occur in all subsections, but are not extensive:* Bulrush series, Bulrush - cattail series, Cattail series, Duckweed series, Mexican elderberry series, Mosquito fern series, One-sided bluegrass series, Pondweeds with floating leaves series, Pondweeds with submerged leaves series, Saltgrass series, Sedge series and Spikerush series.
> *Series restricted to riparian settings:* Arroyo willow series, Black willow series, Buttonbush series, California sycamore series, Fremont cottonwood series, Mixed willow series, Mulefat series, Narrowleaf willow series, Pacific willow series, Red willow series and White alder series.

**Fauna**. Former inhabitants include grizzly bear, wolf, tule elk, and pronghorn antelope. Much of the natural habitat has been modified throughout the section. The section contains wetlands that are important feeding and resting areas for migrating waterfowl. Many waterfowl species are year around residents. Mammals include mule deer, black-tailed deer, coyotes, muskrats, beavers, ground squirrels, cottontails, jack rabbits, kangaroo rats and the endangered kit fox. Common birds include hawks, golden eagle, owls, white-tailed kite, quail, mourning dove, mockingbird, scrub jay, gulls, herons, crows, western meadow lark, finches, sparrows, roadrunners (southern part) and the introduced Chinese ringneck pheasant. Tule elk herds have been reestablished in some southern parts of the section.

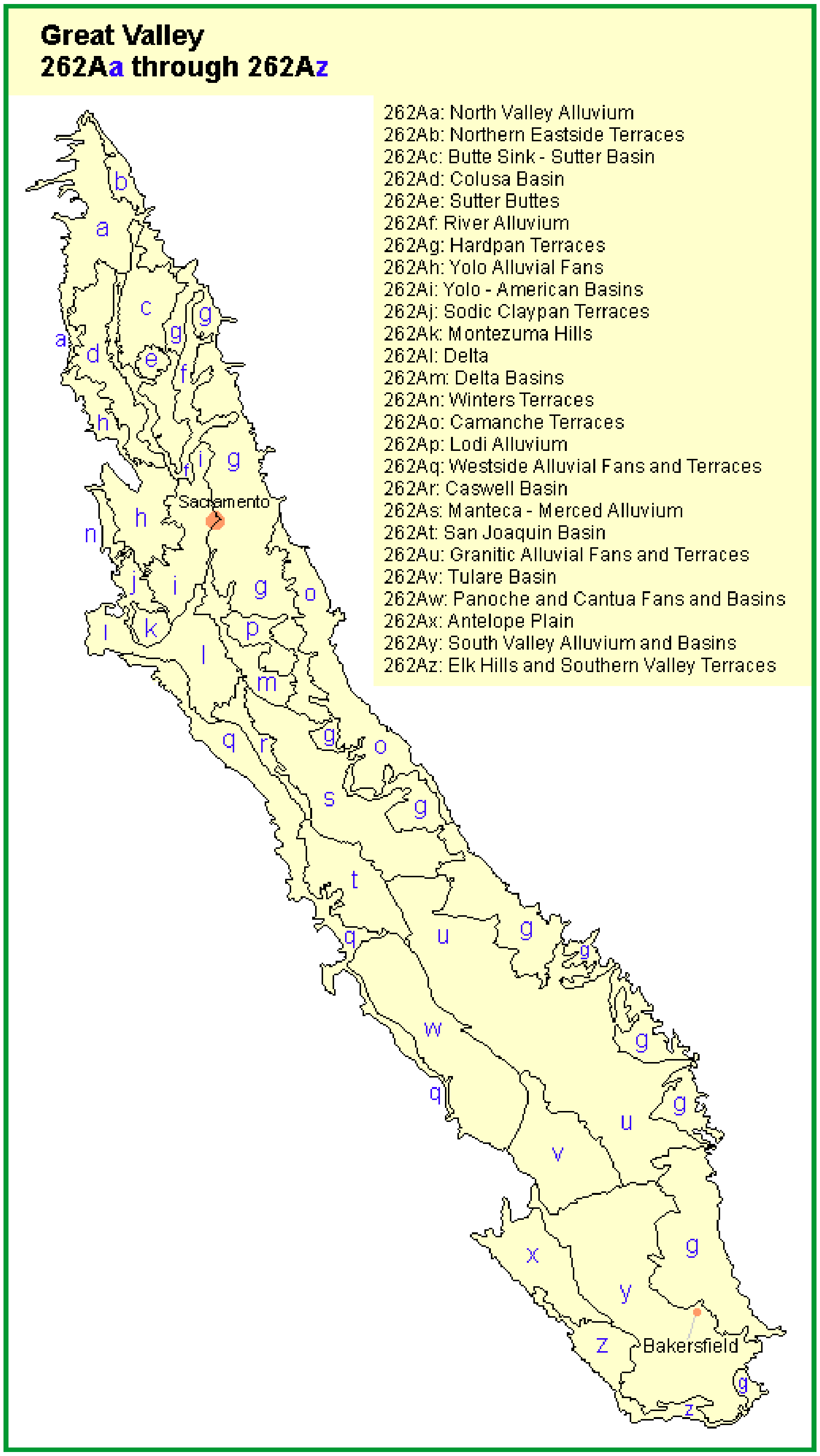
**Elevation**. Sea Level to 2000 feet.

**Precipitation**. 5 to 25 inches.

**Temperature**. 56° to 62°F.

**Growing Season**. 250 to 300 days.

**Surface Water Characteristics**. Many slow moving rivers flow to the delta east of San Francisco Bay via the Sacramento and San Joaquin River systems. Flows to these levied, alluvial channel river systems is regulated throughout the year by the many dams occurring in adjacent sections. Constructed deep water ship channels also connect San Francisco Bay to Sacramento and Stockton. Many rivers and perennial streams flow west from the Sierra Nevada foothill section to the Sacramento and San Joaquin Rivers. The many alluvial channels that flow eastward from the Coast Ranges to the Sacramento and San Joaquin Rivers are mostly dry during summer months, only a few are perennial streams. The southern part of the San Joaquin Valley drains to basins and does not reach the San Joaquin River.




**Disturbance Regimes**. *Fire:* Historic occurrence has changed from frequent, fast moving large fires to infrequent small fires, or fire has been mostly excluded because of conversion to irrigated agriculture and urban uses. *Flooding:* Although mostly controlled by levee systems, seasonal flooding was extensive in this section.

**Land Use**. Composition and successional sequence of some communities (especially grassland communities) has changed because of plant and animal species introduced between the early 1800's and early 1900's related to grazing, agriculture, and urbanization. Most of the section is converted to irrigated agriculture. Rapidly expanding urbanized areas are scattered throughout the section. Flood control has decreased the duration and extent of wetlands.

**Cultural Ecology**. Humans have been utilizing the central valley for 10,000 years, and have been an integral part of its ecology for 3,000 to 5,000 years. The valley contains some of the densest year-round prehistoric habitation locations in California, particularly along riparian areas, where intensive occupation, resource procurement and processing practices, and vegetation manipulation through the use of fire sometimes altered the environment. Around the time of the Gold Rush, Euroamericans flooded into the valley, converting the land to agriculture, which became the mainstay of California economy. The river systems provided early transportation routes. Sacramento and Stockton are shipping ports served by deep water channels. Contemporary attitudes and beliefs are varied; lifestyles are both urban and rural; economies are dominated by agriculture, government, and services; populations are diverse.

**Subsections**. The Great Valley section is divided into 26 subsections.

## Subsection 262Ah
### Yolo Alluvial Fans

This subsection is on a late Quaternary alluvial plain on the lower west side of Sacramento Valley. The climate is hot and subhumid. MLRA 17e.

**Lithology and Stratigraphy**. This subsection contains Pleistocene and recent alluvium. The alluvium is from granitic, volcanic, sedimentary, and metamorphic rock sources.

**Geomorphology**. This subsection is mainly late Pleistocene and recent alluvial fans from the northern California Coast Ranges and from hills on the lower west side of the Sacramento River. The subsection elevation range is from about 20 to about 200 feet. Fluvial erosion and deposition are the main geomorphic processes.

**Soils**. The soils are mostly Typic Xerofluvents, Typic Xerochrepts, and Typic and Mollic Haploxeralfs. Typic Pelloxererts are common in finer sediments, Aquic Haploxeralfs in low areas, and Typic Palexeralfs on older surfaces. The soils are mostly well drained, but some on floodplains are somewhat poorly drained. Most of them are leached free of carbonates. Soil temperature regimes are thermic, and soil moisture regimes are mostly xeric.

**Vegetation**. The predominant natural plant communities are Needlegrass grasslands, and Valley oak series is common on recent alluvial plains. Fremont cottonwood series occurs along streams, particularly along Cache Creek and Putah Creek.

***Characteristic series by lifeform include:***
*Grasslands:* California annual grassland series, Purple needlegrass series.
*Forests and woodlands:* Fremont cottonwood series, Mixed willow series, Valley oak series.

**Climate**. The mean annual precipitation is about 15 to 18 inches. It is practically all rain. Mean annual temperature is about 59° to 60° F. The mean freeze-free period is about 250 to 300 days.

**Surface Water**. Streams in this subsection drain to the Sacramento River. All but the larger streams are generally dry during the summer. There are no lakes.

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## Subsection 262An
### Winters Terraces

This subsection is on terraces with clayey soils along the western edge of the lower Sacramento Valley, adjacent to the northern California Coast Ranges. The climate is hot and subhumid. MLRA 15d.

**Lithology and Stratigraphy**. This subsection contains predominantly Pliocene nonmarine sediments that are only slightly consolidated. There are smaller areas of Quaternary terraces and recent alluvium.

**Geomorphology**. This subsection is on very gently sloping terraces that are dissected and eroded to form gently sloping to moderately steep slopes. There are small areas of recent floodplain and terraces along streams that cross from mountains of the northern California Coast Ranges to reach the Sacramento River. The subsection elevation range is from about 100 to about 200 feet. Fluvial erosion and deposition are the main geomorphic processes.

**Soils**. The soils are mostly Typic Palexeralfs, Typic Haploxeralfs, Entic and Typic Chromoxererts, and Typic Argixerolls. Soils on recent alluvium are Typic Xerorthents, Typic Xerochrepts, Aeric Haplaquepts, and Haploxeralfs. Most of the soils are well drained, but some in recent alluvium are somewhat poorly drained. Bicarbonate weathering and leaching and accumulation of clay in subsoils are the main pedogenic processes in the terrace soils. Soil temperature regimes are thermic. Soil moisture regimes are mostly xeric, with some aquic on floodplains.

**Vegetation**. The predominant natural plant communities are Needlegrass grasslands and Blue oak series. Fremont cottonwood series occurs along streams.

> ***Characteristic series by lifeform include:***
> *Grasslands:* California annual grassland series, Needlegrass series.
> *Vernal pools:* Northern hardpan vernal pools.
> *Forests and woodlands:* Blue oak series, Fremont cottonwood series.

**Climate**. The mean annual precipitation is about 20 to 25 inches. It is practically all rain. Mean annual temperature is about 59° to 62° F. The mean freeze-free period is about 250 to 275 days.

**Surface Water**. Streams in this subsection drain to the Sacramento River. All but the larger streams are generally dry during the summer. There are no lakes, but there is temporary ponding in vernal pools on Pleistocene terraces.

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## Subsection 262Ai
## Yolo - American Basins

This subsection is on an alluvial plain adjacent to the lower Sacramento River. Much of it is flooded during the winter or early spring. The climate is hot and subhumid. MLRAs 16e and 17e.

**Lithology and Stratigraphy**. This subsection contains recent alluvium of stream channel, stream overflow, and alluvial fan deposits. The alluvium is from granitic, volcanic, sedimentary, and metamorphic rock sources in mountains around the Sacramento Valley.

**Geomorphology**. This subsection is on nearly level to very gently sloping stream channels, levees, overflow basins, and alluvial fans. The subsection elevation range is from about 10 to about 40 feet. Fluvial erosion and deposition are the main geomorphic processes.

**Soils**. The soils are mostly Aquic Xerofluvents; Aeric Haplaquepts; and Cumulic and Vertic Haplaquolls. Pelloxererts and Chromoxererts are common on alluvial fans. The soils are moderately well drained to poorly drained. Soil temperature regimes are thermic, and soil moisture regimes are aquic and xeric.

**Vegetation**. The predominant natural plant communities are Emergent aquatic communities and Needlegrass grasslands.

> ***Characteristic series by lifeform include:***
> *Wetlands:* Bulrush series, Bulrush - cattail series, Cattail series, Sedge series.
> *Forests and woodlands:* California sycamore series, Fremont cottonwood series, Mixed willow series.

**Climate**. The mean annual precipitation is about 14 to 18 inches. It is practically all rain. Mean annual temperature is about 60° to 62° F. The mean freeze-free period is about 250 to 275 days.

**Surface Water**. The Sacramento River overflows onto parts of this area and overflowed onto most of the area when it flooded before being controlled by dams, artificial levees, and diversions. Streams drain toward the Sacramento River on alluvial fans and parallel to it in overflow basins. All but the larger streams are generally dry during the summer. There are no lakes, but there is temporary ponding in overflow basins.

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## APPENDIX C - GLOSSARY OF SELECTED TERMS

Included are definitions of selected terms that may not be commonly known to the user of this document. Further definition of geologic, soil and plant community classifications and terminology may be found in Bates and Jackson (1980) for geologic terms, Glossary of Soil Science Terms (1987) and Keys to Soil Taxonomy (1996) for soil terminology, and Sawyer and Keeler-Wolf (1995) for vegetation.

ALLUVIUM — A general term for clay, silt, sand, gravel, or similar unconsolidated detrital material deposited during comparatively recent geologic time by a stream or other body of running water as a sorted or semisorted sediment in the bed of the stream. (Bates and Jackson 1980.)

CIRQUE — A deep steep-walled half-bowl-like recess or hollow situated high on the side of a mountain and commonly at the head of a glacial valley, and produced by the erosive activity of a mountain glacier. (Bates and Jackson 1980.)

COLLUVIUM — A general term applied to any loose, heterogeneous, and incoherent mass of soil material and/or rock fragments deposited by rainwash, sheetwash, or slow continuous downslope creep, usually collecting at the base of gentle slopes or hillsides. (Bates and Jackson 1980.)

DIVISION — An ecological unit in the ecoregion planning and analysis scale of the National Hierarchical Framework corresponding to subdivisions of a Domain that have the same regional climate. (ECOMAP 1993.)

DOMAIN — An ecological unit in the ecoregion planning and analysis scale of the National Hierarchical Framework corresponding to subcontinental divisions of broad climatic similarity that are affected by latitude and global atmospheric conditions. (ECOMAP 1993.)

DRY — A classification of climate based on the Köppen System for regions where evaporation exceeds precipitation. (Bailey 1980.)

ECOREGION — A scale of planning and analysis in the National Hierarchical Framework that has broad applicability for modeling and sampling, strategic planning and assessment, and international planning. Ecoregions include Domain, Division, and Province ecological units.

ECOSYSTEM — A complete interacting system of organisms and their environment. (Forest Service Manual 2060.)

FLOODPLAIN — The surface or strip of relatively smooth land adjacent to a river channel, constructed by the present river in its existing regimen and covered with water when the river overflows its banks. (Bates and Jackson 1980.)

LIFE ZONES — A classification of macroclimatic conditions based on temperature and precipitation that has been widely applied in tropical environments to delineate zones dominated by vegetative communities of characteristic physiognomy and composition. (Holdridge 1967.)

MAJOR LAND RESOURCE AREA (MLRA) — A broad geographical area that has a distinct combination of climate, soil, vegetation, management needs, and kinds of crops that can be grown (USDA, Natural Resources Conservation Service, 1981).

MORAINE — A mound, ridge, or other distinct accumulation of unsorted, unstratified glacial drift, predominantly till, deposited chiefly by direct action of glacier ice, in a variety of topographic landforms that are independent of control by the surface on which the drift lies. (Bates and Jackson 1980.)

PLANT ASSOCIATION — A potential natural plant community of definite floristic composition and uniform appearance. (Forest Service Manual 2060.)

PLANT COMMUNITY — A group of one or more populations of plants in a common spatial arrangement. (Forest Service Manual 2060)

PLAYA — A term used in the southwestern U.S. for a dry, vegetation-free, flat area at the lowest part of an undrained desert basin, underlain by stratified clay, silt, or sand, and commonly by soluble salts. (Bates and Jackson 1980.)

POTENTIAL NATURAL COMMUNITY — The biotic community that would be established if all successional sequences of its ecosystem were completed without additional human-caused disturbance under present environmental conditions. Grazing by native fauna, natural disturbances, such as drought, floods, fire, insects, and disease, are inherent in the development of potential natural communities which may include naturalized exotic species. (Forest Service Manual 2060.)

PROVINCE — An ecological unit in the ecoregion planning and analysis scale of the National Hierarchical Framework corresponding to subdivisions of a Division that conform to climatic subzones controlled mainly by continental weather patterns. (ECOMAP 1993.)

REGIONALIZATION — A mapping procedure in which a set of criteria are used to subdivide the earth's surface into smaller, more homogeneous units that display spatial patterns related to ecosystem structure, composition, and function. (ECOMAP 1993.)

SCALE — The degree of resolution at which ecological processes, structures, and changes across space and time are observed and measured. (ECOMAP 1993.)

SECTION — An ecological unit in the subregion planning and analysis scale of the National Hierarchical Framework corresponding to subdivisions of a Province having broad areas of similar geomorphic process, stratigraphy, geologic origin, drainage networks, topography, and regional climate. Such areas are often inferred by relating geologic maps to potential natural vegetation groupings as mapped by Küchler (1964). (ECOMAP 1993.)

SUBREGION — A scale of planning and analysis in the National Hierarchical Framework that has applicability for strategic, multi-forest, statewide, and multi-agency analysis and assessment. Subregions include Section and Subsection ecological units.

SUBSECTION — An ecological unit in the subregion planning and analysis scale of the National Hierarchical Framework corresponding to subdivisions of a Section into areas with similar surficial geology, lithology, geomorphic process, soil groups, subregional climate, and potential natural communities. (ECOMAP 1993.)

SUBTROPICAL — A classification of climate based on the Köppen System for regions where there are eight months or more warmer than 50° F and the coolest month is warmer than 32° F but colder than 65° F. (Bailey 1980.)

TEMPERATE — A classification of climate based on the Köppen System for regions where there are four to eight months warmer than 50° F and the coldest month is cooler than 32° F. (Bailey 1980.)

TROPICAL — A classification of climate based on the Köppen System for regions where the coolest month is warmer than 65° F (Bailey 1980).

VEGETATION SERIES — An aggregation of taxonomically related plant associations which take the name of the late seral stage species that dominate, or have the potential to dominate the principal vegetative layer in a time frame appropriate to the vegetation or taxonomic group under consideration.

# ATTACHMENT B

**California Natural Diversity Data Base**
**Summary Report**
**Berryessa – Snow Mountain NCA Proposal**

**Occurrence Records in 28 USGS 7.5-Minute Quadrangles:**
**Aetna Springs, Bartlet Mountain, Bartlet Springs, Benmore Canyon, Brooks, Capell Valley, Chiles Valley, Clearlake Oaks, Crockett Peak, Fouts Springs, Gilmore Peak, Glascock Mountain, Hough Springs, Jericho Valley, Knoxville, Lake Berryessa, Lake Pillsbury, Leesville, Lower Lake, Middletown, Monticello Dam, Mount Vaca, Potato Hill, St. John's Mountain, Stonyford, Walter Springs, Wilbur Springs, and Wilson Valley**

**November 29, 2008**

**(Provided Separately)**

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