EXECUTIVE SUMMARY

In 1994, The Fish and Wildlife Service (Service) announced nationally An Ecosystem Approach to Fish and Wildlife Conservation as a means to address fish and wildlife issues, holistically and proactively. This announcement initiated the Service’s transition from political boundary administrative units, i.e. Regions 1-7, to that of hydro physiographic administrative units or ecoregions, e.g. the Klamath/Central Pacific Coast Ecoregion and 51 others. In July, 1993, the Klamath Basin Ecosystem Restoration Office (ERO) was established due to heighten political tensions over competition for water. The allocation issue involved limited water for the endangered short-nosed and Lost River suckers, irrigation and maintenance of refuge wetlands for waterfowl, as well as a wide array of other endangered species and ecosystem restoration issues. ERO was charged with the development of a basin strategy which evolved into the Klamath/ Central Pacific Coast Ecoregion Restoration Strategy (Strategy).

While numerous natural resource plans and strategies have been put forth, no single document has attempted to holistically integrate the issues, needs or action items of the Klamath Basin or the Klamath/Central Pacific Coast Ecoregion. The purposes of the Strategy are to (1) represent in a reserve system all native ecosystem types and seral stages; (2) maintain viable populations of all native species; (3) maintain natural ecological and evolutionary processes; (4) maintain landscapes and communities to be resistant and resilient to change; and (5) provide for health and welfare of ecoregion residents.

The Strategy is presented in four volumes. Volume I — Description of the Ecoregion, describes the ecological and socioeconomic history; functioning of the ecoregion; and the context for understanding the ecological problems that have developed. Volume II — Description of the Ecological Issues, describes the ecological issues or “ecoissues” of the ecoregion including species-level, habitat, ecosystem health, and ecosystem degradation issues. Volume III — A Holistic Ecosystem Restoration Strategy, reviews salient background concepts of ecosystem management, traditional and newer conservation strategies, and scale considerations in conservation, as background to “The Strategy.” The Strategy is then elucidated as a series of five groups of tactics on: (1) general protection, (2)
species level issues, (3) habitat issues, (4) ecosystem health issues, and (5) ecosystem degradation issues. Volume IV — The U.S. Fish and Wildlife Service’s Program, addresses a synthesis of the Ecoregion’s field office roles and responsibilities with respect to Wildlife and Refuges, Ecological Services, Fisheries, Administration including Law Enforcement, Federal Aid, Research Coordination and GIS support. This volume concludes with a delineation of ecoregion goals, priorities, organization plan as well as the Service’s approach to the Northwest Forest Plan, Endangered Species, Refuges, Fishery Resources, Water Resources, Wetlands, Wildlife Resources, Outreach, and organization and internal efficiencies.

Perhaps the greatest value of the Klamath/Central Pacific Coast Ecoregion Strategy resides in the thorough airing of natural resource issues with all publics in the ecoregion. In this context the Strategy serves as an outreach document which levels the “knowledge playing field,” making the best available data regarding an ecoissue available to the general public. However, the Strategy also serves as a pre-project reference for future permittees submitting activity proposals. Lastly, ecoissues are developed in a manner which identifies not only the concerns and actions being taken, but also which organization has responsibility for a particular issue or portion of the ecoregion. Thus the Service’s coordination role relative to fish, wildlife and their habitat is enhanced, and by proactively encouraging other agencies and organizations to do their part, the Service is leveraging limited resources toward more effective and efficient recovery and restoration activities.

Questions and comments may be directed to either Ron Garrett (541) 885-8481 or Allen Cooperrider (707) 486-4059 of the Klamath Basin Ecosystem Restoration Office, 6600 Washburn Way, Klamath Falls, Oregon 97603.
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Smith River
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    Lower Klamath
    Lower Trinity
    South Fork Trinity
    Mid Trinity
    Upper Trinity
    Salmon
    Mid Klamath
    Scott
    Shasta
    Butte
    Upper Klamath
    Lost
    Sprague
    Williamson
Redwood Creek
Mad River
Eel River
    Delta
    Lower Main
    Middle Main
    Upper Main
    Van Duzen
    South Fork
    North Fork
    Middle Fork
Mattole River
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INTRODUCTION

This volume is the first of four volumes describing a strategy for restoring the function and health of the Klamath / Central Pacific Coast Ecoregion (Figure I-1), hereafter termed the "Klamath Ecoregion". In this volume, we describe the ecoregion from an ecosystem perspective and introduce some of the human forces that have caused or are continuing to cause ecosystem degradation.

In volume II, we describe the critical ecological issues of the ecoregion. These "ecoissues" are the result of human activities that are causing major disruption of the ecoregion's health and function.

In volume III, we describe a holistic strategy for addressing these ecoissues. This includes both a description of existing plans and programs for resolving ecoissues as well as proposals for new initiatives.

Finally, in volume IV, the U.S. Fish and Wildlife Service's program in the ecoregion is described. That program represents the Service's role in ecosystem restoration in the ecoregion. The Service recognizes that restoration of this ecosystem will require a concerted, long-term effort of many agencies and individuals.

THE ECOREGION DEFINED

The Klamath Ecoregion is one of 52 ecoregions (Figure I-2) defined by the U.S. Fish and Wildlife Service1. It is located in northwestern California and southcentral Oregon and consists of all the watersheds or hyrdbasins that drain into the Pacific Ocean north to the Smith River (Figure I-3). Thus the ecoregional boundaries are defined in terms of watersheds rather than some other criteria such as geology or vegetation type.

Any ecoregional delineation is bound to be arbitrary. Some interactions occur among ecoregions and thus any delimitation of an area is not going to encompass all species or ecological processes. However, the Klamath Ecoregion boundaries are biologically meaningful in many ways. It encompasses most of the range of coast redwoods2. Mapping of potential natural vegetation of the ecoregion3 indicates that it contains virtually all of the potential natural sites for one vegetation types (Pine-Cypress forest) and most of the sites for four others (Redwood forest, California mixed evergreen forest, Montane chaparral (Arctostaphylos-Castanopsis-Ceanothus, and Fescue-oatgrass) (Figure I-4). Together, these four types make up more than 50% of the ecoregion.
Figure I-1. The Klamath / Central Pacific Coast Ecoregion (DEM Map).
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Figure I-4. Potential natural vegetation of the Klamath Ecoregion.
NEEDLELEAF FORESTS

2  Cedar-hemlock-Douglas fir forest
    (Thuja-Tsuga-Pseudotsuga)

5  Mixed conifer forest
    (Abies-Pinus-Pseudotsuga)

6  Redwood forest
    (Sequoia-Pseudotsuga)

9  Pine-cypress forest
    (Pinus-Cupressus)

BROADLEAF AND NEEDLELEAF FORESTS

29 California mixed evergreen forest
   (Quercus-Arbutus-Pseudotsuga)

SHRUB

33 Chaparral
    (Adenostoma-Arctostaphylos-Ceanothus)

34 Montane chaparral
    (Arctostaphylos-Castanopsis-Ceanothus)

GRASSLANDS

47 Fescue-oatgrass
    (Festuca-Danthonia)
The ecoregion also encompasses most of the Klamath Economic Zone (Figure I-5). The Klamath Economic Zone is based on the biology of salmon. Salmon are a keystone component of the ecoregion, not only ecologically but also economically and culturally. The Klamath Economic Zone, which includes the Klamath Ecoregion as well as the Rogue River drainage to the north, is managed as one unit for purposes of allocating ocean salmon harvesting since stocks from these rivers are found together in the ocean fishery. The Klamath Economic zone is the most inclusive of the ecoregional designations—including all of the Klamath Basin, Klamath Province (as defined by the President’s Forest Plan) and Klamath Ecoregion as shown in Figure I-5.
Figure I-5. The Klamath Economic Zone.
GEOLOGY AND LANDFORMS

The Klamath Ecoregion encompasses portions of four geologic provinces: Coast Ranges, Klamath Mountains, Cascade Range, and Modoc Plateau (Figure I-6).6

Coast Ranges Geologic Province

This province is located along the coastal portion of the ecoregion from Sonoma County to the Oregon border. It includes the entire watershed of most of the smaller coastal streams as well as portions of the Smith River and Klamath River hydrobasin. It consists of a system of north and northwest trending mountain ridges and valleys formed by folding and faulting. The geologic history of this province is complex. The exposed stratigraphy suggests long periods of marine deposition, plutonic intrusion, and intermittent volcanic activity and orogeny (Page 1966).

The predominant formation in the Coast Ranges is the Franciscan Complex of Upper Jurassic and Lower Cretaceous age. Franciscan Complex rocks include graywacke, metagraywacke, argillite, greenstone, chert, blueschist, and associated ultramafic rocks and serpentine. These rocks have undergone periods of intense folding, faulting, and deformation associated with the complex process of tectonic plate movement. The complex Franciscan Formation is divided into three northwest trending belts. They are an eastern belt of metaclastics, a central belt dominated by melange, and a coastal belt of graywacke, shale, and conglomerate. Cretaceous marine formations do form a zone along the coast and lie west of the Franciscan Complex. The Cretaceous marine formations are sandstone, shale and conglomerate.

Klamath Mountains Province

The Klamath Mountains geologic province covers an elongate north-trending area of approximately 12,000 miles square in northwestern California and southwestern Oregon. It includes many individual mountain ranges including the Yolla Bolly, Trinity, South Fork, Salmon, Trinity Alps, Scott, Scott Bar, Marble and Siskiyou Mountains. It has had a long and complex geological history described in detail by Irwin (1966).

This province contains a variety of metamorphic, sedimentary and igneous rocks of various ages. A principal feature of the Klamath Mountains Province that distinguishes it from the Coast Ranges Province is the presence of granitic intrusions of rocks that range from hornblende diorite to true granite in composition. Such rocks are lacking in the Coast Ranges.

A principal feature of the Klamath Mountains is the presence of "peneplains" which are elevated land masses with flattish or gently rounded summits with an approximate accordance in the altitudes of even-crested ridges, given the appearance of a dissected plateau. These areas are
Figure I-6. Major geologic formations of the Klamath Ecoregion.
EXPLANATION

SEDIMENTARY AND VOLCANIC ROCKS

Cenozoic nonmarine (continental) sedimentary rocks and alluvial deposits

Cenozoic marine sedimentary rocks

Cenozoic volcanic rocks

Late Mesozoic (latest Jurassic and Cretaceous) shelf and slope sedimentary rocks

Late Mesozoic (latest Jurassic and Cretaceous) eugeosynclinal rocks of the Franciscan Formation

Mesozoic sedimentary and volcanic rocks older than the Nevadan orogeny; in places strongly metamorphosed

Paleozoic sedimentary and volcanic rocks; in places strongly metamorphosed; includes some rocks of Triassic age in Klamath Mountains; includes some late Precambrian sedimentary rocks in Great Basin

Precambrian rocks of all types including coarse-grained intrusives

Pre-Cenozoic metamorphic rocks of unknown age

INTRUSIVE IGNEOUS ROCKS

Granitic rocks chiefly of Mesozoic age

Ultramafic rocks chiefly of Mesozoic age
particularly important biologically because many of them occur at relatively high altitudes and thus have not been subject to the periodic fresh- or salt-water inundation typical of the Coast Ranges and the lower portions of the Klamath Mountains. As a result, species of plants and animals have remained in place or evolved over long periods in such areas, with resultant high degree of endemism and species richness.

The complex rock pattern and history of the Klamath Mountains have produced no well defined trend in stream drainage and ridge direction such as is found in the Coastal Mountain Province. The principal rivers of the Klamath Province cut transversely across it, running generally westward from the interior valleys, through deep canyons in the mountains themselves.

Cascade Range and Modoc Plateau Provinces

The upper Klamath River basin is within the geologic provinces of the Cascade Range and Modoc Plateau. The Cascade Range extends northward through Oregon and Washington into British Columbia and the Modoc Plateau extends into Oregon and southeastward into Nevada. Most of the Cascade Range is a fairly well defined province, but in the Upper Klamath Basin the separation between it and the Modoc Plateau becomes indefinite (Macdonald 1966).

The outstanding characteristics of the Modoc region are: (1) the dominance of volcanism so recent that the volcanic landforms are still clearly preserved (the most well known being Crater Lake and Mount Shasta); and (2) the presence of broad inter-range areas of nearly flat basalt plains. The basalt plains have given rise to the designation "plateau", however, the region as a whole is not a high, undiversified plain as the name suggests.

The upper Klamath Basin region of the Modoc plateau supports some large and geologically old wetlands. The river systems of this area were once connected with both the Snake River drainage to the north and east, as well as to the Sacramento and San Jouquin drainage to the south. Upper Klamath Lake is one of the oldest fresh-water lakes in North America of its size. Frest and Johannes have stated: "Upper Klamath Lake is one of the few surviving Pliocene lakes and the only one with normal alkalinity and a large relict fauna. It is likely the best remaining window on environments prevalent in the interior West 2-17 million years ago."

CLIMATE

The basic climate of the ecoregion may be characterized as Mediterranean with warm summers with little or no rain during summer and wet and cool winters. This pattern varies considerably from one portion of the ecoregion to another, particularly with regard to precipitation. Mean annual temperatures for eight locations (Santa Rosa, Ukiah, Covelo, Eureka, Crescent City, Weaverville, Yreka, Klamath Falls) within the ecoregion are shown in Table I-1. Mean annual
precipitation and monthly precipitation distribution for six locations in the ecoregion are shown in Table 1-2. Mean annual precipitation for the ecoregion is mapped in Figure 1-7. Note that although total precipitation varies considerably from 82 inches in Crescent City to 13 inches in Klamath Falls, the annual pattern is quite similar.

The Coast Ranges generally have the most typical Mediterranean climate with cool wet winters, snow only at elevations above 2,000 feet or more and dry summers with virtually no rain during July and August and over 70% of the precipitation coming between November and March. However, areas quite close to the coast may get summer precipitation and considerable amounts of fog and fog precipitation.

The Klamath Mountains as well as higher elevations throughout the ecoregion have a somewhat modified climate. They receive some summer precipitation from thunderstorms although this is often spotty. In addition, much of the winter precipitation may come in the form of snow and higher elevations may accumulate considerable snow packs.

The Modoc Plateau sits in the rain shadow of the Klamath Mountains and as a result has substantially less rain than in the coast ranges as can be seen by comparing the precipitation for Klamath Falls with the coastal cities. Summer temperatures also tend to be warmer for similar elevations, but because most of it sits at higher elevations, summer temperatures are generally cooler.
Table I-1. Mean annual temperature for selected stations within the Klamath Ecoregion.
Table I-2. Mean monthly distribution of precipitation for six stations within the Klamath Ecoregion.\(^1\)

<table>
<thead>
<tr>
<th>Station</th>
<th>Covelo, CA</th>
<th>Eureka, CA</th>
<th>Crescent City, CA</th>
<th>Weaverville, CA</th>
<th>Yreka, CA</th>
<th>Klamath Falls, OR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean Annual Precipitation (inches)(^2)</td>
<td>39.3</td>
<td>38.3</td>
<td>82.4</td>
<td>37.1</td>
<td>18.0</td>
<td>13.3</td>
</tr>
</tbody>
</table>

| Distribution of Precipitation by Month as Percentage of Mean Annual Precipitation |
|-------------------------------|-----------------|-----------------|-----------------|-----------------|-----------------|
| October                       | 5               | 7               | 7               | 6               | 7               | 7               |
| November                      | 10              | 13              | 14              | 14              | 14              | 13              |
| December                      | 20              | 16              | 16              | 18              | 17              | 15              |
| January                       | 21              | 17              | 16              | 18              | 17              | 16              |
| February                      | 19              | 15              | 15              | 16              | 14              | 12              |
| March                         | 10              | 14              | 13              | 11              | 10              | 9               |
| April                         | 8               | 8               | 8               | 8               | 6               | 7               |
| May                           | 4               | 5               | 5               | 4               | 6               | 7               |
| June                          | 1               | 2               | 2.5             | 2.6             | 3               | 6               |
| July                          | .5              | .5              | .5              | .4              | 2               | 2               |
| August                        | .2              | .5              | .5              | .3              | 1.5             | 2               |
| September                     | 1.3             | 2               | 2.5             | 1.7             | 2.5             | 4               |

\(^1\) From Rantz (1964)

\(^2\) Based upon 60 years of records from 1900 to 1959

\(^3\) Does not include "fog precipitation"
SOILS

Soils vary considerably throughout the ecoregion in both their fertility and their sensitivity to disturbance. A generalized soil map and soil sensitivity map are shown in Figures I-8 and I-9. Throughout much of the Coast Ranges, the sedimentary soils of Franciscan formation are notoriously fragile. Because of their complex geologic history the Klamath mountains have a diversity of soils ranging from decomposed granitics to volcanic soils. In places there are quite old and deep soils due to long periods without inundation or glaciation. The volcanic soils of Modoc Plateau notoriously porous and by contrast to the Franciscan soils of the Coast Ranges are quite resistant to erosion from human activities.

HYDROLOGY

S.E. Rantz has described in detail patterns of precipitation and runoff for the ecoregion. He presents four hydrographs (Figure I-10) which typify the differing hydrology as one moves from the Coast Ranges to the Klamath Mountains to the Modoc Plateau.

Hydrology of the Coast Ranges is typified by high winter runoff and or infiltration and perennial streams that are groundwater fed. This is typified by the hydrograph for the Eel River (Figure I-10). With little or no summer precipitation the ability of the soil to capture and hold precipitation is quite critical to the hydrological cycle. It has been estimated, for example, that the soil of the Eel River Basin holds about 233 billion gallons of water, or about 120% of the amount in Lake Shasta when it is full.

Another unique aspect of hydrologic cycle in the Coast Ranges is the input of water from fog precipitation or "fog drip". The fog belt or region that receives regular fog, covers approximately 1/3 of the Coast Ranges (Figure I-11). Fog drip is the water that is physically captured by plants, especially large conifers such as redwoods. This is a critical form of precipitation for many plants including especially redwoods and associated flora. Todd Dawson, for example has shown that water from 22-46% of the moisture input to the redwood ecosystem was due to the presence of redwood trees themselves. He further demonstrated that some understory plants derive up to 100% of their water from fog drip and concluded that the presence of trees has a real influence on the magnitude of water input from fog.

Fog drip may also be a significant source of water for recharging aquifers and streams; although this aspect has not been studied in detail in the Klamath Ecoregion there is evidence from other regions that fog drip may be a significant source of groundwater recharge.

The hydrology of the Klamath Mountains is similar to that of the Coast Ranges except that there is no fog precipitation, and significant amounts of precipitation fall as snow rather than as rain. This storage of snow in the mountains and resultant snowmelt results in peak flows in April and May as typified by the hydrograph for the Trinity River (Figure I-10). In addition, there is some
summer precipitation from thundershowers.

The Modoc Plateau differs from the other areas in that precipitation input is significantly lower due to the rainshadow effect of the Klamath Mountains and because of the good infiltration of water due to the presence of porous soils. In addition, the underlying rocks not as permeable resulting in a high water table in many places. Altogether this results in a much flatter hydrograph as typified by Fall Creek and the Shasta River (Figure I-10).
Figure I-11. Mean monthly distribution of runoff at selected gaging stations (from Rantz 1964).
VEGETATION

The vegetation of the ecoregion is as diverse as the climate and landforms ranging from semi-desert Great Basin types to coastal marshes and rainforests. General vegetation types of the ecoregion are shown in Figure I-12.

Major Vegetation Types (Formations)

Thirteen major vegetation types occur within the Klamath/Central Pacific Coast Ecoregion based upon Terrestrial Vegetation of California (Barbour and Major 1988) and Natural Vegetation of Oregon and Washington (Franklin and Dyrness 1973).

Coastal Prairie and Northern Coastal Scrub. The Festuca-Danthonia grassland, or coastal prairie, occurs along the California coast from Santa Cruz northward. Coastal prairie is a discontinuous grassland below 1000 m in elevation and seldom more than 100 km from the coast. Typically it occurs on the ridges and south-facing slopes, alternating with forest and scrub in the valleys and on north-facing slopes. The dominant perennial grasses in this type are Festuca idahoensis, F. rubra, and Danthonia californica. The dominant species of the coastal prairie vary from north to south and with distance inland from the ocean. The Northern Coastal Scrub community extends in a narrow coastal strip from southern Oregon to Pt. Sur, Monterey County. It is dominated by evergreen shrubs less than 2 m tall, but with an additional herbaceous element to the extent that the scrub is interrupted by patches of Coastal prairie. Important shrubs include Baccharis pilularis var. consanguinea, Eriophyllum staechadifolium, Gaultheria shallon, Lupinus variicolor, Diplacus aurantiacus, and Rubus vitifolius. Perennial herbs and grasses were also listed as prominent. This habitat type is relatively stable, with small-scale changes related to agricultural uses and some losses to urbanization in limited areas.

Beach and Dune. The flora, vegetation, and microenvironment of beach and dune are sufficiently different to warrant their separate classification. Beach is defined as the expanse of sandy substrate between mean tide and foredune or, in the absence of a foredune, to the inland reach of storm waves. The beach is characterized be a maritime climate, high exposure to salt spray and sand blast, and a shifting, sandy substrate with low water-holding capacity and low organic matter content. With the exception of Cakile species, beach taxa are perennial. Many, but not all, share the following traits: herbaceous, evergreen, succulent, leaves entire, habit prostrate, leading to nearly complete burial in hillocks of sand. Dunes are defined to include the sandy, open habitat which extends from foredune to typically inland vegetation on stabilized substrate. Plant communities are generally characterized by the following habitats: moving dune, stabilized ridge, vernal pool hollow, and dune forest. In some areas, extent of beaches and dunes have increased over the past several decades. However, there is a general trend toward lower habitat quality due to increasing recreational use, invasion of exotic plants, and, in limited areas, urbanization.
Figure I-12. General vegetation types of the Klamath Ecoregion.
Coastal Saltmarsh. Coastal saltmarshes are restricted to the upper intertidal zone of protected shallow bays, estuaries, and coastal lagoons. Physical conditions are dominated by the tides, and pronounced environmental gradients are established in response to elevational changes in frequency and duration of tidal flooding. Humboldt Bay is the principle site of coastal salt marshes in California. *Spartina densiflora*, an introduced species, remains the usual primary colonist of the tideflats but often shares dominance of the low marsh with *Salicornia virginica*. Although *Salicornia* remains abundant in the high marsh, it often occurs as a codominate with *Distichlis spicata* and *Jaumea carnosa*.

Closed-Cone Pines and Cypress. Closed-cone pines and cypress are unique, disjunct plant communities scattered the length of California's coast, mountains, and islands. The relict species occur on infertile and sometimes unusual substrates. Most stands are influenced by maritime climate. A number of endemic species are associated with these communities, and general plant diversities and densities tend to be reduce on these impoverished sites. The reduced pine species include the closed knobcone pine (*Pinus attenuata*), Monterey pine (*P. radiata*), Santa Cruz Island pine (*P. remorata*), and possibly beach pine (*P. contorta ssp. contorta*) and pygmy pine (*P. contorta ssp. bolanderi*). Cypresses include 10 species, 8 of which are endemic to the state. These major species are intimately related to fire, characterized by a closed-cone habit or by serotinous cones, whereby the ovulate cones remain sealed after maturity, usually accumulating on the tree unit opened by fire. Most of these habitats are in isolated areas with little economic impetus for alteration. Consequently, these communities are relatively stable.

Coastal Forest. Redwood forests are tall, dense, needle-leaved, and evergreen. Dominant are redwood (*Sequoia sempervirens*) and Douglas fir (*Pseudotsuga menziesii*) and Sitka spruce (*Picea sitchensis*). Broad-leaved evergreen medium tall trees gradually increase eastward. The coast redwoods are the tallest trees (112 m), growing at rates near world maximum. Undergrowth is low and patchy with forbs mainly on alluvial sites, shrubs and low trees on the uplands. Mainly western side of Coast Ranges from Monterey county to Oregon. The redwood belt is usually only about 16-24 km wide. During the past few decades, declines in coastal salt marshes have been arrested. Most coastal marshes are now in public ownership. Principal threats include non-point source pollution and susceptibility to oil spills.

California Chaparral. California chaparral is composed mainly of evergreen woody shrubs, and it forms extensive shrublands that occupy most of the hills and lower mountain slopes of California. It is adapted to drought and fire, passing endlessly through cycles of burning and regrowth. Even though chaparral has no commercial value, it forms the most highly valued watershed cover of any vegetation in the state. "Chaparral" is a word of Spanish origin (chaparro) that originally denoted a thicket of shrubby evergreen oaks. The geographic factors that influence chaparral development are slope aspect, coastal-desert exposure, elevation, substrate, and fire. The dominate woody genera of the California chaparral, such as *Adenostoma, Arctostaphylos, Ceonothus, Heteromeles*, and *Rhus*, are absent from other regions having a Mediterranean type climate. Since this common type is favored by fire suppression, it has probably increased in recent decades, and the proportion of its acreage in older successional
stages has also increased.

Mixed Evergreen Forest. The term "mixed evergreen forest" describes a characteristic set of coastal California mountain communities. The mixed evergreen forest can be divided into the *Pseudotsuga*-hardwood forests of the Klamath Mountains and North Coast Ranges and the mixed hardwood forests of southern California and the southern coast ranges. *Pseudotsuga*-hardwood forests form part of an extensive mosaic with northern oak woodland and coastal prairie in the northern central portion of the mixed evergreen forest. As in the Klamath region, these forests show various combinations of *Pseudotsuga*, *Lithocarpus*, and *Arbutus* dominance on deeper, well-drained soils. In southeastern portions of Humboldt and Mendocino Counties, *Pinus ponderosa* becomes a major codominant in forests and woodlands. At higher elevations, *P. lambertiana* is of secondary importance, and to the south, *Quercus agrifolia* becomes an increasingly common associate. Old-growth coastal forest was heavily harvested from the mid-1800s until about 1970. Remaining old-growth stands constitute a small fraction of the original extent, and are almost entirely in public ownership. Nearly two million acres of lower-successional stages are managed by private timber companies. with typical harvest rotations of less than 80 years. Conifers in this type have been heavily harvested for decades, especially in more accessible areas at low elevations. Most significant remnants on public lands are now in reserves. Very little old-growth remains on private lands. Hardwood components of these forests remain largely intact, except where they have been clearcut for conversion to conifer plantations. Near urban areas, hardwood stands are also harvested for firewood and cogeneration fuel.

Vernal Pools. A vernal pool is a small, hardpan-floored depression in a valley grassland mosaic that fills with water during the winter. As it dries up in the spring, various annual plant species flower, often conspicuous concentric rings of showy colors. Pool vegetation is azonal, with edaphic factors more important than the regional climate which affects the surrounding vegetation. There are three general types of vernal pools: valley pools, terrace pools, and pools of volcanic areas. This remnant habitat type is primarily limited to the Santa Rosa Plain. Endangered species protection and land-management planning have stabilized the trend of habitat loss, but urban development pressures continue.

Great Basin Desert including Sagebrush Steppe. The Great Basin desert is the most extensive desert in the U.S., stretching from the southeastern Oregon and Wyoming, south to northern New Mexico, and west into extreme eastern California. Topography of the Great Basin Desert varies but generally consists of wide valley floors between 4000 and 6000 feet interrupted by mountains. Temperatures drop much lower than any other U.S. desert, with a short frost-free season and very cold winters, and precipitation ranges from 4 to 12 inches. Two major vegetation communities occur within this desert, both of which are structurally and floristically simple: sagebrush, *Artemisia* ssp., and shadscale or saltbush associations dominated by saltbushes, *Atriplex* ssp. Species with evolutionary affinities to warmer climates such as rabbitbrush (*Chrysothamnus* ssp.) and blackbrush (*Coleogyne* ssp.) are also present in the Great Basin Desert. The sagebrush steppe consists of a series of generally treeless, shrub-dominated communities located along the eastern and northeastern boundary of California. Species of *Artemisia* are the dominant shrubs, with
perennial bunch grasses including *Agropyron spicatum* and *Festuca idahoensis* characterizing the understory. In past decades, irrigation and overgrazing resulted in conversion loss of Great Basin grassland to cropland and shrubland.

**Montane and Subalpine Vegetation of the Klamath Mountains.** The Klamath montane forests form a series of more or less discrete, island-like patches within a matrix of low-elevation forests and woodlands in northwestern California and southwestern Oregon. Klamath montane forests grow mostly above low-elevation coniferous forests rather than chaparral, woodlands, or grasslands. Dominant species, such as *Pseudotsuga menziesii*, *Pinus ponderosa*, and *P. lambertiana*, are typical of low as well as montane elevations. The habitat requirements, competitive ability, fire resistance, and colonizing ability of individual conifer species have determined their ecological positions in elevational zones and habitats throughout the montane forests of the Klamath region. Decades of timber harvest have reduced the amounts of old-growth montane forests; most significant remnants are now in reserves on public lands. Fire suppression has resulted in increased stand density, high mortality on some sites, and increased likelihood of stand-replacing fires. The extent of non-commercial timber species near timberline remains largely un-changed.

**Transmontane Coniferous Vegetation.** The transmontane region of California traditionally includes the portions of the state lying east of the main crests of the Cascade-Sierra axis and of the southern ranges forming the divide between coastal and desert drainages. Three broad categories of coniferous vegetation occur primarily in the transmontane region of California: northern juniper woodlands, pinon and juniper woodlands, and montane coniferous forests. The northern juniper woodland described by Munz and Keck (1949) is here interpreted to include two phases: a western juniper woodland in open, rolling country and a mountain juniper on ridges and mountain slopes. The western juniper woodland is characterized by open stands or scattered trees of western juniper (*Juniperus occidentalis* ssp. *occidentalis*). The understory may have a grassy understory, particularly where trees are close together, or they may have a shrub understory in more open stands. Understory shrubs, or interspersed stands of low shrubs, are primarily Great Basin sagebrush (*Artemisia tridentata*) on deep soils or well-drained slopes, and black sagebrush (*Artemisia arbuscula*) on heavy soils and rocky substrates. The mountain juniper woodland is characterized by scattered trees of *Juniperus occidentalis* ssp. *australis*, commonly in association with *Pinus jefferyi*, *Cercocarpus ledifolius*, *Purshia tridentata*, and *Artemisia tridentata*. Pinon-juniper woodlands represent the westernmost expression of widespread vegetation types occurring in the Great Basin and Colorado Plateau regions. Dominant include *Pinus monophylla*, *Juniperus osteosperma*, *J. occidentalis*, *P. quadrifolia*, and *P. edulis*. Fire suppression has led to a continued expansion of juniper woodland in the extreme northeastern portion of the ecoregion, at the expense of shrubland and grassland.

**Oak Woodland.** The oak woodland has little floristic unity except the ubiquitous annuals in its ground cover. Species from adjacent grassland, chaparral, and forest communities associate with the "woodland" trees over a wide range physiographical and climatic situations. Open stands of deciduous "white oaks" characterize vast tracts of oak woodland, but evergreen "black oaks" are
often present and sometimes dominant. Also, one or more species of pine may be scattered among the oaks. On the ground, the oak woodland has a significant grassland cover under and between the trees. Different oak species are involved regionally. Oak woodlands remain fairly stable, except in limited areas near urban regions, or where access for firewood cutting or cogeneration fuel concentrates impacts.

**Tule Marshes and Wetlands.** Wetlands are characterized by hydric soils and water-loving plants. Of the many diverse types of wetlands, marshes are the most widely distributed and the best-known form. They are dominated by emergent plants such as cattail (*Typha ssp.*), bulrushes (*Scirpus ssp.*), sedges (*Carex ssp.*), and water-tolerant grasses. Marshes often are complete entities, found in shallow basins. The term may also be used for any emergent hydrophyte community. Water is the driving force in determining wetland type and habitat quality. Water permanency and associated vegetation are key factors in classifying wetlands. Because water cycles are variable, marshes are rarely constant. These fluctuations induce "boom and bust" in wildlife numbers, but are essential to nutrient recycling. Although increased regulation has slowed the rate of decline, loss of freshwater wetlands continues on a localized level due to urban development and intensive agricultural practices.

**Vegetation Series for California**

Vegetation can be described in more detail at the "series" level. The series found within the California portion of the ecoregion are shown in Table I-4. Note that **** of these are rare both within the region and globally.
Table 1-4. Vegetation series within the Klamath Ecoregion (from Sawyer and Keeler-Wolf 1995).
Wildlife

Wildlife habitats according to the California Wildlife Habitat Relationship System are shown in Table I-5.

<table>
<thead>
<tr>
<th>Wildlife Habitat Type</th>
<th>Where Found in Ecoregion</th>
<th>Typical / Dominant Plants</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Tree Dominated Habitats</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Subalpine Conifer</td>
<td>Higher elevations of Klamath Mountains and Modoc Plateau</td>
<td>Engelmann spruce, subalpine fir, mountain hemlock, western white pine, lodgepole pine, whitebark pine</td>
</tr>
<tr>
<td>Red Fir</td>
<td>Higher elevations of Klamath Mountains and Modoc Plateau</td>
<td>red fir</td>
</tr>
<tr>
<td>Lodgepole Pine</td>
<td>Higher elevations of Klamath Mountains and Modoc Plateau</td>
<td>lodgepole pine</td>
</tr>
<tr>
<td>Sierran Mixed Conifer</td>
<td>Mid elevations of Klamath Mountains and southern Cascades</td>
<td>white fir, Douglas-fir, ponderosa pine, sugar pine, incense-cedar, California black oak</td>
</tr>
<tr>
<td>White Fir</td>
<td>Between mixed conifer and red fir habitats in Klamath Mountains</td>
<td>white fir</td>
</tr>
<tr>
<td>Klamath Mixed Conifer</td>
<td>Klamath Mountains</td>
<td>white fir, Douglas fir, ponderosa pine, incense cedar, sugar pine</td>
</tr>
<tr>
<td>Tree Type</td>
<td>Location Description</td>
<td>Ecoregion</td>
</tr>
<tr>
<td>---------------------------</td>
<td>---------------------------------------------------------------------------------------</td>
<td>-----------</td>
</tr>
<tr>
<td>Douglas Fir</td>
<td>Entire length of Coast ranges within ecosystem (primarily at elevations of 500-2000 feet) and Klamath Mountains (primarily at elevations of 1000 to 4000 feet)</td>
<td>Douglas fir</td>
</tr>
<tr>
<td>Jeffrey Pine</td>
<td>Localized areas within Coast Ranges and Klamath Mountains</td>
<td>Jeffry pine</td>
</tr>
<tr>
<td>Ponderosa Pine</td>
<td>Warmer and drier sites of Klamath Mountains and Modoc Plateau</td>
<td>ponderosa pine</td>
</tr>
<tr>
<td>Redwood</td>
<td>Coast Ranges for entire length of ecoregion primarily at lower elevations within fog belt</td>
<td>coast redwood</td>
</tr>
<tr>
<td>Juniper</td>
<td>Drier warmer sites of the Modoc Plateau</td>
<td>western juniper</td>
</tr>
<tr>
<td>Aspen</td>
<td>Higher elevations of the Klamath Mountains and Modoc Plateau</td>
<td>quaking aspen</td>
</tr>
<tr>
<td>Closed-Cone Pine-Cypress</td>
<td>In patches along coast in Sonoma, Mendocino, and Humboldt County; Klamath Mountains</td>
<td>Varies considerably depending upon site; trees include MacNab and Sargent cypress, Bishop pine, Torrey pine, beach pine, knobcone pine</td>
</tr>
<tr>
<td>Montane Hardwood-Conifer</td>
<td>Widely distributed throughout the ecoregion</td>
<td>ponderosa pine, Douglas-fir, incense cedar, California black oak, tanoak, Pacific madrone, Oregon white oak</td>
</tr>
<tr>
<td>Montane Hardwood</td>
<td>Widely distributed in Coast Ranges and Klamath Mountains</td>
<td>canyon live oak</td>
</tr>
<tr>
<td>------------------</td>
<td>----------------------------------------------------------</td>
<td>-----------------</td>
</tr>
<tr>
<td>Blue Oak Woodland</td>
<td>Localized areas of Mendocino County</td>
<td>blue oak</td>
</tr>
<tr>
<td>Valley Oak Woodland</td>
<td>Drier, eastern portions of Mendocino and Sonoma counties</td>
<td>valley oak</td>
</tr>
<tr>
<td>Coastal Oak Woodland</td>
<td>Inland portions of coast ranges from Sonoma County north through Humboldt County</td>
<td>Oregon white oak</td>
</tr>
<tr>
<td>Blue Oak - Digger Pine</td>
<td>Patchily distributed in eastern Mendocino and Sonoma County</td>
<td>blue oak, digger pine</td>
</tr>
<tr>
<td>Eucalyptus⁴</td>
<td>Southern portion of Sonoma County</td>
<td>Blue gum, red gum</td>
</tr>
<tr>
<td>Montane Riparian</td>
<td>Widely distributed throughout the ecoregion</td>
<td>black cottonwood, bigleaf maple, white alder, thinleaf alder</td>
</tr>
<tr>
<td>Valley Foothill Riparian</td>
<td>Widely distributed along Coast Ranges</td>
<td>cottonwood, valley oak</td>
</tr>
</tbody>
</table>

Shrub Dominated Habitats

<table>
<thead>
<tr>
<th>Alpine Dwarf-Shrub</th>
<th>Higher elevations within Klamath Mountains and Modoc Plateau (Mt. Shasta)</th>
<th>varies considerably</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low Sage</td>
<td>Scattered locations within Modoc Plateau</td>
<td>low sagebrush, black sagebrush</td>
</tr>
<tr>
<td>Bitterbrush</td>
<td>Modoc Plateau</td>
<td>antelope bitterbrush</td>
</tr>
<tr>
<td>Sagebrush</td>
<td>Modoc Plateau</td>
<td>big sagebrush</td>
</tr>
</tbody>
</table>

⁴ Gum trees (Eucalyptus) are not native to North America.
<table>
<thead>
<tr>
<th>Habitat Type</th>
<th>Description</th>
<th>Characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Montane Chaparral</td>
<td>Inland portions of Coast Ranges to northern Mendocino County; Modoc Plateau and eastern side of Klamath Mountains</td>
<td>varies considerably</td>
</tr>
<tr>
<td>Mixed Chaparral</td>
<td>Drier sites throughout the ecoregion</td>
<td>varies considerably</td>
</tr>
<tr>
<td>Chamise-Redshank Chaparral</td>
<td>Drier sites throughout the ecoregion</td>
<td></td>
</tr>
<tr>
<td>Coastal Scrub</td>
<td>Discontinuous along entire length of coast</td>
<td>chamise</td>
</tr>
<tr>
<td>Herbaceous Dominated Habitats</td>
<td></td>
<td>varies considerably</td>
</tr>
<tr>
<td>Annual Grassland</td>
<td>Drier sites within Sonoma and Mendocino County</td>
<td>varies considerably</td>
</tr>
<tr>
<td>Perennial Grassland</td>
<td>Drier sites along coast ranges and on Modoc Plateau</td>
<td>California oatgrass, Pacific hairgrass, sweet vernalgrass</td>
</tr>
<tr>
<td>Wet Meadow</td>
<td>Scattered throughout northern portion of Coast Ranges (Humboldt and Del Norte County), Klamath Mountains, and Modoc Plateau</td>
<td>Characteristic genera include Agrostis (bentgrass), Danthonia (danthonia), Juncus (rushes), Salix (willows), and Scirpus (bulrushes)</td>
</tr>
<tr>
<td>Fresh Emergent Wetland</td>
<td>Scattered throughout ecoregion</td>
<td>varies considerably</td>
</tr>
<tr>
<td>Saline Emergent Wetland</td>
<td>Patchily distributed along coast of Humboldt and Del Norte County</td>
<td>varies considerably</td>
</tr>
<tr>
<td>Pasture$^5$</td>
<td>Concentrated along: (1) Russian River drainage in Sonoma and Mendocino Counties; (2) Lower stretches Eel and Mad River drainage in Humboldt County; (3) Scott and Shasta Valley in Siskiyou County; and (4) Upper Klamath River in Oregon and northern Siskiyou County, California.</td>
<td>varies considerably</td>
</tr>
<tr>
<td>-----------------------------------------------</td>
<td>--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
<td>---------------------</td>
</tr>
</tbody>
</table>

**Aquatic Habitats**

<table>
<thead>
<tr>
<th>Riverine</th>
<th>Throughout</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lacustrine</td>
<td>Throughout</td>
</tr>
<tr>
<td>Estuarine</td>
<td>Patchily distributed along coast with largest estuaries in Marin, Humboldt, and Del Norte County.</td>
</tr>
<tr>
<td>Marine</td>
<td>Coast</td>
</tr>
</tbody>
</table>

**Developed Habitats**

$^5$ The type refers to irrigated pasture
| Cropland | Concentrated along:  
|          | (1) Russian River drainage in Sonoma and Mendocino Counties;  
|          | (2) Lower stretches Eel and Mad River drainage in Humboldt County;  
|          | (3) Scott and Shasta Valley in Siskiyou County; and  
|          | (4) Upper Klamath River in Oregon and northern Siskiyou County, California.  
|          | The type refers to irrigated pasture |
| Orchard-Vineyard | Widely distributed from northern Mendocino County southward within ecoregion. |
| Urban | Widely distributed throughout ecoregion--but most concentrated in south--especially Marin and Sonoma County |
These habitat types have been mapped from aerial photography using 1993 Landsat Thematic Mapper images (Figure I-13). The habitat types that can be distinguished from Landsat are shown in Table I-6.
Figure I-13. Wildlife habitat types derived from Landsat thematic mapper ("Fox habitat types").
Table I-6. Vegetation Types Determined from Landsat Thematic Mapper Classified Into Wildlife Habitat Relationship (WHR) Classes.

<table>
<thead>
<tr>
<th>LANDSAT HABITAT TYPE</th>
<th>Included WHR Types</th>
<th>Identified Stages (WHR tree size &amp; closure)</th>
<th>Symbol</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1) Mixed Conifer</td>
<td>(SCN, RFR, SMC, WFR, KMC, RDW, DFR, JPN, PPN, EPN, CPC, LPN)</td>
<td>2S 2P 2M 2D 3S 3P 3M 3D</td>
<td>MCN</td>
</tr>
<tr>
<td>(Needle-leaf, &lt;20% broad-leaf)</td>
<td>(SCN, RFR, SMC, WFR, KMC, RDW, DFR, JPN, PPN, EPN, CPC, LPN)</td>
<td>4S 4P 4M 4D 5S 5P 5M 5D</td>
<td></td>
</tr>
<tr>
<td>1A. Mixed Fir</td>
<td>(SCN, RFR, SMC, WFR, KMC, RDW, DFR)</td>
<td>The above classes repeat for all four tree types. WHR tree size classes are:</td>
<td>MCF</td>
</tr>
<tr>
<td>(Mapped when possible)</td>
<td>(SCN, RFR, SMC, WFR, KMC, RDW, DFR)</td>
<td>Size Class DBH Range (inches)</td>
<td></td>
</tr>
<tr>
<td>1B. Mixed Pine</td>
<td>(JPN, PPN, EPN, CPC, LPN)</td>
<td>2 1 - 6</td>
<td>MCP</td>
</tr>
<tr>
<td>(Mapped when possible)</td>
<td>(JPN, PPN, EPN, CPC, LPN)</td>
<td>3 6 - 11</td>
<td></td>
</tr>
<tr>
<td>(2) Mixed Conifer-Hardwood</td>
<td>(MHC, KMC, DFR, JPN, PPN, EPN, RDW, CPC)</td>
<td>4 11 - 24</td>
<td>MCH</td>
</tr>
<tr>
<td>(Mixed needle-leaf &amp; broad-leaf, &gt;50% Needle-leaf)</td>
<td>(MHC, KMC, DFR, JPN, PPN, EPN, RDW, CPC)</td>
<td>5 &gt;24</td>
<td></td>
</tr>
<tr>
<td>(3) Mixed Hardwood-Conifer</td>
<td>(MHC, MHW, BOP)</td>
<td>WHR canopy closure classes are:</td>
<td>MHC</td>
</tr>
<tr>
<td>(Mixed broad-leaf &amp; needle-leaf, &gt;50% broad-leaf)</td>
<td>(MHC, MHW, BOP)</td>
<td>Closure Class Canopy Closure (%)</td>
<td></td>
</tr>
<tr>
<td>(4) Mixed Hardwood</td>
<td>(MHW, MHC, MRI, VRI, EUC, ASP)</td>
<td>S 10 - 24</td>
<td>MHW</td>
</tr>
<tr>
<td>(Broad-leaf, &lt;20% needle-leaf)</td>
<td>(MHW, MHC, MRI, VRI, EUC, ASP)</td>
<td>P 25 - 39</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>M 40 - 59</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>D 60 - 100</td>
<td></td>
</tr>
<tr>
<td>LANDSAT HABITAT TYPE</td>
<td>Included WHR Types</td>
<td>Identified Stages (WHR tree size &amp; closure)</td>
<td>Symbol</td>
</tr>
<tr>
<td>(5) Mixed Oak Woodland</td>
<td>(VOW, COW, BOW)</td>
<td>(see above)</td>
<td>MOW</td>
</tr>
<tr>
<td>(Oak dominated broad-leaf)</td>
<td>(VOW, COW, BOW)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(6) Mixed Juniper/Pinyon</td>
<td>(PJN, JUN)</td>
<td>(see above)</td>
<td>MJN</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* We do not expect to discriminate WHR size class 1 for trees since areas containing seedlings < 1 inch in diameter are normally, spectrally dominated by the companion vegetation.
### GENERAL SHRUB TYPES

<table>
<thead>
<tr>
<th>LANDSAT HABITAT TYPE</th>
<th>Symbol</th>
<th>Included WHR Types</th>
<th>Identified Stages (WHR shrub closure)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Deadstick Shrub</td>
<td>SHD</td>
<td>(LSG, BBR, SGB, ASC MCH, CRC, CSC)</td>
<td>S P M D</td>
</tr>
<tr>
<td>Soft Shrub</td>
<td>SHS</td>
<td>(BBR, LSG, SGB)</td>
<td>S P M D</td>
</tr>
</tbody>
</table>

### GENERAL HERBACEOUS TYPES

<table>
<thead>
<tr>
<th>LANDSAT HABITAT TYPE</th>
<th>Symbol</th>
<th>Included WHR Types</th>
<th>Identified Stages (WHR herb, closure)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dead Grass/Forb</td>
<td>GSD</td>
<td>(PGS, AGS, CRP, PAS)</td>
<td>S P M D (2-9) (10-39) (40-59) (60-100)</td>
</tr>
<tr>
<td>Green Grass/Forb</td>
<td>GSG</td>
<td>(WTM, PGS, AGS, OVN, CRP, PAS)</td>
<td>S P M D</td>
</tr>
<tr>
<td>Wet Meadow/ Marsh</td>
<td>GSW</td>
<td>(WTM, FEW, SEW)</td>
<td>S P M D</td>
</tr>
</tbody>
</table>

### GENERAL BARREN TYPES

<table>
<thead>
<tr>
<th>LANDSAT HABITAT TYPE</th>
<th>Symbol</th>
<th>Included WHR Types</th>
<th>Identified Zones</th>
</tr>
</thead>
<tbody>
<tr>
<td>Snow &amp; Ice</td>
<td>BSI</td>
<td>(none defined)</td>
<td>(none defined)</td>
</tr>
<tr>
<td>Soil</td>
<td>BSL</td>
<td>(RIV, MAR, EST, LAC, URB)</td>
<td>2</td>
</tr>
<tr>
<td>Gravel/Rock/Talus</td>
<td>BGR</td>
<td>(RIV, MAR, EST, LAC, URB)</td>
<td>2</td>
</tr>
</tbody>
</table>

---

7 We do not expect to discriminate WHR, “size” (actually maturity) classes for shrubs.

8 We do not expect to discriminate WHR height classes for herbaceous types.

9 We combine WHR Zones 3 & 4 to form Zone 2 (exposed during satellite overpass). We do not expect to discriminate WHR substrates. BGR and BSL types occurring in or near rivers and lakes are spectrally identical to BGR and BSL types occurring on upland sites.
<table>
<thead>
<tr>
<th>LANDSAT HABITAT TYPE</th>
<th>Symbol</th>
<th>Included WHR Types</th>
<th>Identified Zones$^10$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water</td>
<td>WTR</td>
<td>RIV, MAR, EST, LAC</td>
<td>1</td>
</tr>
</tbody>
</table>

$^10$ We combine WHR Zones 1, 2 & 3 to form Zone 1 (submerged during satellite overpass). We do not expect to discriminate WHR substrates.
Vertebrate species found within the ecoregion are shown in Table I-7. A total of XX native species have been reported from the region including xx fish, xx amphibians, xx reptiles, xx birds, and xx mammals. In addition, xx non-native or exotic species of vertebrates have become established in the region.
Table I-7. Vertebrate species found within the Klamath Ecoregion.
HUMAN HISTORY

First Nations

Native Americans have occupied the Klamath Ecoregion for at least 10,000 years. The native Americans of the region are from six separate linguistic groups (Figure I-14), thus suggesting that their origins were quite diverse. They lived in scattered temporary and permanent villages throughout the area. As best we understand it native Americans associated with their villages and clans more than with their "tribe" as described by anthropologists of European origin. The anthropologists who studied native Americans, as well as the government officials attempting to deal with them, tried to categorize Indians into discrete tribes. An anthropological map of the native American tribes of California is shown in Figure I-15.

Within this region the Native Americans had developed complex and diverse cultures, well-adapted to the localized landscape conditions and use of native plant and animal materials. Native Americans depended heavily upon salmon (in most of the region), suckers (in Upper Klamath Basin), shellfish (along coast), acorns (drier portions of ecoregion), and deer and elk (throughout the ecoregion). In addition, the native cultures made extensive use of hundreds of other species for food, housing, boatbuilding, basketry, medicine, ceremony, and many other uses.

The native people maintained and subtly manipulated the landscape in a manner that has not been fully appreciated by non-Indians until recently through practices such as burning and seeding. Blackburn and Anderson (1993b) describe this process:

"...it is important to emphasize the fact that the level of environmental management that was achieved in California was such that native peoples did not simply exercise a certain degree of 'control' over specific resources or 'modify the ecology' of particular biological communities. Instead, the domesticatory process here seems to have reached the point where important features of major ecosystems had developed as a result of human intervention, and many habitats (e.g. coastal prairies, black oak savannas, and dry montane meadows) were deliberately maintained by, and essentially dependent upon, ongoing human activities of various kinds. In fact, the various essays in this volume strongly suggest that the vertical structure, spatial extent, and species composition of the various plant communities that early European visitors to California found so remarkably fecund were largely maintained and regenerated over time as a result of constant purposive human intervention."

The most powerful, effective and widespread technique used was fire. However, many other techniques such as complex harvesting strategies were employed.

Contact with European Culture (1700-1900)

The history of native American treatment upon contact with European culture mirrored that
Figure I-14. Linguistic stocks of Native Americans of the Klamath Ecoregion.
Figure I-15. Tribes of Native Americans within the California portion of the Klamath Ecoregion.
interaction in the rest of North America. Although the specifics differ, the various tribes were subjected to unkept promises, random and planned violence, and general mistreatment at the hands of government and citizen alike.

In 1851 a United States Indian Agent, Redick McKee embarked from Sonoma on a five hundred mile journey that encompassed most of the ecoregion—-at least the portion in California. McKee gathered native Americans together and negotiated a series of treaties that would have forever guaranteed them with a few prime sites in the region such as the lower Eel River, Hoopa Valley, Scott Valley, and the Klamath-Trinity region. As token an effort as it was--these treaties were never ratified by Congress.

The persecution of the native Americans continued for many years—with Indians being rounded up onto reservations, shipped to remote locations (e.g. the Modocs were sent to Oklahoma), and generally stripped of resources, power, and pride.

Early European / American Settlement (1700-1900)

The Klamath Ecoregion is somewhat unique in that the European invasions of the last 500 years came from quite different directions: the Russians moving across the Bering Strait and down the coast, the Spanish working their way up California from Mexico, and the Americans moving across the continent from the east.

The Russians were the first non-Indians to arrive in the region. They were primarily fur trappers and traders who had worked their way down the coast from Alaska. They were not, for the most part, interested in setting up permanent Russian settlements or colonies, i.e. bringing wives and families from Russia. Rather they set up trading posts, primarily along the coast. One of the first, Fort Ross, was established in 1812. Of all the immigrants of this period, however, the Russians probably left the least mark on the land. The Russians gradually withdrew from the Northwest, and with the purchase of Alaska from Russia by the United States in 1867 the Russians essentially ceded any interest in establishing settlements in North America. Not having established any permanent settlements in the Klamath Ecoregion, the Russians left only a few artifacts as evidence of their activities during this period.

The Spaniards and later Mexicans were to leave a more permanent mark on the ecoregion. Juan Rodriguez Cabrillo sailed north from Mexico in 1542 as far north as Point Mendocino and is widely credited as being the first European explorer to reach California. It was another 200 years, however, before Spanish and Mexican settlers began to enter California. In 1769 a small band of Spanish and Indians under the leadership of Don Gaspar de Portola journeyed from Baja California and established the first of many missions in San Diego. The following years were to see missions established further north eventually reaching Sonoma County within the ecoregion.

The Spanish influence during this period was largely limited to the southern portion of the
ecoregion. Mission San Francisco Solano, commonly called Mission Sonoma was established in 1823 in the Sonoma Valley near what is now the city of Santa Rosa. This was the northernmost mission in California and for the most part marked the extent of Spanish/Mexican settlement during this period.

The “Americans” were the last to arrive in the region. The first Americans (from the United States) to explore the region were the fur trappers who arrived after 1800. In 1828, Jedediah Smith, an American fur trapper and shortly thereafter the Hudson Bay Company ventured into the region to trade with the Indians. However, few American settlements were established in the region until the massive migration that began around 1830. These settlers settled primarily in the more open valleys along the Russian River in what is now Sonoma and Mendocino Counties, as well as the upper reaches of the Klamath Basin along the Scott, Shasta, Williamson and Lost Rivers, where land was more suitable for agriculture. Other settlements developed along the coast where towns developed around the timber industry which could supply lumber via ship to the rapidly expanding settlements to the south, particularly San Francisco. The gold rush of 1850 brought a tremendous influx of gold seekers to California, initially to the Sierra Nevada, the site of the first major gold discovery. However, gold was discovered in the Klamath Basin in 1852 and this brought a wave of miners to this region. Overall, the period from 1850-1900 saw a tremendous influx of American settlers to the region, although it was for the most part it was concentrated on the coast and in the valleys suitable for agriculture.

It was during this period that the major industries that were to dominate the ecoregion to this day were first established—ranching, mining, timber, fishing, and agriculture. These industries were, for the most part, widely scattered and of low intensity—resulting in limited impact upon the natural resources of the region. The exception, during this period was mining—in particular hydraulic mining which was in common use by the 1870s.

Twentieth Century Development (1900-1950)

The period from 1900 to 1950 in the Klamath Ecoregion was a period in which the basic patterns of immigration, settlement, human infrastructure and industry were continued and expanded. At the turn of the century, most cities and towns of the ecoregion were semi-isolated from each other. This changed dramatically with the widespread increase in motorized travel beginning around 1910. Around 1915**** the “Redwood Highway” was completed linking the coastal cities of Crescent City, Arcata and Eureka with those to the south such as Ukiah and Santa Rosa. Highway connections between the coast and the upper Klamath Basin remained primitive into the 1950s.

With more people the demands and stresses upon natural resources increased. Timber harvest increased—particularly within the coastal redwood region. Concerned with the imminent demise of the redwoods the “Save the Redwood League” was incorporated in 1920. However, elsewhere the combination of inaccessibility and low demand discouraged widespread exploitation
of forests further inland.

During this period large scale water diversion from most of the rivers of the ecoregion was initiated. During the earlier period, prior to 1910 small water impounding dams had been built, but these were mostly small, located on tributaries, and often impermanent—being washed out with larger floods. (A wooden dam was built on the upper Klamath River at Klamathon in about 1889 for a large lumber mill there, but it was destroyed by fire in 1902.) By the early 1900s both the technology and infrastructure was available for bigger dams. So too, was the demand—at first for water then later for water and power. On the Klamath River, Copco dam (Copco #1) was completed in 1917.

It was during this period, however, that the so-called “reclamation” of the wetlands of the upper Klamath Basin was initiated. Beginning in 1905 the Bureau of Reclamation began the “Klamath Project” which ultimately resulted in draining 65 to 80% of the natural wetlands of the area and converting them into agricultural land. At the same time water was diverted to these and other drylands for agricultural purposes.

Recent Development (1950-1996)

The changes of the latter half of the twentieth century represent a continuation of many earlier trends—but more importantly an acceleration of many of the trends. Logging, once largely confined to the redwood forests was expanded to the higher elevation douglas fir and ponderosa pine forests. This post World War II boom in forestry was driven by demand for lumber for new housing. At the same time, it was facilitated by newer technology—namely improved gasoline powered chain-saws and crawler tractors for skidding logs.

Similar patterns occurred in other industries. Improved technology for fishing allowed more efficient and larger ocean harvest of salmon. And larger dams were now being built (Iron Gate completed in 1962; Trinity and Lewiston Dams in 1964). Most significantly, Trinity and Lewiston Dams provided for massive water diversion from the Klamath River Basin into the Sacramento River where the water is used for agriculture. Other dams on the Eel and Russian rivers as well as many smaller streams provided for diversions within the ecoregion.

Human population increased steadily throughout most of the ecoregion—however, the most dramatic increase came in the southern end of the ecoregion in Sonoma County. The population of Sonoma county almost doubled from 1970 to 1990 going from 205,000 to 388,000. Thus, in 1990 based upon County population census data\(^1\), more than one-half of the population of the ecoregion is found in the southern 10% of the region.
CURRENT SOCIO-ECONOMIC CONDITIONS

First Nations

The native American population has been drastically reduced in numbers and distribution. However, 34 tribes still reside within the ecoregion (Table I-8) of which 28 are Federally recognized. They are scattered on rancherias and reservations throughout the ecoregion as shown in Figure I-16.

Having had their land base drastically shrunk, these native Americans are struggling to adjust socially and economically, to the new conditions in the ecoregion. Those tribes that have had the resources to pursue legal strategies for recovering some of their rights have had some success. And some of these legal decisions may have region-wide implications. In particular, the Hoopa and Yurok tribes have successfully sued to have water returned to the Trinity River adequate to support the traditional salmon fishery there. Implementation of this decision will result in less water diversion out of the ecoregion and a general improvement in the flow and water quality in the Trinity and lower mainstem Klamath. Similarly, the Klamath Tribes have sued to provide protection for the Short-nose and Lost River suckers, two endemic fish that provided traditional sustenance for the tribes and are now federally endangered, largely as a result of water diversion and associated agricultural activities.
### Table I-8. Indian Tribes Within or From the Klamath Ecoregion.

<table>
<thead>
<tr>
<th>Federally Recognized Tribes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Big Lagoon Rancheria of Smith River Indians of California</td>
</tr>
<tr>
<td>Big Valley Rancheria of Pomo and Pit River Indians of California</td>
</tr>
<tr>
<td>Cahto Indian Tribe of the Laytonville Rancheria, California</td>
</tr>
<tr>
<td>Cloverdale Rancheria of Pomo Indians of California</td>
</tr>
<tr>
<td>Coast Indian Community of Yurok Indians of the Resighini Rancheria, California</td>
</tr>
<tr>
<td>Covelo Indian Community of the Round Valley Reservation, California</td>
</tr>
<tr>
<td>Coyote Valley Band of Pomo Indians of California</td>
</tr>
<tr>
<td>Dry Creek Rancheria of Pomo Indians of California</td>
</tr>
<tr>
<td>Elem Indian Colony of Pomo Indians of the Sulphur Bank Rancheria, California</td>
</tr>
<tr>
<td>Elk Valley Rancheria of Smith River Tolowa Indians of California</td>
</tr>
<tr>
<td>Hoopa Valley Tribe of the Hoopa Valley Reservation, California</td>
</tr>
<tr>
<td>Hopland Band of Pomo Indians of the Hopland Rancheria, California</td>
</tr>
<tr>
<td>Karuk Tribe of California</td>
</tr>
<tr>
<td>Kashia Band of Pomo Indians of the Stewarts Point Rancheria, California</td>
</tr>
<tr>
<td>Klamath Indian Tribe of Oregon</td>
</tr>
<tr>
<td>Manchester Band of Pomo Indians of the Manchester-Point Arena Rancheria, California</td>
</tr>
<tr>
<td>Modoc Tribe of Oklahoma</td>
</tr>
<tr>
<td>Pinoleville Rancheria of Pomo Indians of California</td>
</tr>
</tbody>
</table>
| Federally Non-recognized Indian Tribes
d | | |
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Federated Coast Miwok Tribe</td>
<td>Melochundum Band of Tolowa Indians</td>
<td>Shasta Tribe</td>
</tr>
<tr>
<td>Smith River Rancheria</td>
<td>Upper Lake Band of Pomo Indians</td>
<td>Klamath Reservation</td>
</tr>
</tbody>
</table>

11 These are tribes which the government considers extinct or terminated.

12 Source: Professor Troy Johnson, California State University, Long Beach, CA (trj@csulb.edu); obtained over Internet

13 The Klamath Reservation was terminated but the Klamath Tribe is still recognized.
Figure I-16. Location of rancherias and reservations of Indian tribes from the Klamath Ecoregion.
Demographics

Population densities for the ecoregion are shown in Figure I-17. Most of the population is concentrated in the southern end of the ecoregion, with more than one-half of the total population of the region found in Sonoma County (Table I-9). Sonoma County is also the fastest growing area within the ecoregion, having doubled in population from 1980 to 1990.
Table I-9. Total Population of Principal Counties within the Klamath Ecoregion

<table>
<thead>
<tr>
<th>County</th>
<th>1980 Census</th>
<th>1990 Census</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sonoma County, CA</td>
<td></td>
<td>388,222</td>
</tr>
<tr>
<td>Mendocino County, CA</td>
<td></td>
<td>80,345</td>
</tr>
<tr>
<td>Trinity County, CA</td>
<td></td>
<td>13,063</td>
</tr>
<tr>
<td>Humboldt County, CA</td>
<td></td>
<td>119,118</td>
</tr>
<tr>
<td>Del Norte County, CA</td>
<td></td>
<td>23,460</td>
</tr>
<tr>
<td>Siskiyou County, CA</td>
<td></td>
<td>43,531</td>
</tr>
<tr>
<td>Klamath County, OR</td>
<td></td>
<td>57,702</td>
</tr>
</tbody>
</table>
Socio-Economic Status of Residents

Statistical measures are weak indicators of “socio-economic status” or the more nebulous “quality-of-life”. However, bottom line measures such as unemployment rates and numbers of people below the poverty line provide some indication of what is happening in a community. Measures of unemployment, education level, median income, and level of education for the principal counties in the ecoregion are shown in Tables I-9 through I-12.
Table I-9.
Table I-10.
Table I-11.
Table I-12.
ECOSYSTEM PROCESSES

One of the keystone elements of modern thinking in ecology and conservation is to give equal attention to ecological processes rather just to composition and structure of ecosystems. In this section, we describe briefly five of the critical or keystone ecological processes occurring at the ecosystem level. Ecosystems complex with millions of ecological processes being played out in diverse and subtle ways at different spatial and temporal scales. Thus, any description of ecological processes must be selective and. We emphasize here processes that: (1) are understood to at least some degree by humans and science, (2) are known to be affected by human activities, or (3) are somewhat unique to the Klamath Ecoregion. The latter would include processes such as “fog precipitation” which is not found in most inland ecoregions.

Energy Flow

The flow of energy through a system is so fundamental to maintaining its function that it is often ignored when considering effects on an ecosystem. Virtually all of the useful energy in most terrestrial ecosystems comes from the sun. This is true in the Klamath Ecoregion as there are no major net imports of energy other than from the sun. However, within the ecoregion and its components distribution of energy is quite uneven, and thus the flows between these components are quite important. Solar energy is captured by plants through the process of photosynthesis and excess energy is stored, primarily in organic (carbon based) compounds such as carbohydrate and cellulose. This pool then becomes the source of energy for all other living organisms in the ecosystem. For example, dead and down woody material and litter is the primary energy source for soil microorganisms that keep soil processes active. Similarly, most of the energy for organisms that live in aquatic habitats comes from the uplands in the form of leaves, litter, and trees that fall into streams and lakes.

Biogeochemical / Nutrient Cycles

Cycling of chemicals or nutrients such as nitrogen, phosphorus, and sulfur are equally important in ecosystems, since these chemicals are not evenly distributed in the ecosystem. Two of the most important nutrients for ecological systems are nitrogen and phosphorus--and they serve well to illustrate differences in sources and sinks for such elements.

The major source of nitrogen in the global ecosystem is in the atmosphere. And the only way in which nitrogen is moved from the atmosphere to earth is through the action of nitrogen fixing bacteria and similar microorganisms--many of which live in symbiotic relationships on the roots of plants. Legumes are best known for their nitrogen fixing association but other plants such as alders (Alnus spp.), ceanothus (Ceanothus), and bitterbrush (Purshia), also harbor nitrogen fixers. As all life forms require nitrogen, ecosystem function is ultimately dependent upon the...
action of these nitrogen fixers. as nitrogen is constantly being released back into the atmosphere. Thus without constant nitrogen fixing, ecosystems would be subject to a net loss of nitrogen and life within them would eventually die out.

Within the ecosystem, nitrogen is quite unevenly distributed. Nitrogen is often the nutrient most limiting for plant growth and most of the available nitrogen is stored in the top few inches of the soil. Similarly slight changes in nitrogen content of plant material may determine whether they are adequate nutritionally for herbivores such as elk or antelope.

In contrast to nitrogen, the ultimate source of most phosphorus is in the rocks and soil. In spite of this, phosphorus can often be limiting in soils and plants. On the other hand, accelerated erosion can often put large amounts of soluble phosphorus into streams and lakes that have not evolved with such inputs causing algal blooms, reduction in available oxygen, and other effects that are generally detrimental to native species, as is happening in Upper Klamath Lake. As with other nutrients wetlands play a key role in buffering the aquatic ecosystem from such pulses of phosphorus.

A system like the Klamath Ecoregion is not, of course, a closed one and there are some net imports and exports of nutrients. Of particular importance is the net nutrient import as a result of spawning runs of anadromous fishes. It is well known that many species such as bears and eagles take advantage of these nutrient flows. At a more general level, however, these runs once represented a net import of roughly 1 pound per acre of "fish fertilizer" per acre for the entire ecosystem. This amount may not be significant in a given year--but over centuries may be of some significance. Furthermore, the distribution of such fertilizer is far from uniform--with some areas receiving more than their share of "fertilizer".

Soil Formation / Soil Erosion Dynamics

Conservation of topsoil is or should be the most basic and fundamental goal of any holistic or ecosystem level conservation effort. Topsoil has been likened to the balance wheel of the ecosystem. It has also been called the placenta of life on earth. It is critical in the hydrological cycle as will be discussed. For these reasons, topsoil has been likened to capital where trees and crops and forage and wildlife habitats are the profit. And of course the cardinal rule of capitalism is not to spend the capital and maybe even put some profit back into the capital account. Yet soil conservation is often neglected or poorly integrated into management or conservation plans and programs.

To understand and plan for soil conservation, one must recognize that topsoil present represents some sort of rough equilibrium between soil loss and soil development. A goal of zero soil loss is unrealistic; some movement or "loss" of soil through erosion, mass slumping, and so on is a
normal ecological process upon which many species are dependent. For example, many riparian wetlands and are continuously formed and/or replenished by suspended sediments moved downstream during periods of heavy flooding. Similarly, many estuarine plants and animals are adapted to capturing and stabilizing silt from upstream.

However, a goal of no "net loss" of soil or topsoil is fundamental to any program of ecosystem conservation or management. This implies that the rate of soil loss must not exceed the rate of soil development. For soils to develop, the rate of soil formation must exceed the rate of loss. Rates of soil erosion are known in a general way by soil scientists and are expressed as an erodability factor in soil surveys. The implicit assumption is that under normal conditions rates of soil development exceed that rate. Any evidence that rates of soil loss are exceeding this rate are positive evidence of net soil loss and thus of ecosystem degradation.

Background (historical) rates of soil erosion have been determined for certain portions of the ecoregion and are shown in Table I-13.

Some portions of the ecoregion are inherently more susceptible to erosion and this affects or should affect management options. A map of soil erodability is shown in Figure I-16. In general terms, the soils of the Coast Ranges, being derived from Franciscan sedimentary deposits, are most erodable, and those of the Modoc Plateau are least erodable.
Table I-13. Erosion rates for selected sites in Klamath Ecoregion in geologic past (from Wahrhaftig and Curry 1967).

<table>
<thead>
<tr>
<th>Area</th>
<th>Geologic Formation</th>
<th>Geologic Age</th>
<th>Age of beginning of erosion (years)</th>
<th>Erosion rate (inches per 100 years)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Crescent City</td>
<td>Wymer</td>
<td>Miocene</td>
<td>10,000,000</td>
<td>0.1</td>
</tr>
<tr>
<td>Fort Bragg</td>
<td>Highest marine terrace</td>
<td>Early Pleistocene</td>
<td>1,000,000</td>
<td>0.6</td>
</tr>
<tr>
<td>Eel and Mattoloe drainages</td>
<td>Shoreline beds at Covelo, etc.</td>
<td>Miocene</td>
<td>10,000,000</td>
<td>0.53</td>
</tr>
<tr>
<td>Annapolis plantation area (Sonoma County)</td>
<td>Ohlson Ranch</td>
<td>Late Pliocene</td>
<td>3,000,000</td>
<td>0.1</td>
</tr>
</tbody>
</table>

Hydrologic Cycle

The hydrology of the Klamath Ecoregion has been outlined earlier. The general pattern of the hydrologic cycle varies little within the region. Moisture from the ocean is moved inland where it is deposited in the form of fog, rain, or snow depending upon the portion of the ecoregion. From there it is used by plants or evaporated (evapotranspiration) or it moves back toward the ocean. Portions of it may infiltrate the ground and move as groundwater or can run across the surface of the land. Eventually it makes it way into small streams and eventually back to the sea. Although the general pattern applies across the region--the specifics may be quite different. For example, most of the summer moisture in coastal regions comes in the form of fog--whereas in the Klamath Mountains it comes in the form of summer thunderstorms.

During this cycle, there are several critical points where the hydrologic cycle may be quite sensitive to changes in the environment. For example, the point where rain comes in contact with the land surface is quite sensitive to changes in that surface. If the surface is covered with diverse vegetation and deep porous soils then most of the precipitation will eventually infiltrate into the ground and become groundwater. On the other hand, if vegetation is sparse and the soils are compacted then most of the precipitation will run-off overground taking soil with it.
A list of critical points in the hydrologic cycle for particular portions of the ecoregion are shown in Table I-14.
<table>
<thead>
<tr>
<th>Phenomena</th>
<th>Critical Points</th>
<th>Portion of Ecoregion</th>
<th>Vulnerability</th>
<th>Description</th>
<th>Human Activities with Potential Effects</th>
</tr>
</thead>
<tbody>
<tr>
<td>Timing of runoff from snow</td>
<td>Forest / vegetation cover in snowfall regions</td>
<td>Higher mountainous regions of upper Klamath Basin and Klamath Geologic Province</td>
<td>Removal of forest / vegetation cover</td>
<td>Vegetation, especially tree cover, slows down the spring and summer snowmelt and thus dampens spring runoff and late spring and summer flows.</td>
<td>Logging (vegetation {tree} removal)</td>
</tr>
<tr>
<td>Amount of infiltration as opposed to runoff</td>
<td>Earth surface and its cover</td>
<td>Loss of vegetation cover; amount of dead material on ground (litter and dead and down woody material); compaction of soil</td>
<td>Vegetation and dead material on ground intercepts precipitation dampening the energy of rainfall and allowing increased infiltration; soil compaction decreases the amount of infiltration.</td>
<td>Logging (removal of vegetation cover; soil compaction; denudation of areas for landings. etc.); - road building (denudation; compaction) ; - overgrazing (removal of vegetation cover; compaction from livestock; decrease in litter cover) - urbanization (removal of vegetation cover)</td>
<td></td>
</tr>
</tbody>
</table>

<p>| Coast Ranges and Klamath Mountain Geologic Provinces (less important in regions of Modoc Plateau with porous soils) | | | | |
| Timing of runoff (winter / spring versus summer) | Earth surface | Coast Ranges and Klamath Mountains Geologic Provinces (less important in regions of Modoc Plateau with porous soils) | Loss of vegetation cover; amount of dead material on ground (litter and dead and down woody material); compaction of soil | Result of increased infiltration above; infiltration slows down movement of water compared to runoff thus extending the water flow later into the season | Logging (removal of vegetation cover; soil compaction; denudation of areas for landings, etc.); - road building (denudation; compaction); - overgrazing (removal of vegetation cover; compaction from livestock; decrease in litter cover); - urbanization (removal of vegetation cover) |</p>
<table>
<thead>
<tr>
<th>Timing of river flow</th>
<th>Riparian zone</th>
<th>All</th>
<th>Loss of riparian vegetation cover and riparian zone soils</th>
<th>Riparian zones intercept and dampen water flows and allow riparian zone soils to absorb water and release it slowly.</th>
<th>Logging (removal of riparian cover); overgrazing (loss of riparian cover; disturbance of riparian zone soils); channelization (removal of riparian vegetation)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fog Interception</td>
<td>Land surface</td>
<td>Coastal fog zone (redwood zone)</td>
<td>Loss of tree cover</td>
<td>Without tree cover fog is not captured and effective precipitation is reduced</td>
<td>Logging (loss of tree cover)</td>
</tr>
<tr>
<td>Fog Generation</td>
<td>Land surface</td>
<td>Coastal fog zone (redwood zone)</td>
<td>Loss of tree cover</td>
<td>Loss of tree cover causes warming of land surface and reduces amount of fog generated?</td>
<td>Logging (loss of tree cover)</td>
</tr>
</tbody>
</table>

14 This relationship is more speculative than the others but is supported by some empirical data and is based upon accepted meteorological principles.
Major natural (non-human) disturbance regimes within the Klamath Ecoregion include fire, wind, and flooding. Evidence from upland areas of the Klamath Mountains suggest that fire is the most common disturbance in forest stands with wind being next most important. Fire accounted for over 80 percent of the disturbances with wind accounting for roughly another 10 percent.

The importance of fires as agents of disturbance has been recognized for many years. However, historic fire patterns have only been characterized for a few vegetation types within the ecoregion. Historic fire patterns can be characterized by "mean fire interval" (equivalent to "mean fire return interval") and by "fire frequency". The former is the arithmetic average of all fire intervals in a designated area during a designated time period. "Fire frequency" is the number of fires per unit time in some designated area. Both of these measures are scale dependent in that the number will vary depending upon the size of the "designated area". Thus, comparisons of such measures of fire history from different studies can be misleading. Nevertheless, they do provide some utility in comparing historic fire patterns among different sites and vegetation types and in assessing how humans have changed historic fire patterns. Table I-XX summarizes historic fire return intervals for some vegetation types within the Klamath Ecoregion. They range from around 8 years for many ponderosa pine types to as much as 57 years for red-fir / white pine types.

Along rivers, flooding can also be an important disturbance regime--and calculations provided by Rantz (1964) allow calculation of frequency of flood events of a given magnitude for any given river in the ecoregion. The greatest known floods in the ecoregion are those of the winter of 1861-62. The peak discharge for the Klamath River in December 1961 was computed as 450,000 cfs compared to a mean annual flood of 152,000 cfs. The floods of 1955 were of comparable magnitude, however, with a peak discharge of 425,000 cfs recorded for the Klamath River on December 22, 1955.

Succession refers to the change in plant communities following natural or human disturbance. The pathways of succession i.e. the plant communities and their composition and their order are more or less predictable and have been described for many vegetation types. For example, brush fields that have been burned will first be invaded by annual grasses and forbs, then by perennial grasses and forbs, then eventually by brush species that will come to dominate the site. Details of what actual species will vary depending upon the characteristics of the site such as soils, slope, elevation and so on. It will also vary depending upon the type and severity of the disturbance. For example, some shrubs will sprout quickly from live roots after light fires. In such circumstances they will return to dominate the site much faster than when the fire is so hot that the roots are killed.

Succession is thus thought to be more or less predictable. However, current thinking in both forestry and range management is suggesting that if disturbances are beyond a certain threshold, the plant communities will not necessarily return to their original state. This newer
understanding of succession has important implications with regard to how biotic communities respond to human activities for, if true, it suggests that some human activities may cause irreversible effects on plant communities or effects that are irreversible only over long (geologic) time periods or by investment of large amounts of human energy and resources into restoration.
HUMAN MODIFICATION OF THE ECOSYSTEM

In this section we describe how humans have modified the ecosystem. In the first section we describe the major activities that have impacted the system such as timber harvest and water diversion. In the second section, we describe effects these activities have had on the ecosystem or ecosystem level functions. Finally, in the third section we describe how these activities have affected wild species or species groups.

Activities

We describe here major human activities affecting the ecosystem along with some of the obvious effects on ecological function. Most human activities involve a complex suite of actions. Thus, for example, under “timber harvesting” we include not only the cutting and removal of trees but also road building, fire suppression, herbicide application, and monoculture—all activities that are typically carried out as part of a timber harvest industry.

**Timber Harvesting.** Decades of timber harvesting have impacted the carrying capacity of the natural resources of the ecoregion. Suppression of natural wildfires has resulted in growth of fuel loads resulting in catastrophic fires and interference with normal stages. Harvest practices have exposed highly erodible soils leading to siltation of streams and rivers affecting spawning. Harvest practices have reduced old growth needed by key species and caused fragmentation affecting neotropic species. Road building has caused siltation of streams and rivers. Silvicultural practices including herbicide application and single species reforestation have changed species composition and reduced diversity.

**Mining.** Mining activities in the ecoregion started in the mid 1800s with large areas affected by gold. Many of these areas have not been reclaimed, adding to sedimentation of the streams and rivers. Old unreclaimed mining sites can contribute to contaminants. Current suction mining can cause stream sedimentation and stream habitat, and impact fish directly.

**Water Diversion / Hydropower.** Water diversions reduce habitat for aquatic species by reducing discharge in rivers and streams. Changes in natural discharge patterns reduce or eliminate channel maintenance flows and can impact water quality, particularly during low flow periods. Dams can hinder or prevent fish passage to important habitats. This has been a particular problem for anadromous salmonids in the ecoregion where access to hundreds of miles of stream habitat has been prevented in the Klamath, Trinity and Eel River basins. Large storage reservoirs have inundated important upland habitats.

**Livestock Grazing.** Livestock grazing reduces upland and riparian vegetation for waterfowl, upland game and song bird nesting cover, changes the structure and diversity of vegetative communities, physically alters stream systems detrimental to fish populations, increases competition with native wildlife and contributes to loss of wetlands.
Agricultural Irrigation. Irrigation projects throughout the ecoregion have resulted in the construction of hundreds of miles of canals, drains, ditches, and dikes. Water removed from reservoirs is used for farming activities which result in reduced quality and quantity of return flows. Contaminants leached from soils and pesticides and fertilizers applied to crops and soil are carried into river systems and marshes. Siltation reduces productivity of adjacent marshes and topsoil loss is significant on fallowed farmland. Conversion of wetland to farmland has resulted in a loss of over 75% of historic wetland areas in the upper Klamath Basin alone.

Contaminants. Contaminants associated with domestic uses, livestock waste and agricultural drainage waters, chemical spills and industrial effluents, can cause chronic to catastrophic impacts to fish and wildlife and their habitats.

Overharvest / Overexploitation. Some species of plants and animals have been harvested or exploited at unsustainable levels. For example, anadromous fish populations have dwindled over the past several decades due to several reasons. Excessive depletion of remaining fish stocks by the combination of commercial, sport, and Native American harvest has exacerbated the situation. Some species such as the grizzly bear and gray wolf have been deliberately extirpated from the ecoregion. In other cases, local populations of species such as elk and bighorn sheep have been extirpated through combinations of habitat degradation and overharvest of remaining animals. And many species of plants such as Pacific Yew have been reduced to low numbers when sudden demands have encouraged unsustainable harvesting before protective measures could be enacted.

Urbanization. The increase in human populations has led to the conversion of wildlife habitat to agriculture and home sites. There is an increased demand for water removal for human use. Waste water and storm water can lead to increased water quality problems. There is an increased demand for all natural resources, creating competition. Urbanization is most pronounced in the southern portion of the ecoregion in Sonoma County—but it is a factor around all the major cities and towns in the ecoregion.

Road Building. Building of roads has had many unexpected and frequently unintended effects. Roads fragment habitat, allow easy human entry into formerly semi-protected areas, prevent use of habitat by certain species, facilitate invasion of exotic plants and animals, and more.

Introduction of Exotic Species. Many exotic species have arrived in the ecoregion as unintended side-effects of other human activities such as agriculture and road building. However, many species such as Eucalyptus and brook trout were deliberately introduced into the environment—often with dramatic and unintended consequences to the ecosystem and to other species.

Alteration of Disturbance Regimes. Humans have drastically altered pre-European settlement disturbance regimes, particularly fire and flooding regimes. Many areas were regularly burned by Native Americans. Following European settlement much energy has gone into preventing both human caused and natural fires from burning. This has generally resulted in a decrease in low intensity fires. Similarly, through dams and diversions, humans have dampened the effects of
flooding along most of the rivers of the ecosystem. By contrast, through timber harvest and livestock grazing, humans have converted a much larger portion of the ecoregion into early successional stages.
Ecological Effects of Human Activities

We describe here some of the ecological effects of the human activities described above, with emphasis upon ecosystem and community level effects.

**Soil Loss.** Human activities, particularly logging and associated forest practices in the Coast Ranges and Klamath Mountains have resulted in accelerated soil loss from the ecoregion. This has been documented for several sites, particularly the Mad and Eel Rivers. Some erosion rates for basins within the Klamath Ecoregion are shown in Table I-15. These erosion rates range from XX to XX, and are clearly much higher than those geologic erosion rates described earlier.

Over 30 years two geologists from the University of California compared geologic and current erosion rates for this region and reported to the State Legislature as follows:

> "The sediment discharge data...indicate that the land surface in the entire drainage basin of the Eel River is presently lowering at a rate of 3.33 inches per century (computed as solid rock, specific gravity 2.5) or 5.85 inches per century (computed as soil, specific gravity 1.4). Similar figures for the Mad River are 1.25 and 2.30 inches per century. These figures are approximately 10 to 20 times the rates of erosion reported for comparable climates in other parts of the world. The figures for the Eel and the Mad are for suspended sediment only, and do not include data for the flood years 1955 and 1964, whereas the worldwide figures include bedload, dissolved solids, and flood data. Thus the differences reported here are less than the actual differences.

Geologic analysis of selected areas in the North Coast Ranges shows that the rate of erosion in this area, measured over time spans of 1,000,000 to 10,000 years, is 0.1 inch to 0.6 inch per century. The more reliable geologic data give the lower figures. These geologic figures are comparable to worldwide rates of erosion and are 1/30 to 1/5 the present rate of erosion measured from sediment discharge data.

Studies on the marine terraces of the North Coast Ranges show that the weathered rock in these terraces has formed at rates of approximately 0.05 inch to 0.1 inch per century. Thus, the rate of soil regeneration is 1/10 to 1/100th the rate of destruction of soil in the North Coast Ranges.

The measured rates of erosion in the Eel and Mad River drainages are clearly not normal, and are presumably caused by the activities of man. We do not know where all this sediment is coming from. Part of it is undoubtedly coming from landslides, but landslides cannot account for all of it. Part may be from hillside creep, but geologic, physiographic, and vegetational evidence is lacking for creep on a scale to account for this as a long-term process over the entire drainage basin. A significant part must be from accelerated erosion following logging and road-building. Since only a part of the basins of these two streams is currently being
<table>
<thead>
<tr>
<th>Stream</th>
<th>Location</th>
<th>Area of watershed (square miles)</th>
<th>Year</th>
<th>Sediment Discharge (million tons per year)</th>
<th>Sediment Yield (tons per square mile)</th>
<th>Erosion Rate $^{15}$</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mad River</td>
<td>Kneeland</td>
<td>352</td>
<td>1971</td>
<td>1,831</td>
<td>5,201</td>
<td>Brown (1975)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Kneeland</td>
<td>352</td>
<td>1972</td>
<td>1,741</td>
<td>4,946</td>
<td>Brown (1975)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Arcata</td>
<td>485</td>
<td>195 7-64</td>
<td>2,100</td>
<td>4,329</td>
<td>Brown (1975)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Arcata</td>
<td>485</td>
<td>196 5-71</td>
<td>2,860</td>
<td>5,897</td>
<td>Brown (1975)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Arcata</td>
<td>485</td>
<td>1971</td>
<td>2,178</td>
<td>4,491</td>
<td>Brown (1975)</td>
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<td>Arcata</td>
<td>485</td>
<td>1972</td>
<td>3,140</td>
<td>6,474</td>
<td>Brown (1975)</td>
<td></td>
</tr>
</tbody>
</table>

$^{15}$ Based upon soil bulk density of 1.4.
affected by these activities. The rate of erosion for the parts affected may be many times the average rates reported here.

The implications of these data are that, unless this phenomenal rate of erosion is arrested, the bulk of the topsoil (upper 4 feet of weathered rock) in which the Douglas Fir and Redwood are rooted on hillsides will be destroyed over large parts of the Eel and Mad River drainages within a few hundred years. These areas may then become barren rocky hillsides. Regeneration of the forest under these conditions will be difficult if not impossible in the present climate, and both the forest industry and the water storage capability of the region will be seriously impaired.

We have found no evidence from the last 30 years to contradict their conclusions. In fact, the accumulating evidence suggests that most all of the coastal basins within the North Coast Geologic Province south of the Smith River are eroding at rates that far surpass rate of soil formation.

Hydrologic Disruption. Soil erosion has been accompanied by significant disruption of the hydrologic cycle. This has come about in several ways. The effects of human activities on hydrologic function are complex and do not lend themselves to simple generalizations or "cookbook" analysis procedures. Thus it is difficult to generalize about what is happening over a broad ecoregion. The following description thus represents an overview of how humans have affected hydrologic function across the ecoregion; some particular effects will apply to a given hydrobasin while others may not.

Hydrologic function is disrupted when critical phenomena is affected by human activities as outlined in Table I-14. Major functions affected include decrease in fog precipitation, timing of snow runoff, amount of infiltration (as opposed to runoff), general alteration of hydrograph (timing of river flows), and change in magnitude and frequency of flood flows.

The widespread cutting of forests appears to have decreased the amount of fog precipitation along the coast through both decreasing the fog frequency and decreasing the capacity of the vegetation to capture "fog drip". While this has not been conclusively demonstrated on a watershed or basin scale, the preponderance of evidence from stand level studies of fog precipitation suggests that removal of tree cover will reduce effective fog precipitation. There is no reason to think that the effect would not be working at larger geographic scales. This effect would only affect the north coast redwood / fogbelt portion of the ecoregion.

Cutting of forests can also significantly affect the timing of runoff from snow. Snow that has accumulated in clearcut areas tends to melt earlier, thus causing increased severity of spring floods. Equally significantly, overcutting of forests and overgrazing of rangelands have decreased the ability of the vegetation to intercept precipitation, thus resulting in decreased infiltration into the soil (and water table) and increased overland flow. In general, removal of
vegetation can alter the hydrograph of a stream that is the timing and magnitude of flows. It is hard to generalize about this phenomena, however, because the same activity may have effects that work in opposite directions. For example, removal of overstory canopy may decrease water infiltration into soil but at the same time it decreases water loss to the atmosphere from transpiration or evapo-transpiration.

Perhaps the most significant of all the pure hydrologic effects of humans is the alteration of the flooding regimes of rivers. This can occur indirectly from overcutting forests, overgrazing rangelands, or urbanizing wildlands. Or it can occur directly by building and operation of dams and diversions. Floods are important events in maintaining river systems. Changing the pattern of flooding and other dynamics of the river system is detrimental to the river ecosystem. Thus “flood control” may be beneficial to some elements of human society but it can be deadly to fish, amphibians, and many other species dependent upon aquatic and riparian habitats.

There is little doubt that the major dams in the ecoregion have played a major role in altering the stream and streamside habitat of these rivers.

Water Pollution. Water pollution is typically a result of a number of effects operating simultaneously—influx of sediments and/or contaminants, decreased seasonal water flow, increased temperature of water as a result of loss of streamside vegetation or release of warmed water. Under provisions of the Clean Water Act waters which are so polluted as to prevent beneficial uses of the waters need to be declared “impaired” by the state water quality control board. It is indicative of the degree of pollution of the streams of the north coast that virtually all the major rivers south of the Smith have been declared impaired (Table I-16). In most cases the pollutant is sediment, although the streams at the southern end of the ecoregion such as Stemple Creek are impaired by nutrients, presumably from non-point source agricultural discharge. Those streams impaired by sediment tend to be those of the Coast Range Geologic province where there has been severe logging on unstable sedimentary-derived Franciscan soils. Some of the larger rivers including the Klamath, Eel and Mattole are also impaired by high temperatures.
Table I-16. List of Impaired Waterbodies Within the California Portion of the Klamath Ecoregion (from California Regional Water Quality Control Board (1996)).

<table>
<thead>
<tr>
<th>Waterbody</th>
<th>River Basin</th>
<th>Pollutant</th>
<th>Notes:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stemple Creek</td>
<td>Stemple Creek</td>
<td>Nutrients</td>
<td></td>
</tr>
<tr>
<td>Estero de San Antonio</td>
<td>Stemple Creek</td>
<td>Nutrients</td>
<td></td>
</tr>
<tr>
<td>Americano Creek</td>
<td>Americano Creek</td>
<td>Nutrients</td>
<td></td>
</tr>
<tr>
<td>Estero Americano</td>
<td>Americano Creek</td>
<td>Nutrients</td>
<td></td>
</tr>
<tr>
<td>Gualala River</td>
<td></td>
<td>Sediment</td>
<td></td>
</tr>
<tr>
<td>Garcia River</td>
<td></td>
<td>Sediment</td>
<td></td>
</tr>
<tr>
<td>Navarro River</td>
<td></td>
<td>Sediment</td>
<td></td>
</tr>
<tr>
<td>Albion River</td>
<td></td>
<td>Sediment</td>
<td></td>
</tr>
<tr>
<td>Big River</td>
<td></td>
<td>Sediment</td>
<td></td>
</tr>
<tr>
<td>Noyo River</td>
<td></td>
<td>Sediment</td>
<td></td>
</tr>
<tr>
<td>Mattole River</td>
<td></td>
<td>Sediment, Temperature</td>
<td></td>
</tr>
<tr>
<td>Eel River</td>
<td></td>
<td>Sediment, Temperature</td>
<td></td>
</tr>
<tr>
<td>Tomki Creek</td>
<td>Eel River</td>
<td>Sediment</td>
<td></td>
</tr>
<tr>
<td>Van Duzen River</td>
<td></td>
<td>Sediment</td>
<td></td>
</tr>
<tr>
<td>Mad River</td>
<td></td>
<td>Sediment, Turbidity</td>
<td></td>
</tr>
<tr>
<td>Redwood Creek</td>
<td></td>
<td>Sediment</td>
<td></td>
</tr>
<tr>
<td>Klamath River</td>
<td></td>
<td>Temperature, Nutrients</td>
<td></td>
</tr>
<tr>
<td>Scott River</td>
<td>Klamath River</td>
<td>Sediment, Temperature</td>
<td></td>
</tr>
<tr>
<td>Shasta River</td>
<td>Klamath River</td>
<td>Dissolved Oxygen, Temperature</td>
<td></td>
</tr>
<tr>
<td>Beaughton Creek</td>
<td>Klamath River</td>
<td>Discharge of Wastes</td>
<td></td>
</tr>
<tr>
<td>Trinity River</td>
<td>Klamath River</td>
<td>Sediment</td>
<td></td>
</tr>
<tr>
<td>South Fork Trinity River</td>
<td>Klamath River</td>
<td>Sediment</td>
<td></td>
</tr>
</tbody>
</table>

Notes: 16 Impaired waters are water bodies that cannot reasonably be expected to attain or maintain applicable water quality standards.
Habitat Loss. Direct loss of habitat from urbanization, sububanization, and agricultural development is an easily observable effect in the ecoregion. Although, to our knowledge it has not been quantified. It is most pronounced in the southern end of the ecoregion where the population is doubling roughly every 10 years. Most of the good agricultural lands within the ecoregion have already been developed. Thus conversion of wildlands to agricultural land is not a major impact within most of the ecoregion. However, there are two major exceptions. In Sonoma and Mendocino Counties large acreages of wildlands are being cleared and planted to vineyard. And in various portions of the forested lands, wild forests are being converted into tree farms.

Habitat Degradation. Less dramatic but more pervasive is the degradation of habitat as a result of such things as loss of habitat structure. For example, the removal of standing dead trees ("snags") from a forest stand will make it unsuitable for bird species that nest in cavities in such snags. Habitat degradation can come about in an almost endless variety of ways and is a result of many human activities such as timber harvest, livestock grazing, water diversion, off-road vehicle use and so on. In fact, most human activities will contribute to habitat degradation for some wild species to some degree. The challenge to conservation is not to eliminate all degradation but rather to control it or zone it in both space and time so that the overall health of the larger regional ecosystem remains intact.

Habitat Fragmentation. Habitat fragmentation is the process by which habitats are increasingly subdivided into smaller units or patches resulting in loss of continuity or connectedness with other patches. It is usually accompanied by habitat loss, although certain human constructs such as highways and canals can fragment habitat with only minimal overall loss of habitat area. Furthermore, fragmentation typically results in an increase in "edge" habitat—that habitat that is found in the ecotone or area of gradation from one type to another, such as the edge of a forest. Fragmentation typically results in larger contiguous populations of species being divided up into several smaller populations with little or no interchange between them. And this, in turn, can lead to local extirpation of these populations for a variety of reasons including:

1. The vulnerability of small populations to being extirpated by a chance event such as flood or fire;
2. The loss of viability of the population due to inbreeding or other genetic problems;
3. The vulnerability to extirpation as a result of random variation in demographic parameters (birth rates, death rates, sex-ratios);
4. Combinations of these and other factors.

The results of fragmentation and the vulnerability of small populations to local extinction or extirpation are explored and explained in detail elsewhere (see Hunter (1996); Meffe and Carrol (1994); Primack (1993); Primack (1995); Soule (1987)).
Within the Klamath Ecoregion the habitat fragmentation is occurring as a result of the following activities.

Timber Harvest - Extensive timber harvest has resulted in landscapes with only fragmented patches of late-seral or old-growth forests as for example with the redwood forests. In more extreme cases, only fragments of mid-seral forest remain as for example has occurred in the Douglas fir and redwood forests of Sonoma and Mendocino Counties.

(Sub)Urbanization - Building of housing tracts, parking lots, malls and so on has fragmented much of the remnant wildlands, particularly in Sonoma County and around the larger towns and cities in the region.

Highways - Major highways, especially when fenced with cyclone or other fence provide barriers to movement of many species large and small.

Dams - Dams, both big and small, provide barriers to upstream and downstream movement of many fish species. In addition to problems caused by the dams themselves, the reservoirs are often stocked with predatory fish that pose another barrier to successful movement past the dam.

These are but a few of the types of fragmentation that can and is occurring in the ecoregion. Fragmentation can have an effect at many different scales. Large predatory species such as mountain lions are often the first to be affected by fragmentation since they require large blocks of contiguous habitat for survival. However, smaller species may be affected locally by such things as irrigation ditches or two lane paved roads.

Successional Disruption / Altered Disturbance Regimes. Successional disruption occurs when the patterns of disturbance and subsequent succession is altered resulting, among other things in a changed proportion of seral or successional stages in the landscape. The cases of coast redwoods and valley oaks represent two different extremes of this sort of phenomena. With coast redwoods, late seral or old-growth once likely comprised at least 90 to 95 percent of the forest; with the accelerated cutting of the redwood forest, now less than 4 percent of the landscape consists of late seral stages. There are lots of very small redwood trees but very few big, old ones. With valley oaks, human activities such as grazing and other agricultural practices have prevented the regeneration of young oaks with the result that there are quite a number of remnant big, old oaks but very few small or medium size trees coming along to replace them.

In both cases the natural distribution or mix of seral stages of the community has been truncated or replaced by some sort of lopsided distribution. Since many species are associated only with certain seral stages, this is accompanied by extensive loss of species—particularly those that are obligates on a particular seral stage that has been lost or drastically reduced.
Air Pollution. The effects of air pollution on ecosystem function and health are arguably less well understood than many other ecosystem level effects. Pollutants in air are known to effect species and communities in a variety of ways. For example, many amphibian species are especially sensitive to pollutants including acid rain. The same is true for many lichen species. We are not aware of any ecosystem level effects of air pollution that have been documented for the Klamath Ecoregion.

Displacement by Exotics. Exotic species displace native species in a variety of ways. In particular an exotic can cause decline or extirpation of native species by:

1. an exotic species outcompeting a native species for a resource that is limiting, e.g. starling use of cavities in snags previously used by native western bluebirds;

2. an exotic species preying upon native species, e.g. Sacramento River squawfish (introduced into Eel River) preying upon small native fish including young salmon; or

3. an exotic disease organism or parasite causing debilitation or death of native species, e.g. loss of native bighorn sheep from Lava Beds National Monument.

Numerous examples of all three types of displacement have been observed or documented within the Klamath Ecoregion.

Examples of community or ecosystem level effects are less well understood or documented but not unknown. Exotic species can alter disturbance regimes. For example, cheatgrass can change the disturbance (fire frequency) regime for a plant community. In other cases, herbivorous species such as wild pigs may alter the plant species composition of a community.

Overexploitation / Persecution. Direct loss of species and communities from overexploitation or persecution remains a problem in the Klamath Ecoregion in spite of the fact that most natural resource professions such as forestry, range management, and particularly wildlife management have developed theory and practice to alleviate such practices. Examples from the past of species removed from the ecoregion from persecution include the gray wolf and the grizzly bear. Others which may have been reduced in numbers from overexploitation (together with habitat degradation) include the pine marten and the fisher.

Species Loss or Endangerment

The ultimate effect of many human activities, whether they affect ecosystem structure, function or health or affect species directly, is loss or endangerment of species. The status of species loss in the Klamath Ecoregion is summarized below, and described in more detail in Volume II.
Description of the Ecological Issues.

**Plants.** At least 62 individual vascular plant species "at risk" within the Klamath Basin, including one that is federally endangered.

**Invertebrates.** One species of invertebrate (the Trinity Bristle Snail) is listed as endangered under state law. Knowledge of most invertebrates and their status is minimal.

**Fish.** Forty nine stocks of anadromous salmonids (15 of chinook salmon, 20 of coho salmon, 10 of steelhead, and 4 of coastal cutthroat) have been identified as at some degree of risk (Higgins et al. 1992). Furthermore, four non-salmonid native fish species (Pacific lamprey, green sturgeon, white sturgeon, eulachon) are declining, presumably for same reasons as for anadromous salmonids. Thus most of the native anadromous fish of the region are in decline.

The situation for resident fish is not much better. For example, seven out of twenty (35%) of the native resident fish species of the Klamath Basin are endangered or at risk. This includes the short-nosed sucker and Lost River sucker found in the upper Klamath Basin, which are listed as federally endangered.

**Amphibians and Reptiles.** Ten out of fifty-two (20%) of the amphibians and reptiles of the Klamath basin are at risk, and this ratio is approximately the same for the entire ecoregion. Within the ecoregion, the California red-legged frog has been listed as federally threatened.

**Birds.** Many groups of birds have declined within the ecoregion:

- **Waterfowl** - Waterfowl populations have declined dramatically, particularly in the upper Klamath Basin where populations are only about 1/6th of what they once were.

- **Seabirds** - Seabirds have declined along the coast although with the exception of the marbled murrelet which is now federally endangered, the extent of the decline is poorly understood.

- **Colonial waterbirds** - Several species of colonial waterbirds are thought to be declining in the region.

- **Raptors** - Eighteen out of twenty-eight (64%) of the raptors of the ecoregion are endangered, at risk, or of special concern.

- **Marsh and Shorebirds** - Four species within the Klamath Basin are declining (western least bittern, long-billed curlew, western snowy plover, and tricolored blackbird).

- **Neotropical Migrants** - Neotropical migrants are declining nationwide; 40% of species declining in Oregon; 50% of the species declining in California. These same percentages hold...
for the Klamath Ecoregion.

- **Upland Game Birds** - Three out of eight ((38%) of native bird species of the Orders Galliformes (quail and grouse) and Columbiformes (pigeons and doves) in the Klamath Basin, are declining and considered to be at risk.

**Mammals.** As with other groups a surprisingly high number of mammalian species are to some degree at risk of extinction. These include:

- **Carnivores** - Three out of 21 (14%) of native species of mammalian carnivores have been extirpated from the ecoregion; another 3 (14%) are considered at risk.

- **Rodents** - One species, a rare coastal rodent subspecies (the Point Arena mountain beaver) is federally endangered.

- **Bats** - At least four of the fourteen species (29%) of bats within the Klamath Ecoregion are considered at risk.

- **Ungulates** - One of the four native ungulates of the Klamath Ecoregion (bighorn sheep) has been extirpated from the ecoregion and two others have been Eliminated from a large portion of their range within the region.

**Conclusions**

The relationship between human activities, ecological effects, and species loss or endangerment is not always well understood. However, it is well enough understood to realize that the dramatic increase in endangerment and loss of species is real and serious and is in large part a result of human activities carried out for other purposes with no direct intention of causing species loss. With more humans and resultant increase in human activity the trend is likely to continue unless we make a more concerted effort to minimize the impact of these activities. As will be discussed in Volume III - *A Holistic Strategy for Restoration of the Ecoregion*, putting all the effort on saving species once they are already at risk is unlikely to be efficient or effective in the long run. Rather it is important that we also look at and change the root causes of such endangerment—the human effects on the ecosystem.
MAJOR SUBDIVISIONS OF THE ECOREGION

The ecoregion consists of seven major river systems of hydrobasins (Smith River, Redwood Creek, Mad River, Klamath River, Eel River, Mattole River and Russian River) as well as many smaller coastal watersheds. Because most of the drainages run north to south, these smaller coastal watersheds typically are bounded on the east by one of the larger hydrobasins such as the Eel or Russian River Basin. Virtually the entire eastern boundary of the ecoregion is bounded by the Klamath, Eel or Russian River watersheds.

Smith River

The Smith River (Figure I-18) is the northernmost of the river systems of the ecoregion. The Smith River hydrobasin encompasses approximately **** square miles and includes **** miles of streams. A portion of the river runs through Chetco County, Oregon but most of it is within Del Norte County, California. In fact, the Smith River hydrobasin makes up most of Del Norte County although the mouth and a small portion of the lower Klamath River is also in the county.

Physical Environment. The Smith River originates in the Klamath Mountain geologic province and runs through only a small portion of the Coast Range Province. The underlying rocks in most of the basin consist of Josephine Ophiolite which is an unusual suite of mostly crystalline rocks (peridotite, gabbro, basalt and intermixed serpentine. Uplifted about 200 million years ago and exposed to prolonged erosion, these durable rocks are responsible for much of the scenic qualities of the Smith River canyon, as well as the water clarity.

Many of the soils that have developed in the watershed are unusually resistant to erosion despite the high natural landslide rates. The majority of the area has productive forest soils, although soils derived from serpentine rocks in the western portion of the drainage are often non-productive.

Precipitation normally occurs from November through April in the form of rain below 4,000 feet, with snow at higher elevations. Precipitation amounts are among the highest in the U.S. with average annual totals of from 96-150". The highest annual precipitation recorded in the lower 48 states was 254.9" which occurred in this watershed at Camp X in 1981-1982. Runoff is variable, fluctuating in direct response to individual storms. Snowmelt does not normally contribute an identifiable increase in runoff. The Smith River is unusual in that even during very high winter flows, the river retains a relative clear appearance. The lower turbidity of the water during the winter rains is due primarily to the erosion resistant nature of the soil and the enormous flushing power of the river.

The Biological Environment. The Smith River hydrobasin contains a diversity of vegetation that ranges from lush coastal redwoods to high mountain peaks and meadows. The area has many
Figure I-18. The Smith River Basin.
unique botanical communities and over twelve endemic species with limited distributions (Table I-17).

Wildlife is similarly diverse with over 300 species of vertebrates found in the inland areas and many more along the coast.

The Smith River is the last major undammed river in the state and is considered to have some of the best remaining runs of salmon and steelhead, although several stocks are now considered to be at risk (Table I-18). The combination of durable bedrock materials and high natural landslide rates has contributed to the high quality anadromous fishery in the Smith River.

A major portion of this hydrobasin is in public ownership, including Redwood National Park, Jedediah Smith Redwoods State Park, Lake Earl State Wildlife Area, and the Smith River National Recreation Area of the Six Rivers National Forest. Redwood National Park is described in more detail under Redwood Creek where it is centered. Lake Earl State Wildlife Area...

In 1990 the Smith River National Recreation Area Act created the Smith River National Recreation Area from existing National Forest lands within the Six Rivers National Forest. It required the government to revise the existing management plan to conform to provisions of the Act and incorporate it into the forest plan for the Six Rivers National Forest. In 1992 a management plan was completed and approved by the Six Rivers Forest Supervisor. The plan divides the area into eight management areas with differing emphases (Figure I-19). These areas and the management emphasis are described in Table I-19. Approximately 299 miles of the Smith River and its tributaries are designated as Wild (78 miles), Recreational (188 miles), and or Scenic (33 miles) under provisions of the Wild and Scenic Rivers Act. In order to protect and interpret unique botanical communities and good representations of vegetation types seven botanical areas have been established within the National Recreation Area (Figure I-20, Table I-20). Three of these have been nominated as "Research Natural Areas".

Socio-Economic Environment. Thomas Keter (1995?) has reviewed the history of land use activities in the Smith River Basin. It followed the pattern of much of the rest of the ecoregion with arrival of Native Americans from 5,000 to 10,000 years ago and later influxes of miners beginning in the 1850s. In 1905 the Klamath Reserve was created by legislation and Executive Orders and in 1907 155,000 acres within the Smith River Basin were added to the reserve. Additional lands were later added to the reserve. At the time the Forest Service took over administration of these lands the region was still largely "undeveloped" in the sense that few trails and fewer roads existed within the basin. In the last 50 years, timber harvest, recreation and tourism has become the most important economic activities within the area. In 1993 97.4 million board feet of timber were harvested in Del Norte County.

Crescent City is the only incorporated city in this basin and has a population of 4,676 or one-sixth of the County population (27,882) as of the 1994 census. Pelican Bay, north of Crescent City is a major prison facility. Because of the combination of the large amount of federal and state lands, as
Table I-17. Unique botanical communities and endemic plant species of the Smith River.
<table>
<thead>
<tr>
<th>Stock</th>
<th>Source: Pacific Salmon at the Crossroads&lt;sup&gt;17&lt;/sup&gt;</th>
<th>Factors in Northern California Threatening Stocks with Extinction&lt;sup&gt;18&lt;/sup&gt;</th>
<th>Stat Status (California)</th>
<th>Fed eral Status</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Risk of Extinction</td>
<td>Cause</td>
<td>Risk of Extinction</td>
<td></td>
</tr>
<tr>
<td>Spring Chinook</td>
<td>High</td>
<td>Habitat deterioration; overutilization</td>
<td>High</td>
<td></td>
</tr>
<tr>
<td>Fall Chinook</td>
<td>Moderate</td>
<td>Habitat deterioration; overutilization</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Summer Steelhead</td>
<td>High</td>
<td>Overutilization</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sea-run Cutthroat</td>
<td>Moderate</td>
<td>Habitat deterioration</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Figure I-19. Management areas within the Smith River National Recreation Area.
Table I-19. Management Emphases for Management Areas within Smith River National Recreation Area.

<table>
<thead>
<tr>
<th>Management Area</th>
<th>Acreage</th>
<th>Management Emphasis</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. North Fork</td>
<td>55,500</td>
<td>Back-country and whitewater recreation, while recognizing the unique botanical communities, outstanding whitewater, and historic and scenic values.</td>
</tr>
<tr>
<td>2. Upper Middle Fork</td>
<td>30,000</td>
<td>Provide and maintain ecological and biological diversity. Timber harvesting will be permitted in plantations only.</td>
</tr>
<tr>
<td>3. Middle Fork / Highway 199</td>
<td>38,400</td>
<td>Maintaining wildlife values and providing for a full range of recreation uses, with particular emphasis on the scenic and recreation values associated with the Smith River, old growth redwoods, and California State Highway 199.</td>
</tr>
<tr>
<td>4. Upper South Fork</td>
<td>21,450</td>
<td>Wild river and roadless backcountry recreation.</td>
</tr>
<tr>
<td>5. Lower South Fork</td>
<td>20,000</td>
<td>Maintaining and protecting natural scenic values in the river canyon while providing for traditional and compatible river sports. Timber harvests based on uneven-aged management with extended rotations shall be allowed where consistent with the protection of the scenic values of the recreation area.</td>
</tr>
<tr>
<td>6. Lower Hurdygurdy Creek</td>
<td>4,000</td>
<td>Maintenance of wildlife values while providing rustic family and group recreation facilities for fishing, swimming, hunting, and camping. Timber harvests based on uneven-aged management with extended rotations shall be allowed where consistent with protection of scenic and wildlife values.</td>
</tr>
<tr>
<td>7. Prescribed Timber</td>
<td>84,500</td>
<td>Provide sustained yields of wood products while maintaining biological and ecological diversity.</td>
</tr>
<tr>
<td>TOTAL</td>
<td>305,000</td>
<td></td>
</tr>
</tbody>
</table>
Table I-20. Botanical Areas within the Smith River National Recreation Area.
well as the prison facility, government is both the largest employer in the region as well as the major source of income to the County.
Klamath River

The Klamath River Basin (Figure I-21) is the largest and most complex area, both ecologically and politically, of the river basins in the ecoregion. It is only the river basin of the ecoregion that cuts across all three geological provinces, and it is the only one which originates in Oregon. The Klamath and its tributaries flow through a total of seven counties, two in Oregon (Klamath and Josephine) and five in California (Modoc, Siskiyou, Trinity, Humboldt and Del Norte).

The Physical Environment. The Klamath River Basin consists of approximately 10 million acres that drains into the Pacific Ocean at the town of Requa in Humboldt County, California (Figure I-21). The river has its headwaters in south-central Oregon. Major tributaries of the Klamath River are the Williamson, Sprague, and Lost Rivers in Oregon, and the Butte, Salmon, Scott, Shasta, and Trinity Rivers in California. The region contains several volcanic mountains within and on its boundaries (Mount Shasta, Crater Lake) and is bisected by the Siskiyou Mountains which include the Marble Mountains, Salmon Mountains, Trinity Alps, and portions of the Yolla-Bolly Mountains.

The upper basin, lying in the rain shadow of these mountains is arid. Within the upper basin are some large and geologically old wetlands centered around Lower Klamath Lake, Tule Lake, and Clear Lake in northeastern California. The lower basin (below Irongate Reservoir) is primarily made up of rugged, mountains which rise to over 8,000 feet in the Trinity Alps. This part of the basin is wetter, receiving moisture from Pacific storms primarily during the winter and spring months.

The Living Environment. The arid upper basin consists primarily of arid grasslands and shrub-steppe rangelands with forests of ponderosa pine and other species at higher elevations. The wetlands of the upper basin were some of the most extensive in the West, even though they never constituted more than 10% of the upper basin's surface area. These wetlands once supported a great diversity of waterfowl, marsh and shorebirds, raptors and other species dependent upon wetlands. At one time over 7 million ducks and geese made use of these wetlands.

The lower basin is primarily forested. These forests range from coastal redwood and Douglas fir forests at the lower elevations, through mid-elevation stands of pines, firs, and oaks to high elevation forests of Engelmann spruce, mountain hemlock, and subalpine fir.

The Klamath Basin is one of the richest biological areas in the country for several reasons. First, the area is geologically very old compared to most of the west, having been covered continuously by vegetation for at least the last 65 million years (the entire Cenozoic Era). Thus, the basin has been a refugium for species destroyed in other areas by submergence, glaciation, desiccation, or lava flows. Second, the area is a zone where three major bioregions—the Cascadian, Californian and Great Basin—converge, supporting species from all three regions. Third, being is adjacent to the ocean, it contains a diversity of estuarine and coastal species as well as upland types.
Figure I-21. The Klamath River Basin.
The basin is well known for its plant diversity. The Siskiyou Mountains, for example, have the highest diversity of conifer species in North America; a 1-square mile area in the Sugar Creek Drainage of the Klamath National Forest has 17 species of conifers. However, it also has a great diversity of animal species. The wetlands in the upper basin are extremely old and represent a critical area for waterfowl and other birds that migrate along the Pacific Flyway. The forests of the lower basin contain habitat for many rare species such as northern spotted owl, marbled murrelet, Pacific fisher, and others. The basin also supports many relict populations of amphibians such as the Siskiyou Mountains salamander, Del Norte salamander, and tailed frog.

The Klamath River was famous for its runs of anadromous fish (fish are born in freshwater then move to the ocean until returning to their native streams to spawn. The river once supported 6 species of salmonids (chinook, coho, pink and chum salmon, steelhead trout, and sea-run cutthroat trout) that represent an estimated 55 separate stocks (genetically distinct populations that return to a particular stream at a given time of year to spawn) (Table I-21). In the 1960's total harvest of Chinook salmon from the Klamath River was averaging 350,000 fish. In addition to salmon, the river basin supports other anadromous fish such as green and white sturgeon and Pacific lamprey.

The upper reaches of the basin support several species of resident fishes including eight endemic species (species found nowhere else in the world). They include species such as the shortnose sucker and Lost River sucker, both of which are now listed as endangered under the federal Endangered Species Act.

**Socio-economic Environment.** The earliest economy of the region was primarily a subsistence economy of the indigenous peoples. Salmon and other fish species provided them with a stable source of food, and other native plants and animals were used for clothing, housing, food and medicine. Although, the indigenous tribes traded freely with peoples from outside the basin, they derived most of their needs from the resources of the basin. The basin contained several distinct language groups including the Penutian speaking Klamath and Modoc tribes of the upper basin. Karanaka (Hokan) speaking Shasta and Yurok tribes of the middle Klamath, the Na-Dene (Athabascan) speaking Hupa tribes of the middle Klamath, and the Algonkian speaking Yurok tribes of the lower river (Figure I-22).

With the European settlement, the economy changed to primarily an export economy. Livestock were raised and crops grown for export to other regions of the country or world. Similarly, the large scale cutting of redwood and then later Douglas fir forests was for export to other regions.

The primary economic activity since 1850 has been farming, ranching, and timber-cutting. However, these monetary economies have coexisted with traditional subsistence activities of indigenous peoples to this day.

<table>
<thead>
<tr>
<th>SPECIES / RUN</th>
<th>STOCK</th>
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<tbody>
<tr>
<td>Fall Chinook</td>
<td>Upper Klamath (Iron Gate Hatchery)</td>
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<tr>
<td></td>
<td>Bogus Creek</td>
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<td></td>
<td>Shasta River</td>
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<td></td>
<td>Salmon River</td>
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<td></td>
<td>Middle Klamath Tributaries (from Weitchpec to Iron Gate Dam)</td>
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<tr>
<td></td>
<td>Lower Klamath Tributaries (below Weitchpec)</td>
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<td></td>
<td>Trinity River Hatchery / Upper trinity (above Junction City)</td>
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<td></td>
<td>South Fork Trinity</td>
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<tr>
<td></td>
<td>North Fork Trinity</td>
</tr>
<tr>
<td></td>
<td>Middle Trinity tributaries (from South Fork to Junction City)</td>
</tr>
<tr>
<td></td>
<td>Lower Trinity tributaries (South Fork to Weitchpec)</td>
</tr>
<tr>
<td>Spring Chinook</td>
<td>Upper Trinity / Trinity River Hatchery</td>
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<tr>
<td></td>
<td>South Fork Trinity</td>
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<tr>
<td></td>
<td>North Fork Trinity</td>
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<tr>
<td></td>
<td>New River</td>
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<td></td>
<td>Salmon River</td>
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<tr>
<td></td>
<td>Wooley Creek</td>
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<td></td>
<td>Elk Creek</td>
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<tr>
<td></td>
<td>Clear Creek</td>
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<tr>
<td></td>
<td>Dillon Creek</td>
</tr>
<tr>
<td>Coho</td>
<td>Iron Gate Hatchery</td>
</tr>
<tr>
<td></td>
<td>Trinity River Hatchery</td>
</tr>
<tr>
<td></td>
<td>Lower Klamath tributaries</td>
</tr>
<tr>
<td></td>
<td>Scott River</td>
</tr>
<tr>
<td></td>
<td>Shasta River</td>
</tr>
<tr>
<td></td>
<td>Salmon River</td>
</tr>
</tbody>
</table>
Middle Klamath tributaries
Lower Trinity tributaries

**Summer Steelhead**

New River
South Fork Trinity River
North Fork Trinity River
Canyon Creek
Bluff Creek
Salmon River
Wooley Creek
Elk Creek
Dillon Creek
Red Cap Creek
Clear Creek
Indian Creek

**Fall / Winter Steelhead**

Upper Klamath (Iron Gate Hatchery)
Upper Trinity (Trinity River Hatchery)
Shasta River
Scott River
Salmon River
Middle Klamath tributaries
Lower Klamath tributaries
Lower Trinity tributaries
Upper Trinity tributaries
New River
North Fork Trinity River
South Fork Trinity River
Figure I-22. Language groups of native Americans within the Klamath River Basin.
Although agricultural and forest products are still the mainstay of the monetary economy—the specifics are changing. For example, the net value of blue-green algae harvested from Upper Klamath Lake now exceeds that of all the livestock grazing in the Upper Basin. Similarly, the demand for specialty forest products such as mushrooms have increased relative to the demand for sawtimber.

Tourism has been a source of income for people of the basin for over 100 years. People come to the area to fish for salmon and other species and hunt waterfowl as well as big game. Tourism continues to be a steady source of income, although the nature of the activity has shifted somewhat with many people coming for backpacking, birdwatching, or river running in addition to or combined with traditional hunting and fishing. What has remained constant is that tourists are attracted to the natural values of the region—the scenic beauty and the native wildlife.

The major towns within the Klamath River Basin are Klamath Falls, Yreka, Hoopa, Happy Camp, and Weaverville.

**** Wild and Scenic River Status ****

Major Sub-basins of the Klamath River. Because the Klamath River is so large and diverse, the major sub-basins of the river are described here. [IN PROGRESS]

- Lower Klamath
- Lower Trinity
- South Fork Trinity
- Mid Trinity
- Upper Trinity
- Salmon
- Mid Klamath
- Scott
- Shasta
- Butte
- Upper Klamath
- Lost
- Sprague
- Williamson
Redwood Creek

Redwood Creek is the next major drainage south of the Klamath River. Redwood Creek drains a watershed of approximately 290 square miles (185,600 acres) that originates in the coast ranges of central Humboldt County and drains generally northward for about 50 miles where it reaches the ocean near the town of Orick (Figure I-23).

Physical Environment. Redwood Creek generally follows the trace of a north-south fault line (The Grogan Fault). The geology of the area has been summarized by Susan Cashman and others. The terrain is steep and most of the bedrock lacks shear strength which contributes to high erosion rates in the basin. This natural susceptibility, combined with human actions described under "socio-economic environment" has led to severe degradation of this system as manifested in accelerated erosion and sedimentation of rivers. K.M. Nolan and others has described Redwood Creek as "a rapidly eroding landscape that is sensitive to effects of both land use and major storms."

Living Environment. Although Redwood Creek supports a diversity of wildlife it is probably best known for its coastal redwood forests. The Tall Trees Grove situated along alluvial flats of lower Redwood Creek support some of the oldest and tallest trees redwoods in the region. A coast redwood discovered there in 1963 measured 367.8 feet and is known as the world's tallest tree.

Socio-economic Environment. Redwood Creek originally was inhabited by two Indian tribes--the Yurok which were found in the lower portion of the basin and the Chilula which were found in the upper basin. While the Yurok were also found along the coast and lower stretches of the Klamath River--the Chilula were primarily found only in the vicinity of upper Redwood Creek and adjacent territory along the lower Trinity River over the hill to the east--lands shared with the Hupa. The Chilula were similar to the Hupa in speech and culture and were often allied with them in hostility to the Teswan or coast Yurok.

Following the arrival of Europeans in the region--timber harvest became the dominant land use in the basin. David Best has summarized the history of timber harvest in the region through 1978. Logging began along the broad flood plains at the mouth of the river in the latter half of the 19th century, then moved upstream and upslope with changing demands and changing equipment. By 1978 81 percent of the coniferous forests in Redwood Creek had been logged.

In 1968, the U.S. Congress passed legislation establishing Redwood National Park centered within the Redwood Creek watershed. This initial designation of approximately 94 square miles was designed to preserve significant examples of virgin coastal redwood forests. Most of the parkland was located in the downstream one-third of the Redwood Creek drainage basin. Soon after the park was established, conservation groups and government agencies became concerned that continuing timber harvesting on private lands upstream and upslope was threatening the ecological integrity of the newly created park. These agencies believed that timber harvesting was
increasing runoff and sediment production in the watershed and thus threatening parkland resources.

In response to this concern studies of erosion, sediment transport, and aquatic habitat were begun in 1973 through a cooperative effort of the National Park Service and U.S. Geological Survey. These studies were designed both to understand natural processes within the basin and to assess how timber harvesting within the basin had affected these processes. Results from much of this research indicated that timber harvesting was capable of increasing the naturally high rates of erosion.

As a consequence of these studies, Congress authorized expansion of Redwood National Park in 1978 to approximately 214 square miles (~137,000 acres)--more than doubling its size (Figure I-24). It also directed the National Park Service to rehabilitate logged-over lands and created a Park Protection Zone of 30,000 acres (Figure I-24 from the park in Redwood Creek in which timber harvest operations were to be reviewed by the National Park Service in order to limit the effects on the park downstream.

Redwood National Park is operated in conjunction with adjacent State Parks (Jedediah Smith State Park, Del Norte Coast Redwoods State Park, and Prairie Creek Redwoods State Park), thus providing a stretch of approximately 60 miles of continuous parkland from the middle of Redwood Creek north along the coast to the mouth of the Smith River (Figure I-25).
Figure I-XX. Redwood Creek hydrobasin.
Figure I-XX. Redwood National Park and park protection zone.
Figure I-XX. Redwood National and State Parks complex.
Eel River

The Eel River was named by Dr. Josiah Gregg in 1849 when his exploring party encountered a small group of native Americans carrying "eels" (lampreys) which they had caught in the river. The Eel River is the second largest of the rivers in the Klamath Ecoregion, surpassed only by the Klamath, and the third largest in the state. The river basin encompasses approximately 3,684 square miles and has a mean annual discharge of 5.4 million acre feet. The mainstem Eel River has its headwaters in Mendocino County near Bald Mountain, and flows south to Lake Pillsbury, thence 12 miles west to Van Arsdale Reservoir, then northwest approximately 157 miles to the Pacific Ocean just north of Ferndale in Humboldt County (Figure I-XX). The river basin lies primarily in Humboldt and Mendocino Counties, but also extends into Trinity, Lake, and Glenn Counties. Scott Downie and others have provided a synthesis of existing conditions and issues in their "State of the Eel" report, and much of the information summarized here is from that document.

The climate of the Eel River basin is one of the wettest in California. Throughout the winter, heavy rains fall during intense storms of moderate duration and produce about 9 percent of the annual runoff of the State even though the basin only comprises only 2 percent of the state's area. The coastal region of the basin is generally cool and foggy, while farther inland, temperatures are more variable and average precipitation is lower. Snow falls in the higher elevations in the eastern part of the basin, but runoff from snowmelt is minor.

Average annual rainfall in the basin is about 59 inches, and average annual runoff is about 35 inches. Most runoff occurs during and shortly after the late fall and winter storms. Because of the impermeability of the soil and mantle rock, base flow is poorly sustained.

The Eel River basin is underlain almost entirely by sedimentary rocks of the Franciscan Formation. Regional uplifting and faulting of these rocks have produced a rugged topography characterized by steep slopes and narrow canyons which trend northwesterly parallel to the zones of weakness associated with faulting. Weathering of the Franciscan Formation has produced moderately deep loamy soils which are highly erodable.

The Eel River has the highest recorded average annual suspended-sediment yield per square mile of drainage area of any river of its size or larger in the United States. This yield, in tons per square mile, is more than 15 times that of the Mississippi River and more than four times that of the Colorado River. The erosion rate in the Eel River Basin is a major watershed-management problem. Evidence from 30 years ago suggests that the entire drainage of the Eel River is presently lowering at a rate of from 3.3 to 5.85 inches per century which is from 10 to 100 times the expected rate of soil formation. Thus Clyde Wahrhaftig and Robert Curry suggested in 1967 to conclude:

"The measured rates of erosion in the Eel and Mad River drainages are clearly not normal, and are presumably caused by the activities of man...A significant part must be from
Figure I-XX. The Eel River Basin.
accelerated erosion following logging and road-building... The implications of these data are that, unless this phenomenal rate of erosion is arrested, the bulk of the topsoil (upper 4 feet of weathered rock in which the Douglas Fir and Redwood are rooted on hillsides will be destroyed over large parts of the Eel and Mad River drainages within a few hundred years. These areas may then become barren rocky hillsides. Regeneration of the forest under these conditions will be difficult if not impossible in the present climate, and both the forest industry and the water storage capability of the region will be seriously impaired.  

No evidence has been presented in the intervening 30 years to contradict that conclusion.

Vegetation - [Eel Swap***]

Wildlife of the Eel River Basin is typical of other Coast Range areas. Five major threats to wildlife species have been identified: (1) loss of late successional vegetation; (2) alternation in disturbance regimes (particularly fire); (3) roads; (4) habitat fragmentation; and (5) exotic species.

The fish fauna of the Eel River is shown in Table I-XX. The high percentage of exotics is of more than passing interest since many of them are responsible for the decline of the native fish fauna. In particular, Sacramento squawfish are believed to present a threat to salmon and steelhead populations within the basin. Stocks of salmonids that are believed to be "at risk" are shown in Table I-XX.

[TO BE COMPLETED]

The Eel River comprises several subbasins with quite different landscapes, settlement patterns, and problems. These are summarized in Table I-XX and are described briefly below.

Delta
Lower Main
Middle Main
Upper Main.
Van Duzen
South Fork
North Fork.

[TO BE COMPLETED]
Table I-XX. Fish fauna of the Eel River.
<table>
<thead>
<tr>
<th>Stock</th>
<th>Subbasin / Tributary</th>
<th>Source: Pacific Salmon at the Crossroads(^{19})</th>
<th>Source: Factors in Northern California Threatening Stocks with Extinction(^{2})</th>
<th>Status: California</th>
<th>Status: Federal</th>
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<tbody>
<tr>
<td>Fall Chinook</td>
<td>Lower Eel</td>
<td>Moderate</td>
<td>Habitat deterioration; overutilization</td>
<td></td>
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<td>Entire basin</td>
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<td></td>
<td>Stock of Concern</td>
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<tr>
<td>Coho Salmon</td>
<td>Entire basin</td>
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<td></td>
<td>Stock of Concern</td>
<td></td>
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<tr>
<td>Summer Steelhead</td>
<td>Middle Fork</td>
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<td></td>
<td>Stock of Concern</td>
<td></td>
</tr>
<tr>
<td></td>
<td>North Fork</td>
<td></td>
<td></td>
<td>High</td>
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<td></td>
<td>Van Duzen River</td>
<td></td>
<td></td>
<td>High</td>
<td></td>
</tr>
<tr>
<td>Sea-run Cutthroat</td>
<td>Lower Eel</td>
<td></td>
<td></td>
<td>Stock of Concern</td>
<td></td>
</tr>
</tbody>
</table>

\(^{19}\) Nehlson et al. (1992)

\(^{20}\) Higgins et al. (1992)
<table>
<thead>
<tr>
<th>Table I-XX. Comparison of Sub-basins of Eel River&lt;sup&gt;21&lt;/sup&gt;.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Low Elevation (feet)</strong></td>
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<tr>
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<tr>
<td>Sea level</td>
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<tr>
<td>1,800</td>
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<tr>
<td>High Elevation (feet)</td>
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<td>Perennial Stream Miles</td>
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<td>Acreage:</td>
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<td>Predominant Land Uses</td>
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<td>Principal Communities</td>
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</table>

<sup>21</sup> Modified from Downie et al. (1995)
Middle Fork. The Middle Fork originates in the Yolla Bolly-Middle Eel Wilderness and flows south and then west into the mainstem Eel below Dos Rios. It consists of approximately 140,000 acres of which almost 90% is in federal ownership, mostly in the Mendocino National Forest.

This area was occupied by the Witukomno'm division of Yuki Indians. The Yuki appear to be the earliest tribe to settle in the region. During the period of white settlement Indians from many tribes were rounded up and placed on a reservation in Round Valley in the center of this watershed. The Round Valley reservation is now home to Indians from several tribes including Yuki, Pit River, Nomlacki, Concow, Pomo, and Wailacki.

The Middle Fork contains the highest peaks in the Eel River watershed, with some as high as 7,400 feet. Like the rest of the basin soils are highly erodable and sensitive to human impacts. This watershed has a typical Mediterranean climate with 80% of the precipitation coming between November 1 and April 1. With elevations ranging from 880 feet at Dos Rios to over 7,000 feet in the Yolla Bolly Mountains, a diversity of vegetation types and wildlife species is present. Round Valley, in the center of the watershed contains one of the few large remnant stands of valley oaks within the region, although they are primarily on private or reservation lands and are at risk from a variety of activities.

The headwater streams provide spawning areas for several species of anadromous fish including summer steelhead, coho and spring chinook salmon, and Pacific lamprey. The Middle Fork of the Eel is believed to have the largest run of summer steelhead in California. Summer steelhead have a unique life history which includes entering river systems in the spring and residing in large pools over the summer before spawning in the fall. During the summer these large fish are vulnerable to poaching. Summer steelhead are found in only five river drainages in California (Smith River, Redwood Creek, Klamath River, Mad River, and Eel River) and are a stock at risk of extinction along most of the Pacific Coast.

Covelo, with a population of ***** is the main town in the region. The predominant land uses in the region is agriculture, logging, and tourism.

A watershed analysis has been completed by the Forest Service and BLM for a portion of the Middle Fork of the Eel and a separate one has been done for Black Butte Creek—a major tributary of the Middle Fork. However these focus mostly upon federal lands within these areas.

[TO BE COMPLETED]
Mattole

Russian River

Bear River / Freshwater Creek, etc. (Humboldt Coastal Streams)

Big / Navarro / Garcia etc. (Mendocino Coastal Streams)

Gualala / Salmon etc. (Sonoma County Coastal Streams)
LITERATURE CITED


ENDNOTES


2. Coastal redwoods extend a few miles north of the ecoregion into Oregon; There are also scattered patches as well as some larger stands of redwood south of San Francisco Bay.

3. Kuchler (1964)

4. For a discussion of the role of salmon as keystone species see Wilson and Halupka (1995). Salmon fishing was once an important industry in the ecoregion. Although it has declined with the decline of the salmon, locally it is an important source of food and income. Culturally, salmon have always been important to native Americans in the region and remain so today. Newer settlers to the region also place great importance upon salmon.

5. Forest Ecosystem Management Assessment Team (1993)


7. Taylor (1985); Taylor and Bright (1987)


9. Rantz (1964); Rantz (1967); Rantz (1968)


11. Azevedo and Morgan (1974); Dawson (1996); Ingraham and Matthews (1995); Ingwersen (1985)


16. Blackburn and Anderson 1993a

17. Blackburn and Anderson (1993b)


21. County lines do not coincide with those of the ecoregion. Del Norte, Humboldt, and Mendocino Counties (California) are entirely within the ecoregion; portions of Klamath County (Oregon) and Siskiyou, Trinity, and Sonoma Counties (California) lie outside the ecoregion. Small portions of Josephine County, Oregon and Marin and Lake County, California lie within the ecoregion.


25. This number is based upon a rough estimate of 2 million fish at an average of 10 pounds per fish (equaling 20 million pounds) spread over an ecoregion of roughly 20 million acres.


27. Nathaniel Shaler (cited in Perry [1996:267])


29. Aztet and Martin (1991)

30. Romme (1980)

31. Martin and Sapsis (1991)


33. Reid (1993)

34. Reid (1993); Christner and Harr (1982)

35. Trush (1994)

36. USDA, Forest Service (1992)

37. Cashman et al. (1995)

39. Goddard (1914); Kroeber (1925:137)
40. Best (1995)
41. Downie et al. (1995)
42. Brown and Ritter (1971)
43. Brown and Ritter (1971)
44. Brown and Ritter (1971)
45. Brown and Ritter (1971)
46. Wahrhaftig and Curry (1967)
47. Wahrhaftig and Curry (1967)
48. Downie et al. (1995)
49. Jones (1992)
50. USDA Forest Service and USDI Bureau of Land Management (1994)