


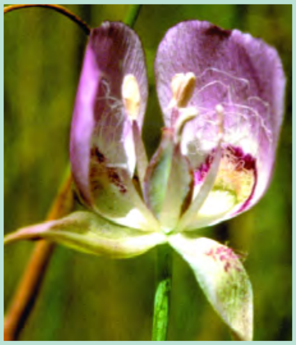


East Cascades – Modoc Plateau and West Cascades

ECOREGIONAL ASSESSMENTS

MAIN REPORT

JUNE 2007

The Nature Conservancy
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Washington's Natural Heritage Program

Washington Department of FISH and WILDLIFE

The East Cascades - Modoc Plateau
and
West Cascades
Ecoregional Assessments

Main Report

Prepared by
The Nature Conservancy
and the
Washington Department of Fish and Wildlife

June 2007

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The subteams benefited from the knowledge of many biologists. The lists of those wildlife, fish and freshwater systems experts which contributed their time during the development of target lists and freshwater system classification are in Appendices 4F, 4H and 4I.

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Last and most importantly, the people listed below on the Core Team, and the Advisors, contributed large portions of their time to this effort over the last 5 years, and they should be proud of the level of teamwork exhibited across 3 states and two ecoregions while completing these assessments.

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Executive Summary

Ecoregional assessments offer a means to evaluate and implement biodiversity conservation at a regional scale. An ecoregional assessment identifies a portfolio of sites for conservation action with a goal of protecting biodiversity and ecologically significant populations. These assessments are the result of rigorous analysis that has been extensively reviewed by experts, and represent a comprehensive effort to spatially prioritize biodiversity at the watershed scale. Our intent is to create a shared vision for agencies and other organizations at the regional, state and local levels which will ensure efficient allocation of conservation resources. Biodiversity conservation in these ecoregions will be most effective if all conservation organizations coordinate to protect and restore biodiversity according to the priorities identified by this process.

The East Cascades – Modoc Plateau and West Cascades Ecoregions encompass a highly diverse area including parts of three states, 11 major river basins (Ecological Drainage Units or EDUs), and a total of more than 121,500 km^2 (46,900 mi^2). The two ecoregions were concurrently analyzed by a team of experts, led by The Nature Conservancy (TNC) and the Washington Department of Fish and Wildlife, from 2002 to 2007.

Both ecoregions are primarily under federal ownership with 49% and 7% managed by the U.S. Forest Service and Bureau of Land Management, respectively. Thirty-five percent of the total area in the East and West Cascades is in private ownership. Each state, various tribal entities, other federal agencies, and local communities also manage a significant land area. Protected areas are primarily comprised of higher elevation forested and alpine lands. Roughly 13% and 15% of the East Cascades and West Cascades respectively is currently under permanent conservation protection (GAP 1 or 2 status).

Each ecoregion was divided into sections (four in the west, six in the east) to stratify the analysis of terrestrial species and systems. Freshwater targets were stratified by EDUs. All analyses were done separately for the two ecoregions. Terrestrial and freshwater data were kept in separate layers so areas important for one set of targets (e.g., terrestrial only) could easily be identified. The ecoregions were further subdivided into sub-watershed assessment units (AUs) and all data were allocated among AUs. The average size of an assessment unit was 2,677 hectares (6,615 acres).

Conservation targets in the assessment were divided between coarse and fine-filter targets. Coarse-filter targets represented all ecological systems known to occur in the ecoregions. Fine-filter targets were made up of rare or declining species, as well as those that may not be adequately captured through the coarse-filter analysis. Conservation goals were set to capture representation of all coarse and fine-filter targets across the ecoregions. The team identified 68 terrestrial and over 300 freshwater system targets. The team also identified 464 species targets, of which 125 were found in both ecoregions. This included 89 fish, 193 terrestrial animals, and 182 plant species.

Separate terrestrial and freshwater suitability indices were developed to determine the areas of the ecoregion that had the highest likelihood of successful conservation. This facilitated choosing amongst assessment units (the units of analysis), when multiple units contained conservation targets. The suitability indices incorporated biological and non-biological "factors": land use (agriculture, urban), land management status (12 GAP status subcategories), dams, mines and road density. The conservation goals and the suitability index were used to identify a set of priority conservation areas (i.e., TNC portfolio sites) that support all of the ecoregion's biodiversity.

Due to the complexity of analyzing such a large sum of data over an expansive area, the planning team used a site selection algorithm tool called MARXAN. This tool was used to develop the conservation portfolio and informed the utility and irreplaceability analyses.

This algorithm was designed to minimize the overall cost or size of the portfolio, while meeting the conservation goals of each target. MARXAN initially generated a draft version of the portfolio. Outside experts from a variety of organizations reviewed this draft. The final draft portfolio was modified to reflect expert review and a final portfolio of conservation sites was produced for the ecoregion.

The conservation portfolio for the East Cascades - Modoc Plateau Ecoregion contains 107 sites covering approximately 48% of the ecoregion. The West Cascades portfolio consists of 143 sites or about 56% of the ecoregion. The sites average about 25,000 ha (61,177 ac) and most were selected because they were important for both terrestrial and freshwater conservation targets. However, roughly 44% of AUs in the portfolio have been identified as being important for terrestrial or freshwater targets only. There are 57 mainstem river sites in the two ecoregions which fall within, and connect the integrated portfolio sites. Twenty-four percent of each ecoregional portfolio is currently in a designated protected area.

In general, conservation targets with goals that were based on percentage of occurrences or percentage of area (e.g., salmon, and terrestrial and freshwater systems) met their conservation goals. However, many terrestrial species targets did not have a sufficient number of occurrences within the ecoregion to meet their goals.

This assessment resulted in a series of products useful to those involved in the conservation of biodiversity in the East Cascades – Modoc Plateau and West Cascades Ecoregions. These products can be used alone, in conjunction with one another, or with other information to enhance on-the-ground biodiversity conservation. The main products are:

- Terrestrial and freshwater ecological systems classifications.
- Terrestrial and freshwater suitability indices that rank AUs based on the likelihood of successful conservation.
- Irreplaceability and utility maps showing the relative conservation value of all places in the ecoregion.
- Integrated conservation portfolios, depicting the most important and suitable areas for biodiversity conservation. A summary of known target occurrences, land cover, land use, and management is provided for each site.
- Three scenarios for biodiversity conservation, representing different levels of risk.
- The conservation portfolios and utility maps can inform a range of biodiversity conservation initiatives. Special consideration should be given to those projects that occur within portfolio sites or within high value AUs. To date, the Washington Department of Fish and Wildlife has committed to the use of the conservation utility maps. These maps have informed their State Comprehensive Wildlife Conservation Strategy (SCWCS). The Nature Conservancy uses portfolio sites to focus all of their on-the-ground conservation and policy work. First-iteration assessments have been prepared for all ecoregions in Washington, Oregon, and California, and will be updated on a periodic basis.

These ecoregional assessments can inform conservation decision-making across ecoregions. The sites described are approximate, and are often large and complex enough to require a range of resource management strategies. Ultimately, the exact boundaries and management of any potential conservation area will be based on the policies, values, and decisions of the affected landowners, governments, and other community members. The ultimate vision of the ecoregional assessment process is to facilitate the thoughtful coordination of current and future conservation efforts by the growing number of federal, provincial/state, local, private and non-governmental organizations engaged in this field.

Chapter 1 – Introduction

1.1 Background

Worldwide, the ever-increasing demands on natural resources require society to make important decisions about resource use and biodiversity conservation. Society faces the critical challenge of protecting the planet's natural heritage while minimizing conflicts with legitimate uses of natural resources. However, in most parts of the world, society and its elected officials have yet to address such issues in a comprehensive and strategic manner. Citizens, stakeholders, and elected officials should collaborate to set a vision for biodiversity conservation that is informed by the best available science and that acknowledges some level of risk. Towards this end, The Nature Conservancy, in cooperation with key partners, is helping society make informed decisions about where conservation should be done by developing scientifically rigorous conservation assessments for every North American ecoregion. These comprehensive assessments evaluate the full spectrum of biodiversity in a given ecoregion, identifying areas of biological significance where conservation efforts should have the greatest potential for success.

This report contains assessments for both the East Cascades and Modoc Plateau Ecoregion and the West Cascades Ecoregion, and will usually be referred as the East and West Cascades Ecoregional Assessment. These two adjoining ecoregions were analyzed at the same time, although all data were analyzed without one ecoregion influencing the other. This assessment began in October 2002 as a partnership between The Nature Conservancy and the Washington Department of Fish and Wildlife (WDFW). NatureServe, the Oregon Natural Heritage Information Center (ORNHIC), and the Washington Natural Heritage Program (WNHP), were major contributors of technical expertise and data. The project has also benefited from the participation of many other scientists and conservation experts as team members and expert reviewers, including representatives from the United States Forest Service (USFS), U.S. Fish and Wildlife Service (USFWS), and Oregon Department of Fish and Wildlife (ODFW), as well as many other organizations and individuals.

1.2 Purpose, Methods and Products

The purpose of this ecoregional assessment is to identify priority areas for conserving the biodiversity of the East Cascades - Modoc Plateau and West Cascades Ecoregions (Figure 1). This assessment is a guide for planners and decision-makers and has no regulatory authority. The assessment and its various products are not intended to provide all the answers for dealing with biodiversity conservation across the ecoregion. It does provide tools that should be used in conjunction with other biological, social and economic information and objectives to guide actions for conserving biodiversity. Because this assessment covers over 12 million hectares (ha), and uses sub-watersheds (averaging 2,700 ha) for assessment units, additional information should be sought when using the results of this assessment on a more local scale. The assessment should be treated as a first approximation; the gaps and limitations described herein must be taken into consideration by users. This work was prepared with the expectation that it will be updated as the state of scientific knowledge improves, analytical methods are further advanced, and other conditions change.

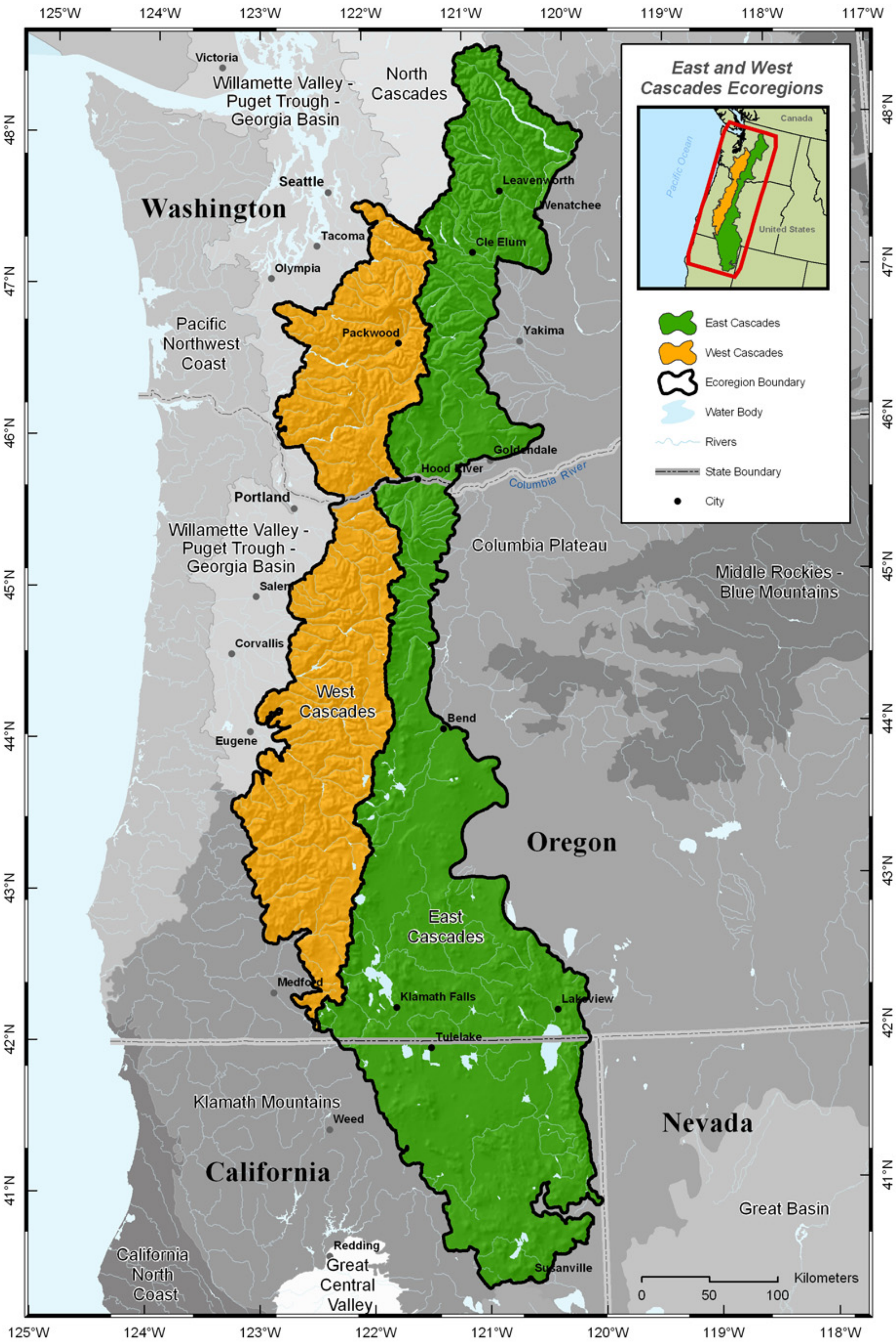

Figure 1. The East Cascades – Modoc Plateau and West Cascades Ecoregions

1.2.1 Assessment Methods

This assessment used an approach developed by The Nature Conservancy (Groves et al. 2000, 2002) and other scientists to establish conservation priorities within ecoregions, the boundaries of which are defined by their distinct vegetation and native species. This report documents the assessment process, including the steps taken to design a conservation "portfolio" for each ecoregion. It also presents a comprehensive, ecoregion-wide analysis that identifies and prioritizes places of conservation importance.

Six expert technical teams collaborated on a series of analyses. Three teams covered the terrestrial environment's plants, wildlife and ecological systems. A fourth team studied the ecoregion's freshwater systems and a fifth its freshwater species. The sixth team handled geographic information systems (GIS) and data management tasks. The terrestrial and freshwater teams began by selecting the species, communities and ecological systems that would serve as the conservation targets. Conservation targets are those elements that are determined by the teams to be representative of the biodiversity necessary to adequately identify priority conservation areas (that represent optimal concentration of biodiversity).

A computer program, MARXAN, was used to select a set of sites that meet the goals for target species and habitat types at the lowest "cost." Cost represents a suite of economic, social and environmental factors and cost was minimized by selecting the sites rated as most suitable for long-term conservation. Site suitability was calculated using an index of existing land management status, land use, urban proximity and road density. MARXAN compared each part of each ecoregion against all others and analyzed millions of possible site combinations to select the most efficient portfolios. Separate draft portfolios were created for terrestrial and freshwater biodiversity. Those terrestrial and freshwater portfolios were overlaid, and the areas in common served as the basis for an integrated portfolio. MARXAN was run again, stacking the two datasets to achieve a set of areas that met goals for both datasets. MARXAN outputs were also used to generate maps that rated the conservation value and depicted the relative irreplaceability of all sites across the ecoregion.

The technical teams then worked with the MARXAN outputs to refine both the terrestrial and freshwater portfolios based on expert review. These portfolios highlight areas of high conservation value for terrestrial and freshwater species and systems. The terrestrial and freshwater portfolios were then overlaid in order to demonstrate areas of overlap.

1.2.2 Assessment Uses and Report

The East and West Cascades Ecoregional Assessment is a guide for natural resource planners and others who are interested in the status or conservation of the biological diversity of this ecoregion. This assessment is simply a guide for prioritizing work on the conservation of habitats that support the extraordinary biological diversity of the ecoregion. It is a tool that should be used in conjunction with other biological information, particularly when used at local scales, as well as with information about social and economic priorities.

The assessment consists of four volumes:

- The Main Report contains an overview of the ecoregional assessment process, the methods used, and presents the results of the assessment.
- Appendices present a glossary, target lists, lists of reviewers and details on the methods and results. They are numbered according to the chapter in the Main Report they most relate to.
- Maps are presented in 11x17 format, and illustrate the assessment process and results, including the terrestrial and freshwater classifications, irreplaceability and

utility analyses, and the portfolios. They are also numbered by the chapter they relate to. Additional poster-sized maps are available on the CD which show the portfolio sites in greater detail, including whether each assessment unit was pick for terrestrial, freshwater, or both sets of targets.

- Site Summaries for each of the conservation areas identified in TNC's portfolio are organized by ecoregion on the CD, and are also available organized by state. They provide information on land use, management status and ownership, and conservation targets present at the site.

The results of this assessment are available to all parties interested in conserving biodiversity in the East and West Cascades Ecoregions. The Nature Conservancy and the Washington Department of Fish and Wildlife will use the assessment results and those of similar assessments to prioritize their projects and funding allocations. Governments, land trusts, and others are encouraged to use the assessment as a resource to guide conservation strategies.

This report and much of the data used in the assessment are available on CD from The Nature Conservancy or the Washington Department of Fish and Wildlife, and the report will also be available at www.conserveonline.org.

Chapter 2 – Ecoregional Overview

2.1 West Cascades Ecoregion

2.1.1 Geography

The West Cascades Ecoregion encompasses 4.0 million ha, extending west from the Cascade Crest to the Puget Sound and Willamette Valley lowlands and from Snoqualmie Pass south across the Columbia Gorge to the Klamath Mountains in southwest Oregon, almost to the California border (Map 2.1). Because many watershed assessment units on the western edge of the ecoregion extend into the neighboring ecoregions, a total of 4.2 million ha was included in this assessment. This mountainous, heavily forested ecoregion is bounded on the west by farms, woodlands and cities in the Puget Trough and the Willamette Valley or by the drier forests and valleys of the Klamath Mountains. The eastern boundary is the crest of the Cascades, where the mesic forests begin to give way to the drier forests of the East Cascades. The topography and soils of the West Cascades Ecoregion have been shaped dramatically by its volcanic past.

2.1.2 Geology

Geologically, the West Cascades Ecoregion has two distinct areas: the younger volcanic crest (approximately 3 million years old) composed of prominent mountains, and the "old Cascades" to the west of the crest in Oregon, and interspersed in Washington (at least 30 million years old). The ecoregion consists mostly of highlands modified by montane glaciers and associated riverine valleys. The typical elevation range is 1,000 to 7,000 feet above sea level, with the highest peak rising to more than 14,000 feet on Mount Rainier and the lowest elevations in the Columbia River Gorge at 50 feet. In Oregon, Mount Hood reaches 11,240 feet, with a dozen other mountains topping 8,000 feet.

The older mountains feature long ridges with steep sides and wide, glaciated valleys, and remnants of long-extinct volcanoes. Isolated younger volcanic peaks such as Mount St. Helens, Mount Rainier, Mount Hood, Mount Jefferson and the Three Sisters, rise above surrounding steep mountain ridges. These younger mountain peaks were formed primarily from extrusive volcanic activity.

Natural lakes are numerous, with most being created by glacial processes and landslides. Small, steep-gradient streams feed major rivers, and most of them in Washington drain into the Puget Sound. In the northern two-thirds of the ecoregion in southwestern Washington and Oregon, streams flow into the Cowlitz, Lewis or Willamette Rivers, and then to the Columbia River system; the southern third of Oregon's West Cascades drains to the Pacific Ocean through the Umpqua and Rogue River systems.

2.1.3 Climate

The climate varies with elevation and, to a lesser extent, latitude. Higher elevations typically receive heavy winter snows. In general, the climate of this ecoregion is wet and relatively mild. Average annual precipitation ranges from about 55 to 140 inches. Most precipitation occurs from October through April. The highest elevations are continuously covered with snow for the winter months. Middle elevations have significant snow pack that fluctuates over the course of the winter with rain-on-snow events. The lowest elevations accumulate little snow and generally have a transient snow pack. The drier parts of the ecoregion in southern Oregon have a fire regime more similar to the Klamath Mountains, with frequent lightning-caused fires. In the northern part of Oregon and southwestern Washington, the natural fire regime historically produced less frequent but more severe fires. In northern Washington, natural fires rarely occurred.

2.1.4 Vegetation

Conifer forests dominate the vegetation of the West Cascades Ecoregion. Douglas-fir/western hemlock (*Pseudotsuga menziesii / Tsuga heterophylla*) forests are typical at low elevations, generally up to about 3,300 feet. However, most of the previously-harvested forests of the lowlands and lower slopes now support mixed conifer-deciduous forests, with young Douglas-fir and western hemlock forests found in a mosaic with hardwood species such as bigleaf maple (*Acer macrophyllum*) and red alder (*Alnus rubra*). There is a greater frequency of fires in the southern Oregon portion of the ecoregion where Ponderosa pine (*Pinus ponderosa*), sugar pine (*Pinus lambertiana*), and incense cedar (*Calocedrus decurrens*) often are found with Douglas-fir at the lower elevations.

Middle elevations are characterized by Pacific silver fir (*Abies amabilis*), western hemlock, Douglas-fir, and noble fir (*Abies procera*). High elevations have mountain hemlock/silver fir forests and subalpine parklands. The highest elevations on volcanic peaks support alpine heath, meadows, and fellfields (stony habitats with low mat and cushion plants) among glaciers and rock. Special habitats include riparian areas dominated by broadleaf species, wetlands, grassy balds, and oak woodlands. Cascade wetland types are highly variable and include wetland meadows fed by snowmelt, high elevation lakes with broad wetlands, bogs, and riparian wetlands that border streams.

2.1.5 Biodiversity of the West Cascades Ecoregion

Wildlife species richness is not as high in the West Cascades as it is in other temperate conifer forests, however the ecoregion is notable for comparatively high amphibian endemism. A diverse range of plant species including numerous endemics are found in the ecoregion but are especially concentrated near Mount Rainier in Washington and the Columbia River Gorge.

A number of amphibian targets are either West Cascade endemics or have a limited distribution. The Cascades torrent salamander (*Rhyacotriton cascadae*) and Larch Mountain salamander (*Plethodon larselli*) are restricted to the ecoregion, whereas Cope's giant salamander (*Dicamptodon copei*), Van Dyke's salamander (*Plethodon vandykei*), and the Cascades frog (*Rana cascadae*) occur only in the West Cascades and Pacific Coast ecoregions. Of these, the Larch Mountain and Van Dyke's salamanders and the Cascades frog are federal Species of Concern. Most of these amphibians are also closely associated with fast-moving, cold mountain streams.

Many large and wide-ranging mammals are declining throughout the West Cascades due to the loss of contiguous suitable habitat or as a result of declining forage. Wide-ranging carnivores including the gray wolf (*Canus lupis*), grizzly bear (*Ursus horribilis*), wolverine (*Gulo gulo*) and lynx (*Lynx canadensis*) have been extirpated from the ecoregion, while others such as mountain lion (*Felix concolor*) and black bear (*Ursus americanus*) persist as apparently stable, self-sustaining populations. Black-tailed deer (*Odocoileus heminonus*) and elk (*Cervus elaphus*) populations that expanded during the era of extensive logging are now declining as most logged areas that provided abundant forage have reforested. Ungulate herbivory is an increasing problem on private farmlands and young forest plantations due to declining browse on public lands. Mountain goats (*Oreamos americana*) occur only in the Washington portion of the ecoregion and exist in a number of small, scattered populations. Fire suppression has degraded critical mountain goat foraging habitat as conifers have invaded natural openings (WDFW 2003). The fisher (*Martes pennanti*) is a wide-ranging carnivore that has been extirpated from the ecoregion but reintroduced to a portion of the southern Oregon Cascades.

Most of the ecoregion's avian targets are forest passerines. Several species are considered at-risk due to loss of habitat. Extensive commercial harvest of older forest has reduced suitable habitat for the northern spotted owl (*Strix occidentalis caurina*) and the marbled murrelet (*Brachyramphus marmoratus*), which are now listed under the Endangered Species Act.

Only three reptiles were identified as targets in the West Cascades. The western pond turtle (*Clemmys marmorata*) is listed as an endangered species in Washington and a remnant population occurs in the Columbia River Gorge. The species has declined dramatically in Washington, but less so in the Oregon and California portions of its range.

Numerous invertebrates, including a number of beetles, butterflies and snails, are considered conservation targets within the ecoregion. The margins of the ecoregion contain fescue grasslands that attract the mardon skipper (*Polites mardon*), a federal candidate butterfly that is more commonly associated with the Puget Trough Ecoregion. Because of the long-term data collected by the Survey and Manage Program, the Cascades has among the most comprehensive inventories of freshwater mollusks. Furthermore, over 7,000 species of arthropods and terrestrial snails have been characterized in the two ecoregions (USFS and BLM 2001).

Loss, fragmentation and degradation of aquatic and riparian habitats, and old growth forests have contributed to the decline of a number of species within the ecoregion. Chinook salmon (*Oncorhynchus tshawytscha*), coho salmon (*Oncorhynchus kisutch*), bull trout (*Salvelinus confluentus*), and steelhead (*Oncorhynchus mykiss*) are among the well-known aquatic species at-risk within the ecoregion. Substantial efforts have been undertaken to protect these species.

The Columbia River Gorge and Mount Rainier National Park support high plant diversity including a number of rare and endemic species. Data collected by the Survey and Manage program has identified 98 species of fungi, ten lichens, and six bryophytes that are considered imperiled by NatureServe (Oregon Natural Heritage Information Center 2004). The extraordinary plant diversity and concentration of rare plants in the Columbia River Gorge is the result of a transition from coastal to interior climates that create an array of suitable habitats. The western Gorge has at-risk species associated with waterfalls and riparian areas such as cold water corydalis (*Corydalis aqua-gelidae*) as well as Howell's bentgrass (*Agrostis howellii*) that occurs in waterfall spray zones. A number of cliff garden species such as northern false coolwort (*Bolandra oregano*) are typical of Gorge endemics. Elsewhere, local endemics include Hells Canyon rockcress (*Arabis hastatula*) and Gorman's aster (*Aster gormanii*) found in smaller cliffs and rockpiles in Oregon's northern Cascades

2.1.6 Land Use and Ownership

Most of the region is forested, and is managed for forest production or values. As of 2001, approximately 1% of the ecoregion had been converted to urban and/or agricultural uses (NLCD 2001). Public lands comprise 63% of the ecoregion, with 78% of those lands managed by the USFS. (Table 2.1, Map 2.2).

The USFS manages the area from seven main offices: the Mt. Baker-Snoqualmie National Forest, the Gifford Pinchot National Forest, the Mount St. Helens Volcanic Monument, the Mount Hood National Forest, the Willamette National Forest, the Umpqua National Forest, and the Rogue River-Siskiyou National Forest. A significant percentage of the Gifford Pinchot, Mount Hood, and Willamette National Forest are within designated wilderness. The BLM manages land in both states, and the National Park Service has two large parks, Mt. Rainier and Crater Lake National Parks. Most of the remaining public land is managed by the Washington Department of Natural Resources. There are two small state forests in Oregon, and a number of small state parks, but the majority of the land is USFS or privately owned.

Table 2.1. Land Ownership in the West Cascades Ecoregion

Land Owner	Hectares	% of Ecoregion
United States Forest Service	2,071,800	48.9
Private	1,539,000	36.4
Bureau of Land Management	244,500	5.8
Other State Lands	161,400	3.8
National Park Service	129,900	3.1
Municipal Lands	52,600	1.2
State Parks and Special Designations	23,200	0.6
Tribal Lands	7,200	0.2
Department of Defense	1,500	0.1
United States Fish and Wildlife Service	1,200	0.1
The Nature Conservancy	1,100	0.1
Corps of Engineers	300	0.1
Other Federal Lands	200	0.1

Less than 0.2% of the West Cascades Ecoregion is under tribal ownership. In Washington, however, much of the ecoregion is within the ceded lands, and usual and accustomed fishing areas of tribes residing in the Puget Trough Ecoregion. Usual and accustomed areas are judicially defined areas where tribal members have fishing rights based on historical use patterns of their tribe. Tribes in Washington manage tribally-owned lands on reservations and are actively involved in research activities on ceded lands. Tribes are active participants in discussions about natural resources management and conservation activities within their usual and accustomed areas.

Outside the Interstate 5 corridor in Washington, the greater Vancouver area, and the lands around Springfield, private timber companies own much of the private land in the West Cascades Ecoregion. Forests have long been the foundation of the local economy in the West Cascades, and decades of logging put the region at the center of controversies over northern spotted owl conservation, logging of old growth forests, and management of federal lands. Most of the ecoregion’s population is found in small towns in the river valleys where increasing recreational uses supplement the traditional timber-based economy. Land uses range from intensive forestry to municipal supply watersheds to wilderness.

Small rural communities and dispersed settlements are located in the river valleys. The valleys are also grazed by livestock, used to produce hay and other crops, and are major travel corridors for tourists and commerce. Many towns are increasingly promoting recreational opportunities, including hiking, camping, fishing, hunting, birding, mountain biking and skiing, to supplement timber harvest revenue. However, timber harvest is expected to remain important to local West Cascades economies in the future.

2.1.7 Environmental Issues

Water quantity and quality in the Cascades is the best in any of the ecoregions in both Oregon and Washington. Extensive public ownership of the landscape has protected these upstream reaches from some of the disruptions common farther downstream. Also, the introduction of riparian rules into the Forest Practices Act regulations for private land over the last 30 years has reduced harvest impacts on riparian areas.

According to analyses by the USFS, the major factors that have influenced patterns of riparian condition in the western Cascades are (1) fire, (2) floods, (3) timber harvest and log transport, (4) road construction and residential development, and (5) flow regulation by dams (Oregon Progress Board 2000). In the absence of human activities, mesic riparian forests were not as susceptible as surrounding uplands to disturbance by fire. Therefore, prior to logging, riparian areas had relatively high densities of large conifer trees and were characteristic of late-successional forests of the Pacific Northwest. Timber harvest in streamside areas resulted in a 50% or more loss of the large conifers in many drainages of this ecoregion (ODFW 2006). Although streamside early-successional vegetation such as alders can regenerate relatively quickly, rebuilding the supply of large wood that provides habitat structure and complexity in the streams will require recovery times from decades to centuries.

Because of protection afforded by the Northwest Forest Plan, the prognosis for resident fish populations is fair to good throughout most of the region, but trends indicate a decline in the health of migratory salmon and trout populations. As in many ecoregions, better data on fish distributions and abundance are needed, including selected anadromous species, such as Chinook salmon and steelhead, and resident species, such as redband trout (*Oncorhynchus mykiss spp.*).

Most of the changes in the structure and function of the westside forests have been well documented in the comprehensive Forest Ecosystem Management Assessment Team (FEMAT 1993) report. This assessment outlined declines in old growth dependant species, and attempted to develop a strategy to assure the long-term viability of these species based on a system of reserves on public lands. The Northwest Forest Plan that was developed by the FEMAT refocused forest management to make protection of biodiversity the primary goal of federal lands. Today, more than two-thirds of the federal forest land in this ecoregion is managed for biological diversity in late successional reserves, riparian reserves, and extensive wilderness areas.

The legacy of intensive timber harvest has left much of the Douglas-fir zone, especially on private lands, in early successional stages (approximately 0-40 years of age). These stands are often very dense and lack key habitat attributes such as large trees, snags, downed wood, and a diversity of stand densities. Throughout the lower to mid-elevations, plantations established after timber harvest have higher tree densities and more simplified forest structure than what would be expected in forest stands shaped by natural disturbance. Despite their name, many late-successional reserves on federal land contain extensive areas of early seral stands, similar in character to some commercial timber plantations.

2.2 West Cascades Section Descriptions

Table 2.2. Sections of the West Cascades Ecoregion. (Map 2.1)

Section	Hectares	% of Ecoregion
Mount Rainier	812,300	19.2
Columbian Cascades	1,227,400	28.9
Middle Oregon Cascades	1,279,700	30.2
Umpqua Cascades	920,000	21.7
Total	4,239,400	100.0

2.2.1 Mount Rainier Section

This section receives greater accumulations of snow, and has more alpine and subalpine habitat than other West Cascades sections. Its topography is more rugged than those to the south. We used Watershed Assessment Unit (WAU) boundaries that captured the Goat Rocks but left most of the Cispus River watershed (except the uppermost portion in the Goat Rocks) in the Columbian section to the south. We included the valley of the Cowlitz River and small tributary WAUs in the Rainier section because of the inordinate geologic influence of Mount Rainier on this major valley bottom.

2.2.2 Columbian Cascades Section

Bisected by the Columbia River, this section is punctuated with isolated, tall volcanic cones such as Mount Hood and Mount Adams on the extreme eastern boundary of the section, as well as Mount St. Helens at its center. It has relatively little alpine and subalpine habitat. Due to their topography and vegetation, we used WAU boundaries that captured the Cispus River watershed (except Goat Rocks) and all Cowlitz tributaries that flow west out of the ecoregion. The southern boundary of the section is the ridge between the Clackamas River watershed (in this section) and the Santiam River watershed in the Middle Cascades to the south.

2.2.3 Middle Oregon Cascades Section

The "old Cascades" comprise most of the western part of this section, characterized by long ridges with steep sides and wide, glaciated valleys, and occasional remnants of long-extinct volcanoes. The young, tall volcanoes, Mount Jefferson, Mount Washington, the Three Sisters and Diamond Peak dominate the eastern edge of the section. The section has extensive lava flows, alpine and subalpine parklands, and numerous lakes, along with the most extensive mountain hemlock (*Tsuga mertensiana*) forests in the ecoregion. The Calapooya divide splits this from the Umpqua Cascades to the south.

2.2.4 Umpqua Cascades

The Umpqua Cascades is the southern-most section in the ecoregion. It is the warmest, driest and lowest elevation section in the West Cascades, with floristic and climatic similarities to the Klamath Mountains to the south and west. It has the greatest frequency of lightning strikes, and the highest natural fire frequency in the ecoregion as well, which results in a diverse low-elevation forest mosaic. Sugar pine (*Pinus lambertina*), incense cedar (*Calocedrus decurrens*) and Ponderosa pine (*Pinus ponderosa*) are a much more important component in this section than in the northern sections, and white and Shasta red fir (*Abies concolor* and *A. magnifica* ssp. *shastensis*) replace Pacific silver fir (*Abies amabilis*) and mountain hemlock at higher elevations.

2.3 East Cascades Ecoregion and Modoc Plateau

2.3.1 Geography

The East Cascades Ecoregion encompasses 7.6 million ha, extending from just east of the Cascade Mountains crest to the warmer, drier high desert to the east (Map 2.1). For purposes of this assessment, the boundary between the East and West Cascades Ecoregions follows the crest of the Cascades through Washington and Oregon. Also, due to the fact that many watershed assessment units on the eastern edge of the ecoregion extend into the neighboring Columbia Plateau Ecoregion, the total area assessed was 7.9 million ha. The boundary extends from the Sawtooth Range Ridge near Lake Chelan in Washington south across the Columbia River Gorge through Oregon and encompasses the Modoc Plateau in northeastern California. As such, the East Cascades Ecoregion is a transition zone, from the high mountains to the arid interior, with the eastern border following the Ponderosa pine forest – lowland shrub-steppe/western juniper transition into the Columbia Plateau Ecoregion.

The Upper Klamath Basin and the Modoc Plateau are large land forms that characterize the southern portion of the ecoregion. The Modoc Plateau has a diverse geography, with portions draining into closed basins such as Goose Lake and Surprise Valley, and most of the remainder draining into the Pitt River, a tributary of the Sacramento River. These areas contain a series of broad, relatively flat mid-elevation valleys that once supported a vast expanse of lakes and marshes that drained into the Klamath River. Upper Klamath Lake is Oregon's largest lake and is the biggest remnant of this wetland system. Most of these wetlands have been drained and converted to agriculture. Much of the remainder of the East Cascades to the north in Oregon is drained by the Deschutes River system, which includes a series of large lakes and reservoirs near its headwaters.

2.3.2 Geology

The East Cascades in Washington and northern Oregon resulted from tectonic uplift and subsequent erosion by alpine glaciers and landslides. The combination of these processes and volcanic activity created rugged ridges extending southeast to east from the Cascade crest. Broad valleys occupy the lowlands between the mountain ridges. Isolated volcanic cones occupy steep mountain ridges, but tend to be smaller than those in the Western Cascades with the exception of Mount Adams. The East Cascades have diverse geological characteristics, including large serpentine areas in the Wenatchee Mountains. The typical elevation range is between 2,000 and 7,000 feet. Mount Adams is the highest peak at 12,276 feet. The lowest elevation is in the Columbia River Gorge at 100 feet.

Overall, the slopes on the east side of the Cascade Mountain range are less steep and cut by fewer streams than the West Cascades Ecoregion. The East Cascades' volcanic history is evident through numerous buttes, lava flows, craters, and lava caves, and in the extensive deep ash deposits created by the explosion of historical Mount Mazama during the creation of Crater Lake, and recent activity near Mount Lassen. However, the Warner and other small mountain ranges are older, and contain characteristics of some of the desert mountain ranges from the adjacent Northern Great Basin.

2.3.3 Climate

There is a dramatic moisture gradient across the ecoregion as the precipitation diminishes from the cold, wet Cascade crest (up to 120 inches of precipitation per year) to the warm, dry eastern border with the Columbia Plateau and Great Basin (less than 20 inches per year). Most precipitation accumulates from November through April. A snow pack develops at higher elevations. Precipitation also changes significantly from north to south, with annual rainfall below 12 inches per year in portions of the Modoc Plateau in California.

2.3.4 Vegetation

This ecoregion has one of the most extensive Ponderosa pine forests in the western U.S., occurring in all parts of the ecoregion, from Wenatchee to Mount Lassen. At mid elevations, there are areas of Douglas-fir and grand fir (*Abies grandis)* forests to the north, and white fir and Douglas-fir forests to the south. The ecoregion includes a large pumice zone in central Oregon, dominated by lodgepole pine (*Pinus contorta*), one of the very few places where the species is the climax tree (not replaced by other conifers if fire is suppressed). Oregon white oak (*Quercus garryana*) woodlands occupy lower elevations near the Columbia River in the central portion of the ecoregion and also the western parts of the Modoc and Upper Klamath Basin sections in the south. Subalpine fir (*Abies lasiocarpa*), mountain hemlock (*Tsuga mertensiana*) and Engelmann spruce (*Picea engelmannii*) are found at higher elevations, with mountain hemlock replaced by Shasta red fir in the Upper Klamath Basin. Whitebark pine (*Pinus albicaulis*), lodgepole pine, and western larch (*Larix occidentalis*) are common components of many of these forests. In the Modoc Plateau, Douglas-fir becomes less important, western white pine (*Pinus monticola*) woodlands dominate many areas, and Jeffrey pine (*Pinus jeffreyi*) and Washo pine (*Pinus washoensis*) occur with or replace ponderosa pine.

Historically, fires occurred at irregular intervals from under 10 years in the lowland foothills to 150 years or more at high elevations. Forest stand patterns on the landscape often reflect this complex fire history. In some areas, decades of fire suppression have resulted in large areas of dense, fire-prone forest. Shrub-steppe vegetation composed of big sagebrush (*Artemesia tridentata*) or antelope bitterbrush (*Purshia tridentata*) and native bunchgrasses occurs along the foothills and higher south-facing slopes.

The southern portion of the ecoregion has extensive valleys and flatlands between the forested mountains and foothills, which include large marshes, irrigated meadows and pastures, and arid juniper and sagebrush steppes. These habitats are a critical part of the Pacific flyway, supporting vast numbers of shorebirds and waterfowl, the densest wintering concentration of bald eagles in the world, and many other wildlife species.

2.3.5 Biodiversity of the East Cascades Ecoregion

The variety of habitat types in the East Cascades has led to a unique and diverse flora and fauna. An abundance of species are supported by high elevation meadows, parklands and forests: low-elevation dry forests, oak woodlands, cliffs and talus slopes, riparian corridors, and a variety of aquatic habitats. Numerous lakes, reservoirs and marshes characterize the East Cascades, providing exceptional habitat for waterfowl, shorebirds and wading birds, aquatic mammals, amphibians, fish, aquatic plants and invertebrates. In fact, the East Cascades support an unusually high aquatic biodiversity among ecoregions in the U.S., including a large number of endemic freshwater snails and fish.

Large mammals are emblematic of the ecoregion, which supports populations of elk, black-tail deer, mule deer, bighorn sheep, mountain lions, and black bears. Mountain goats inhabit high elevations in the central and northern part of the ecoregion in Washington, but are largely absent from the southern portion of their range, and absent from Oregon. Grizzly bears and gray wolves no longer occur in the ecoregion, however lynx and wolverines may occasionally visit the northernmost portions. Fisher, once common in this ecoregion, now occurs only in the extreme southwestern portion of the East Cascades. The western gray squirrel is at-risk within the ecoregion in Washington as it is restricted to two isolated populations, but populations in Oregon and California are more robust.

Wetlands in the ecoregion are home to many birds including bald eagles, geese, ducks, herons, cranes, rails, and various songbirds. Golden eagles (*Aquila chrysaetos*) inhabit a small portion of their historical ranges and are limited in distribution while the peregrine falcon (*Falco peregrinus*) is making a comeback. The threat of catastrophic wildfire and competition with barred owls (*Strix varia*) are concerns for the conservation of the spotted owl, a federally listed species that occurs within the ecoregion.

The western pond turtle is listed as an endangered species in Washington, although it has more robust populations in the Oregon and California portions of its range. The largest wild population in Washington occurs within the ecoregion in the Columbia River Gorge.

Anadromous fish such as steelhead, coho and Chinook salmon inhabit East Cascade streams and rivers. Their distribution and numbers are significantly reduced, particularly due to dams that restrict their passage through much of the ecoregion. Rainbow (*Oncorhynchus mykiss*) and cutthroat trout are the common cold water inhabitants. Bull trout occur within the ecoregion but their range has been significantly reduced. Kokanee (*Oncorhynchus nerka*) can be found in lakes in the northern and central portions of this ecoregion in Washington. The federally-listed Lost River sucker (*Deltistes luxatus*), and shortnose sucker (*Chasmistes brevirostris*), bull trout, and salmon stocks drive many of the conservation activities in the ecoregion.

Meadow endemics characterize the most at-risk flora within the East Cascades. Applegate's milk vetch (*Astragalus applegatei*) is Oregon's most endangered plant, found in valley bottom meadows in the Klamath Basin. Pink-root yampah (*Perideridia erythrorhiza*) is another very rare, threatened endemic, found in meadows around Klamath Lake. Another southern Oregon endangered endemic is Oregon semaphore grass (*Pleuropogon oregano*), located in montane meadows. In northern Oregon, long-bearded sego lily (*Calochortus* *longebarbatus var. longebarbatus*) is endemic to drier meadows, and is recovering from over-grazing and fire suppression, while pale blue-eyed grass (*Sisyrinchium sarmentosum*) is endemic to wet meadows, mostly east of Mount Hood.

In Washington, the Wenatchee Mountains have a concentration of rare and endemic plants, second only to the Columbia River Gorge. This includes a few at-risk species located near Leavenworth: the federally Endangered showy stickseed (*Hackelia venusta*) and Oregon checker-mallow (*Sidalcea oregana var. calva*), as well as the Wenatchee larkspur (*Delphinium viridescens*) that occurs in mid-montane meadows.

A few endemics are restricted to ash and pumice habitats in the East Cascades. Anxious milkvetch (*Astragalus anxius*) is the most rare, found in two places in California's Modoc Plateau. Pumice grape fern (*Botrychium pumicola*) is found only on bare ash in openings in the pumice zone and on high pumice ridges near the Cascade Crest.

2.3.6 Land Use and Ownership

Public lands in the East Cascades comprise 61% of the ecoregion, with the USFS accounting for 73% of that area (Table 2.3, Map 2.2). The ecoregion includes all of the Wenatchee, Deschutes, Winema, Fremont, and Modoc National Forests, and part of the Gifford Pinchot and Mount Hood National Forests. The region also has significant first nation ownership, with large areas owned and managed by the Yakama Nation and the Confederated Tribes of Warm Springs, accounting for about 6% of the ecoregion. Other major landowners in the East Cascades ecoregion include the BLM in southern Oregon and California, the Washington Department of Natural Resources, WDFW, ODFW and private timber companies.

Table 2.3. Land ownership in the East Cascades and Modoc Plateau Ecoregion.

Land Owner	Hectares	% of Ecoregion
United States Forest Service	3,788,947	47.9
Private	2,637,889	33.3
Bureau of Land Management	577,058	7.3
Tribal Lands	450,642	5.7
State Parks and Special Designations	124,769	1.6
Other State Lands	121,818	1.5
National Park Service	95,530	1.2
United States Fish and Wildlife Service	89,102	1.1
The Nature Conservancy	19,946	0.3
Other Federal Lands	4,767	0.1
Municipal Lands	500	0.1
Department of Defense	52	0.1

In Washington, much of the ecoregion is within the ceded lands and usual and accustomed fishing areas of tribes. The tribes manage tribally-owned lands on reservations and are also involved in monitoring and research activities on ceded lands. Tribes are active participants in discussions about natural resources management and conservation activities within their usual and accustomed areas.

Dominant land uses are forestry, livestock grazing, recreation and conservation. In Washington and the rapidly developing areas around Bend in Oregon, timber companies have recently begun to sell their lands in the mid-elevation forest and transition zones to developers. In Washington and California, less than 2% of the ecoregion had been converted to agricultural or human uses by the early 1990s and has increased over the past decade. By 2001, 5% of the ecoregion was converted, with the majority of that occurring in Oregon near Bend, Klamath Falls, and Lakeview (NLCD 2001). The development that has occurred in Washington is concentrated in the Chelan, Wenatchee, upper Yakima and Little White Salmon valleys.

2.3.7 Environmental Issues

Past forest practices and fire suppression have transformed open, park-like stands of Ponderosa pine or western larch into young, dense mixed-species stands. These current mixed-conifer forests are at increased risk of forest-destroying crown fires, disease, and damage by insects. Shading from encroaching trees and fire suppression have reduced the vigor of shrubs, particularly bitterbrush, an important forage plant for mule deer. Efforts to reduce fire danger and improve forest health may help restore habitats but require careful planning in order to provide important habitat features (e.g., snags, downed logs, hiding cover). Similarly, reforestation efforts that follow wildfires should be carefully planned to create stands with suitable tree diversity, understory vegetation and natural forest openings.

Increasing home and resort development in forested habitats makes prescribed fire difficult in some areas and increases the risk of high-cost wildfires. Although many urban-interface “fire proofing” measures can be implemented with minimal effects to wildlife habitat, some poorly-planned efforts have unintentionally and unnecessarily harmed habitat.

Enormous efforts were undertaken in the 1900s to drain vast acreage of wetlands in the upper Klamath Basin for agriculture. As a result, the great shallow lake and marsh systems of the basin have been reduced by an estimated 75% (Oregon Progress Board 2000). Today the Klamath Project, the largest of many irrigation projects in the region, provides irrigation for approximately 230,000 acres in southern Oregon and northern California.

Many of the Klamath Basin’s historical wetlands are now used for crops such as cereal grains, alfalfa hay, potatoes, onions, sugar beets, and cattle grazing. Runoff from these agricultural lands delivers increasing amounts of nutrients and sediments into Upper and Lower Klamath Lakes. Reductions in riparian vegetation and associated wetlands have contributed to this problem by decreasing the potential for nutrient filtration and uptake in streamside areas. Riparian areas throughout the Klamath Basin have been highly altered and, in many cases, eliminated by agricultural activities. Despite the losses, large marshes are still found in this region, concentrated mostly in the Klamath Basin around Upper Klamath Lake and Klamath Marsh.

2.4 East Cascades and Modoc Plateau Section Descriptions

Table 2.4. Sections of the East Cascades and Modoc Plateau Ecoregion. (Map 2.1)

Section	Hectares	% of Ecoregion
Wenatchee	895,000	11.3
Yakima	716,000	9.0
Eastside Oak	845,000	10.7
Pumice and Pine	1,342,000	17.0
Upper Klamath Basin	2,018,000	25.5
Modoc Plateau	2,096,000	26.5
Total	7,912,000	100.00

2.4.1 Wenatchee Section

This section is part of the old North Cascades subcontinent. The Cascade range is wider in average width in this section than in sections to the south. Uplifted Mesozoic metasedimentery rocks that were heavily influenced by glaciation characterize the geology of the section. The Wenatchee Mountains with their associated concentration of rare plants and serpentine soil are also characteristic. This section has high elevation and highly dissected landscapes, which support the greatest area of alpine and subalpine parklands in the East Cascades. Ponderosa pine, Douglas-fir, grand fir and subalpine fir form major forest zones on the drier east side of this area, whereas Pacific silver fir, mountain hemlock, western hemlock and western redcedar form prominent forest zones in the western edge of the ecoregion as it transitions to the West Cascades. Subalpine larch (*Larix lyallii*) and whitebark pine (*Pinus albicaulis*) form prominent zones as forests approach timberline. The southern boundary follows a combination of geological and zonal-vegetation features above the Yakima River valley bottom cutting across the northern most portions of the Yakima River drainage. The northern boundary is the Methow River-Lake Chelan divide.

2.4.2 Yakima Section

This section has high elevation ridges composed of eroded Tertiary Cascade volcanoes along the crest and lower elevation, folded Columbia River basalt ridges along the foothills. Here, the width of the Cascades is narrower and has lower elevation than in the Wenatchee section. Alpine and subalpine parklands extend along ridges eastward up to 11 miles from the crest. Ponderosa pine, Douglas-fir, grand fir and subalpine fir are the section's major forest zones with Pacific silver fir, mountain hemlock, western hemlock and western red cedar creating prominent forests in West Cascades transition zones. Ponderosa pine with isolated Oregon white oak stands form lower treeline woodlands. The boundary with the Wenatchee section is drawn to include the Yakima River valley bottom, which contains recent glacial deposits and basalt bedrock characteristic of the Yakima section. The Yakima-Eastside Oak section boundary follows the Toppenish-Lower Yakima Water Resource Inventory Area (WRIA) line and includes the upper most WAUs of the Klickitat associated with the Goat Rocks.

2.4.3 Eastside Oak Section

Although this section is the driest and lowest in elevation in the East Cascades, it has alpine and subalpine parklands associated with Mount Adams and Mount Hood. Columbia River basalt, volcanic rocks and deposits form broader less-dissected slopes than the sections to the north. Oregon white oak, with and without Ponderosa pine, is characteristic of the lower treeline of this section, which includes all of the Satus Mountains. The Yakima-Eastside Oak section boundary follows the Toppenish-lower Yakima WRIA line and includes all but the upper most WAUs of the Klickitat that are associated with the Goat Rocks. In Oregon, the break between this section and the Pumice and Pine section is the divide between the White River and Warm Springs River drainages.

2.4.4 Pumice and Pine

This section comprises most of the central Oregon portion of this ecoregion. It includes Paulina Peak, Black Butte, Mount Batchelor and Broken Top as well as Mount Jefferson, the Three Sisters and Diamond Peak along the western edge. It includes the expansive Ponderosa pine zone, occupying most of the northern part of the section, and the large area of lodgepole pine on the deep pumice deposits from the great explosion of Mount Mazama 6,000 years ago, which created Crater Lake. It has the lowest relief in the ecoregion, and contains some of the most extensive pine forests remaining in the western U.S.

2.4.5 Upper Klamath Basin

This section is split from the Pumice and Pine section by the watershed break between the Deschutes and Klamath Basins. To the east, areas which drain into Goose Lake are in the adjacent Modoc Plateau section. The section is characterized by the Klamath Lakes, which are remnants of giant Pleistocene lakes that contained some of the most extensive wetland systems in the U.S. Alpine and subalpine habitats are limited to the Sky Lakes and Crater Lake areas at the northwest edge of the section. The area has extensive mid-montane Ponderosa pine forests and fairly diverse valley areas, with a mix of shrub-steppe vegetation from the east and south, and occasional chaparral and oak habitats from the west. The southwestern boundary with the Klamath Mountains has particularly high biodiversity, due to the low elevations (4,000 feet) of the Cascades crest in this area.

2.4.6 Modoc Plateau

This section includes Goose Lake, the Warner Mountains, and the basins of the Modoc Plateau. The area is underlain primarily by Miocene to late Pleistocene volcanics and there are numerous geothermal areas, some of which are being considered for development. The section receives little precipitation (< 20 inches, mostly as snow) and much of the runoff is captured in closed-basin alkaline lakes. The southern part of the plateau is drained by the Pit River system. Ecosystems of the Plateau are influenced by proximity to the Great Basin and the Sierras. Forested areas include ponderosa, knobcone and Jeffrey pine, western juniper, and aspen and oak woodlands. There are also extensive shrublands and grasslands that are similar in composition to those to the east of the Plateau.

Chapter 3 – The Assessment Process

This ecoregional assessment was led by a core team composed of the major partners and collaborators (see Acknowledgements). The core team was responsible for determining the basic direction of the assessment process, setting timelines for work products, and maintaining progress towards the completion of the assessment. The core team met quarterly in order to update the partners involved and to review progress on various aspects of the assessment. The core team oversaw the work of six technical teams: terrestrial communities and systems, freshwater systems, plant species, wildlife species, fish species, and GIS/data management. Each technical team contributed to the steps described below and adopted innovations when necessary to address specific data limitations and other challenges.

This assessment followed a framework developed by Groves et al. (2000, 2002). The analysis results in three main products: a conservation portfolio, irreplaceability values for all assessment units, and a set of alternative portfolios. The assessment process can be broken into seven parts: (1) identify conservation targets; (2) assemble GIS data on locations of targets; (3) set goals for each target, (4) create a suitability index; (5) generate a draft integrated portfolio; (6) refine the draft portfolio through expert review; and (7) prioritize the assessment units and conservation areas.

3.1 Identify Conservation Targets

Conservation targets are those elements of biodiversity (plants, animals, plant communities, habitat types, etc.) that are represented in the analysis. Targets were selected to represent the full range of biodiversity in the ecoregion and to include any elements of special concern.

Robert Jenkins developed the concept of coarse-filter and fine-filter conservation targets for use in conservation planning (Jenkins 1996, Noss 1987). This approach hypothesizes that conserving multiple examples of all communities and ecological systems (coarse-filter targets) will also conserve the majority of species that occupy them. This method attempts to compensate for the lack of detailed information on the vast number of poorly-studied invertebrates and other species.

Fine-filter targets are species which either are not captured by coarse-filter targets or warrant special attention to ensure they are represented in the portfolio. They are typically rare or imperiled species but can include wide-ranging species or species that have genetically important disjunct populations. Unlike fine-filter targets for which there is an existing taxonomy, many coarse-filter targets had to be defined specifically for these ecoregions (see Chapter 4).

3.2 Assemble Information on the Locations of Targets

Data were assembled for target “occurrences” (e.g. the location of species populations, communities, or the spatial extent of a habitat or ecological system) from a variety of sources. Terrestrial data was gathered for the extent of both ecoregions, and freshwater data was gathered for the 11 Ecological Drainage Units (EDUs) that intersect those two ecoregions. Agency databases make up the bulk of these data, but the technical teams also assembled other readily available data and consulted specialists for specific target groups. The target data for plants and animals were screened by examining each record’s age and precision. Records considered too old or imprecise were excluded from the analysis. For some targets, data was only available for a small portion of their range, and therefore these data were usually excluded from the analyses to prevent skewing the result.

Decisions were made by the technical subteams regarding the best way to describe and map occurrences of each target depending on the life stage or habitat represented by the spatial data. Targets are represented in a GIS as points for specific locations, such as rare plant population locations, or polygons to show the spatial extent of fine- or coarse-filter targets.

3.3 Set Goals for Each Target

The analytical tool MARXAN, used for optimal site selection, requires a numerical conservation objective for each target. These conservation objectives, or goals, are expressed as number of occurrences or land area and they largely determine the number of assessment units or the amount of land included in the portfolio.

The goals represent our best effort at ensuring long-term survival of species, and are set based on the distribution and rarity of each target. Hence, the goals are a device for assembling a portfolio of conservation areas that captures multiple examples of the ecoregion's biodiversity (Tear et al. 2005). These goals also provide a benchmark for measuring the progress of conservation in the ecoregion over time. See Chapter 8 for more details.

3.4 Develop a Suitability Index

For purposes of analysis, each ecoregion and EDU was divided into a total of almost 8,000 assessment units (AUs; Map 3.1, described in Chapter 8.2). The selection of AUs was influenced by a "suitability index," which was intended to indicate the relative likelihood of successful conservation at an AU. The index was based on the judgments of the team and other experts. The index included factors likely to impact the quality of the habitat for native species, such as the extent of roads or developed areas, or the presence of dams, as well as factors likely to impact the cost of managing the area for conservation, such as proximity to urban areas, the percent of public versus private lands, or the existence of established conservation areas. Another consideration in building the suitability index was the availability of GIS data for each of the potential factors. Separate suitability indices were derived for terrestrial and aquatic analyses (described in Chapter 6).

The suitability index influences the final selection of conservation areas when the algorithm must choose between potential locations (i.e. there are more targets available than needed to meet conservation goals). Some factors in the suitability index are related to matters of conservation policy. For example, structuring the index to favor public over private land presumes a policy of using existing public lands to conserve biodiversity wherever possible, thereby minimizing the involvement of private or tribal lands.

3.5 Generate an Integrated Draft Portfolio

An ecoregional assessment entails hundreds of different targets existing at thousands of locations, therefore the relative biodiversity value and relative conservation suitability of thousands of AUs must be evaluated. This complexity precludes simple inspection by experts to arrive at the most efficient set of potential conservation areas. To deal with this complexity, we used the optimal site selection algorithm MARXAN (Ball and Possingham 2000). MARXAN (or its predecessors SPEXAN and SITES) has been used for a variety of terrestrial and aquatic conservation assessments around the world (Beck and Odaya 2001, Andelman and Willig 2002, Noss et al. 2002, Lawler et al. 2002, Leslie et al. 2003, Carroll et al. 2003). MARXAN finds reasonably efficient solutions to the problem of selecting a system of spatially cohesive reserves (Possingham et al. 2000, McDonnell et al. 2002).

To use MARXAN, we input data describing the target locations and the conservation suitability of each of the thousands of AUs in the two ecoregions. The number of targets, amount of each target, and rarity of targets present in a particular AU determines its biodiversity value. Data for both terrestrial and aquatic targets and terrestrial and aquatic suitability are used in the analysis to arrive at an integrated portfolio (Chapter 8).

MARXAN begins by selecting a random set of AUs, i.e., a random conservation portfolio. The algorithm then iteratively explores improvements to this initial portfolio by randomly adding or removing AUs. At each iteration the new portfolio is compared with the previous portfolio and the better one is accepted. The algorithm uses a method called simulated annealing (Kirkpatrick et al. 1983) to search for the optimal portfolio, thus greatly increasing the chances of converging on a highly efficient portfolio. Typically, the algorithm is run for one to two million iterations. Ten or more replicate runs of the algorithm are executed and the "best" run, i.e., the most efficient run, is used in the next step of portfolio development.

The size of the conservation portfolio is mainly determined by the goals – the larger the goals, the larger the portfolio. The goals used for our portfolio represent just one policy option for the conservation of native biodiversity. To illustrate that there are a range of policy options for biodiversity conservation, we also generated "lower" risk and "higher" risk portfolios after the medium risk portfolio was finalized through expert review.

3.6 Refine Draft Portfolio through Expert Review

MARXAN is a decision support tool that analyzes data to generate a conservation portfolio. Expert review and revision are necessary to compensate for various shortcomings of the input data. Experts reviewed the draft portfolio to correct errors of omission or inclusion by the computer-driven process. These experts also assisted with refining boundaries of potential conservation areas. Nine meetings with experts were held throughout the two ecoregions to solicit expert opinions regarding the portfolio. Despite drawbacks of possible bias associated with expert opinion, we believe the process of finding and fixing errors in the portfolio greatly enhanced the output of the data analysis. After incorporating input from reviewers, the final set of AUs was grouped into Portfolio Sites (or Priority Conservation Areas). Lower and higher risk portfolios were developed, but they were not subjected to expert review.

3.7 Prioritize Assessment Units and Conservation Areas

Limited resources and other social or economic considerations may make protection of the entire portfolio impractical. This situation can be addressed two ways. First, we should narrow our immediate attention to the most important conservation areas within the portfolio. This can be accomplished by prioritizing potential conservation areas. Second, we should provide decision makers with the flexibility to pursue other options when portions of the portfolio are too difficult to protect. Assigning a relative priority to all assessment units in the portfolio will inform decision makers about other options for conservation.

The prioritization of potential conservation areas was based on the irreplaceability and suitability index scores of AUs that comprise each area (Chapter 9). To give a sense of their relative priorities, the mean irreplaceability and mean vulnerability (or the inverse of suitability) index scores of each conservation area are depicted in a scatterplot. This method is similar to those of Pressey et al. (1996, as described by Margules and Pressey 2000), Noss et al. (2002), and Lawler et al. (2003). Irreplaceability indicates the conservation value of an area as measured by the number of times each assessment unit was picked by the model. The suitability index was a surrogate for "vulnerability" which is meant to indicate the degree of threat to biodiversity. The more vulnerable a potential conservation area or portfolio site is thought to be, the greater the urgency for conservation action, while those areas which are less vulnerable may already be managed for conservation, or may be more easily protected in the future.

Chapter 4 – Targets

Conservation targets are those elements of biodiversity (plants, animals, habitat types, etc.) that are represented in the analysis. Targets were selected to represent the full range of biodiversity in the ecoregion and to include any elements of special concern.

4.1 Terrestrial Ecological System Targets

4.1.1 Selecting Targets

The technical team chose to use ecological systems to represent the coarse scale vegetation and habitat types in the ecoregional assessment. A terrestrial ecological system is defined as a group of plant community types (associations) that tend to co-occur within landscapes with similar ecological processes, substrates, and/or environmental gradients (Comer et al. 2003).

We relied on available interpretations of vegetation and ecosystem patterns across the study area and reviewed associations of the International Vegetation Classification/National Vegetation Classification (IVC/NVC) in order to help define the limits of systems concepts (NatureServe 2004). Upland and wetland ecological system units are defined to emphasize the natural or semi-natural portions of the landscape. Areas with very little natural vegetation, such as agricultural row crops and urban landscapes, are excluded from ecological systems.

Ecologists from WANHP, ORNHIC and NatureServe developed a list of 68 ecological systems that occur within the West Cascades and East Cascades-Modoc Plateau Ecoregions (Appendix 4A). Sixty-six of these 68 systems occur in the East Cascades and Modoc Plateau ecoregion: three Alpine, 32 Forested, 11 Shrubland, six Grassland, 11 Wetland, and three Sparsely Vegetated Ecosystems. In the West Cascades Ecoregion, 38 ecosystems occur: two Alpine, 18 Forested, five Shrublands, five Grasslands, six Wetlands, and two Sparsely Vegetated Ecosystems.

This list of system types was drawn from the NatureServe Ecological System classification for North America (Comer et al. 2003). Appendix 4B contains a NatureServe report with definitions of the 68 ecological systems for the two ecoregions.

More systems occur in the East Cascades - Modoc Plateau because many of the West Cascades forested systems spill over onto the Eastern Cascades, in addition to several forested ecosystems that occur only on the interior, and several sagebrush and steppe ecosystems that occur only on the east side and on the Modoc Plateau.

4.1.2 Collecting Ecological Systems Data

We developed three GIS layers (maps) to represent the diversity of vegetation across the ecoregion.

Vegetation Map of Ecological Systems

A wall-to-wall map of ecological systems for the East and West Cascades Ecoregional Assessment was created by crosswalking several existing vegetation coverages together (Map 4.1). For the East Cascades, several National Forests (Deschutes, Fremont, Gifford Pinchot, Wenatchee and Winema-Fremont) and Crater Lake National Park, contributed their latest 1:24,000 vegetation maps. The recent Southwest regional Gap Analysis Program (ReGAP) vegetation maps for U.S. Department of Agriculture (USDA) zones 8 and 9, which mapped ecological systems at 1:100,000 scale, were used for large areas of the northern portion of the ecoregions. “Calveg,” the classification produced at 1:100,000 scale by the California Department of Forestry and Fire Protection, was used for the California extent of the Modoc Plateau section of the East Cascades. USFS 'Plant Association Group' (PAG) maps, highly detailed vegetation models linking forest types with local site factors, were used for the vast majority of the West Cascades. Areas with no detailed vegetation coverage, only a small portion of the East Cascades, were filled in with coarser data such as Oregon Gap Analysis Program (GAP) data circa 1999. These source maps were then tiled together in a GIS environment and crosswalked to a single suite of ecological systems known to occur in the ecoregions that could be mapped on an ecoregion-wide scale. Some map units were a combination of small patch systems (for example, montane shrubland and alpine systems). Finally, the 1:100,000 scale National Landcover Dataset was used to identify areas converted to agriculture and urban areas. These converted lands would not be counted towards coarse-filter goals.

Late Seral Forests

Seral stage information was inferred from the quadratic mean diameter (QMD) data developed by the Interagency Vegetation Mapping Project (IVMP 2002). As bounded by the diameter at breast height (DBH) classes within the dataset, we classified all forests larger than 30 inches QMD in the West Cascades and 20 inches QMD in the East Cascades as late seral. This data was not continuous over the full extent of the eastern portions of the planning area. Therefore, late seral information was obtained from the Modoc National Forest for a portion of that sub-section.

Minimum Dynamic Areas

We aggregated mapped polygons of ecological systems into a lower elevation forests and higher elevations forests, and in areas with at least 30,000 ha of continuous forest. This is based on the average area burned in a 25 year period (fire history from 1400-2000 AD, Berkley et al 2002, Weisberg and Swanson 2002), and that the size will account for 20-50% of a given area being burned. Therefore, 30,000 ha should be able to support healthy forests with frequent, low intensity fires and occasional high intensity fires, for at least 100 years. We customized which ecological systems were aggregated by section, as each section had a different suite of forested systems. West Cascade forests appear on the landscape in lower and upper elevational bands, while the East Cascade and Modoc Plateau, being such a narrow and steep gradient, were not separated by elevation. Details of which ecological systems were included in each aggregated set are available in Appendix 4D.

4.1.3 Data Gaps

Matrix-forming systems by definition contain considerable environmental and ecological variation. Our means of accounting for this internal heterogeneity was to stratify the matrix-forming systems by landforms. The accuracy of these map units is scale-dependent. While the map of systems is appropriate for use at the ecoregional level, this information should be regarded as a coarse-scale representation of the potential distribution of existing vegetation.

There is incomplete seral-stage data for the East Cascades, and datasets available for portions of the two ecoregions were in coarse and sometimes dissimilar categories. Non-forested systems are not always well identified, as there is no consistent and comprehensive wetland classification and GIS dataset for the areas within the two ecoregions. Therefore, biologists from the Oregon and Washington Heritage Programs crosswalked existing data to identify the most important wetland areas. Also, grasslands in general are not handled well by the datasets and imagery was used to identify terrestrial systems.

4.2 Terrestrial Plant Species and Plant Association Conservation Targets

4.2.1 Selecting Targets

Rare plant species and unique plant associations are nearly always included as conservation targets in ecoregional assessments (Groves 2003). Rare plant species include those taxa threatened by habitat loss or change as well as species whose status is relatively secure but are endemic to an ecoregion. Using Natural Heritage ranking terminology (NatureServe 2006), species with global status ranks (G ranks) of G1 and G2 are always conservation targets while species with lower ranks (G3, G4 or G5) are included as targets on a case by case basis. Potential target species were evaluated by their G rank, S or state rank, distribution (endemic, peripheral, disjunct, limited or widespread), rate of decline, or other factors that may identify them as a target for conservation. Unique plant associations as determined by Natural Heritage Programs are included as conservation targets based on many of the same criteria as rare plants, such as rarity, threats and endemism. However, because of limited distribution data and changing classifications, only selected wetland plant associations were considered for conservation target selection in the East and West Cascades Ecoregions.

4.2.2 Data Sources and Data Screening

The plant species conservation target list for the East and West Cascades Ecoregional Assessment was developed primarily from input and data maintained by state heritage programs: WANHP, ORNHIC, and California Natural Diversity Data Base (CNDDB). Each program provided records for plant species that were located within the ecoregional boundaries, inclusive of a 5 km buffer extending beyond the boundaries. The data included all pertinent information for element occurrence records (EORs) including location, date of last observation, species identification, global and state ranks, mapping accuracy, and spatial distribution. This initial list consisted of 499 targets, including a number of duplicate taxa with different names. After the duplicate taxa (n=86) were eliminated, the list contained 413 taxa. This list was then sent out for review with instructions to evaluate the taxa as conservation targets for the ecoregions and to propose additions and deletions.

Several additional sources for rare plant information were recommended and checked against the draft list. These sources included the Interagency Survey and Manage Species (ISMS) database maintained by the USFS for the Northwest Forest Plan, Willamette Valley-Puget Trough-Georgia Basin Ecoregional Assessment (Floberg et al. 2004), USFS Sensitive Species List—Region 6, and the Warm Springs Indian Reservation species of concern list (Helliwell 1988).

4.2.3 Plant Species Targets

Incorporating comments from reviewers and potential targets from additional sources resulted in a list of 426 taxa. These taxa were then evaluated for their inclusion as conservation targets resulting in recommendations of 182 taxa (Appendix 4D). This final list includes 123 taxa in the East Cascades- Modoc Plateau, and 92 taxa in the West Cascades (Table 4.1).

Table 4.1. The final plant target list by functional groups.

Ecoregion	Liverwort	Moss	Lichen	Fungus	Non-vascular	Vascular	All groups
East Cascades	0	1	3	1	7	111	123
West Cascades	7	4	10	1	3	69	92
Common to both	0	1	3	1	3	25	33
Total	7	4	10	1	7	155	182

Most plant targets are vascular plants (85%), the functional group that is most well known. However, lower plant taxa are well represented as conservation targets in these ecoregions and they have been a particular focus of surveys within the National Forests that are covered in the Northwest Forest Plan (FEMAT 1993).

Table 4.2. The final plant target list by global ranks.*

Ecoregion	Number of targets with Grank of:						
	G ?	G 1	G 2	G 3	G 4	G 5	All ranks
East Cascades	1	11	29	40	26	16	123
West Cascades	1	10	17	25	30	9	92
Common to both	1	1	6	10	12	3	33
total	1	20	40	55	44	22	182

* Considers species having T ranks as being synonymous with G Ranks. T ranks reflect the imperilment or rarity of varieties or subspecies.

While most plant conservation targets are imperiled or vulnerable species (G1-G3; 63%) there are a considerable number of lower ranked species (G4-G5) that are included as targets. Many of these are endemic species that may be relatively abundant and relatively secure in terms of threats, but still represent important aspects of biodiversity in the ecoregion.

4.2.4 Plant Association Conservation Targets

Known locations of rare natural communities, also known technically as plant association occurrence data, were obtained from the WANHP database; the ORNHIC and CNDDB databases do not currently maintain records on rare plant community locations. Very few records are documented in any of the heritage programs, as few agencies regard unique communities with any formal conservation status. The classification, survey, mapping, delineation and documentation of individual stands of rare and of-concern plant associations are relatively new to science and conservation biologists. Many more locations are known or suspected to occur on the landscape than are documented in conservation databases.

Wetlands are an exception to this general lack of rare plant association location information. These communities have been the subject of surveys for quite some time, largely due to the significant losses that wetlands have suffered since European settlement in the Pacific Northwest. The protected status of wetlands through regulation has also resulted in more comprehensive inventories for these plant communities. Wetlands were included as plant communities as well as ecological systems and their location and classification information was gathered from heritage programs and knowledgeable experts. Even in these cases, we did not feel that we have reasonable coverage of wetlands across these two ecoregions and they remain a sizeable data gap, along with upland associations that should have been included in the study.

4.3 Wildlife targets

4.3.1 *Selecting Targets*

The wildlife team dealt with selecting terrestrial vertebrate and invertebrate targets as well as freshwater invertebrates within the East and West Cascades Ecoregions (Appendix 4E). We used the target criteria developed by The Nature Conservancy (Groves et al. 2000) as a starting point. Target species were selected if their G rank indicated they were imperiled**,** if they were federally listed as threatened or endangered, or if we considered them a species of special concern (Table 4.3). Species of special concern included state listed, declining, endemic, disjunct, vulnerable, keystone, or wide-ranging species and those that met specified Partners in Flight criteria (TNC 2000b). Species that were peripheral to part of the ecoregion but well distributed in others were targets only in ecosections central to their distribution.

Table 4.3. Number of wildlife targets meeting various selection criteria for East and West Cascades organized by taxa.

Taxa Group	Total Targets	Extirpated from Ecoregion	Potential Endemics	State listed (T&E)	Federal listed (T&E)
Amphibian	16	1	4	1	0
Reptile	5	0	0	1	0
Bird	48	1	0	9	3
Mammal	23	1	0	8	4
Insect [a]	27	0	20	1	0
Mollusk [a]	73	0	63	0	0
Crustacean	1	0	1	1	1
Total	193	3	88	21	8

[a] Global ranks have yet to be assigned to some invertebrate targets.

Prior to outside review, team members evaluated the vertebrate and invertebrate target lists. The draft lists were then sent with a list of species considered but rejected, to regional experts to identify omissions and errors. The final list of targets is in Appendix 4F and a summary appears in Tables 4.4 and 4.5 below.

Table 4.4. Final wildlife target list organized by global ranks.

Ecoregion	Number of targets with G-Rank of:						
	G?[a]	G1	G2	G3	G4	G5	All ranks
East Cascades	12	32	18	18	29	47	156
West Cascades	28	2	14	21	19	32	116
Common to both	7	2	9	14	17	30	79
Total	33	32	23	25	31	49	193

[a] Global ranks have yet to be assigned to some invertebrate targets.

Table 4.5. Final wildlife target list organized by functional groups.

Ecoregion	Amphibian	Bird	Mammal	Reptile	Mollusk	Insect	Crustacean	All groups
East Cascades	14	47	18	5	55	16	1	156
West Cascades	13	28	18	3	29	25	0	116
Common to both	11	27	13	3	11	14	0	79
Total	16	48	23	5	73	27	1	193

4.3.2 Data Sources

Usable data was gathered from a number of sources including:

- Washington, Oregon and California Natural Heritage Programs
- Oregon and Washington Departments of Fish and Wildlife
- Yakama Nation
- West Fork Timber
- Bureau of Land Management
- U.S. Forest Service
- U.S. Fish and Wildlife Service

Data was excluded if the last observed date was before 1984, locational uncertainty was too imprecise, status of target was historic or extirpated, sighting was not verified by a credible observer, or the type of data was not correct for that species (e.g., most birds required breeding evidence).

The majority of the wildlife data for Oregon and California came from ORNHIC and CNDDB. These two data sets followed NatureServe methodologies and were usable in their existing form. Most of the other data sets had to be transformed into element occurrences (EOs), including all the data for Washington and the USFS data.

4.3.3 Data Gaps

We could not locate occurrence data for a number of fine filter targets, especially invertebrates. For other targets, data distribution was very inconsistent geographically, and therefore we did not use it to avoid biasing the site selection model. We had useable EOs for only half the targets, with the largest gaps in data for invertebrates. Also, with the exception of woodpeckers, raptors, and some wetland species, little data was available for most birds and a number of mammals and reptiles. Some gaps were the result of differences in survey effort among states, such as invertebrate data in Washington.

4.4 Freshwater Systems Targets

4.4.1 Freshwater Targets Overview

Freshwater coarse-filter targets, or freshwater ecological systems, are based on a unique classification of watersheds at multiple scales. Freshwater ecological systems are coarse-filter targets defined and selected to represent and stratify freshwater habitat across EDUs. Fine-filter targets include species at risk that inhabit aquatic habitat exclusively. Many functionally aquatic species, such as birds, amphibians, reptiles, and wetlands plants, were assessed together with terrestrial targets rather than with freshwater targets. Freshwater ecological systems and species targets were developed by a Freshwater Technical Team and were defined for each EDU that intersects the ecoregions. The EDUs intersecting the East and West Cascades that we analyzed were the: Puget Sound, Okanagan, Yakima/Palouse, Lower Columbia, Willamette, Deschutes, Rogue-Umpqua, Upper Klamath, Pit, Great Basin and Honey Lake (Map 4.2). Freshwater systems data were not developed for the Great Basin and Honey Lake, as they barely touch the East Cascades Ecoregion. Therefore, we relied upon expert input for assessment units within those EDUs. Also, the John Day-Umatilla and Olympic-Chehalis EDUs barely enter the East and West Cascades, and were not considered in the aquatic analysis for these two ecoregions. Details on freshwater EDU assessment methods are in Appendix 4G.

4.4.2 Definitions

Aquatic ecologists from The Nature Conservancy have developed a hierarchical classification framework based on abiotic variables that distinguishes various types of freshwater ecological systems (Higgins et al. 2005). In theory, the classification accounts for the environmental processes and physical features that are responsible for determining the assemblage of aquatic species in a watershed. Because available biological information is usually inadequate to determine biotic classifications (e.g., *alliances* or *associations*), freshwater ecological systems derived using this method serve as surrogates for the biodiversity. These surrogates are used as coarse-filter targets and include *macrohabitats* and *aquatic systems*.

Macrohabitats are the finest-scale biophysical classification unit used as conservation targets. Macrohabitats are lakes and stream/river segments that are delineated, mapped and classified according to the local environmental factors that likely determine the types and distributions of aquatic assemblages.

Aquatic ecological systems are stream macrohabitats and lake networks within nested watersheds representing a range of areas with distinct geomorphological characteristics tied together by similar environmental processes (e.g. hydrologic, nutrient and temperature regimes).

Ecological Drainage Units (EDUs) are higher level geographic units by which assessments are stratified, and within which systems are classified. EDUs are major basins defined to represent biodiversity distinctions at regional scales and are roughly equivalent in scale to ecoregions. They are typically aggregates of 8-digit HUCs, and are derived by segmenting freshwater ecoregions defined by the World Wildlife Fund (Abell et al. 2000). A separate assessment was conducted independently for each EDU. EDU assessments were integrated with terrestrial assessments in the complete ecoregional assessment.

4.4.3 Macrohabitats

Freshwater systems targets for all EDUs intersecting the East and West Cascades ecoregions were classified using methods developed by The Nature Conservancy (Higgins, et al. 2005), with the exception of the Great Basin and Honey Lakes EDUs. The classification method applied begins with classification of stream macrohabitats across the EDU. The macrohabitats are then grouped to form ecological systems, or watersheds with common assemblages of macrohabitat types.

Macrohabitats are classified within each EDU using environmental variables that are known to influence the distribution of biota. Each macrohabitat type represents a different physical setting that forms a unique set of habitats. While each EDU classification is based on those variables that best define their respective biota, there are a number of variables which are typically common to all classifications: watershed area, elevation, geology, and stream gradient. Watershed area (size class) correlates strongly with stream size, hydrologic flow regime, and dominant discharge. Elevation influences hydrologic regime, species distributions, and stream temperature. Geology influences water chemistry, surface-ground water interactions, stream substrate, and stream morphology. Gradient is a correlate for stream energy - an important determinant of biotic distribution at all trophic levels.

These four classification variables were common to all EDU classifications, though some EDU classifications applied other variables, such as connectivity and hydrologic regime. Each EDU selected classes of these variables that best represented the unique character of the EDU. For example, while elevation is clearly a strong determinant of biotic distribution, the specific elevation breaks that are relevant will vary across EDUs. Similarly, dominant geologic classes and their relative influence varies substantially across EDUs. Variables and classes within those variables for each EDU were selected based on literature reviews and with significant input from advisors (Appendix 4G).

Stream macrohabitat reaches are defined spatially as stream reaches derived from the U.S. Geological Survey (USGS) National Hydrography Dataset (NHD) 1:100,000 hydrography, downloaded from http://nhd.usgs.gov.data.html. Processing these reaches in a GIS for further classification was accomplished using GIS tools ("NHD-prep.aml") developed by the Conservancy's Freshwater Initiative (Fitzhugh 2005). These GIS tools are also used to define system watersheds, and in combination with elevation data, to determine gradients. Data sources for other variables vary across EDUs and are often derived from state agency sources.

4.4.4 Freshwater Ecological Systems Classification

Freshwater systems are nested watershed polygons classified according to their component stream macrohabitat attributes. Each system type represents a set of watersheds of the same size class with similar combinations of macrohabitat types. There are four scales of nested ecological systems watersheds (Map 4.3).

Class 1 – Headwaters streams < 100 km^2
Class 2 – Small rivers 100 – 999 km^2
Class 3 – Medium rivers 1000 – 10,000 km^2
Class 4 – Large Rivers > 10,000 km^2

Classification uses clustering techniques to determine statistically meaningful combinations of macrohabitat types within watersheds. Clustering techniques varied to some degree across EDUs, and was performed separately for each system size class. All watersheds with contributing areas less than 100 km^2, or Class 1 systems, were analyzed separately from Class 2 and Class 3 systems. Detailed descriptions of clustering methods are provided in Appendix 4G, and the complete list of systems by EDU are in Appendix 4H.

4.5 Freshwater Species Targets

4.5.1 Selecting Targets

Based on a rigorous selection process, the freshwater fish team compiled a list of fine-filter target fish species in need of conservation protection within the waters encompassed by the East and West Cascades Ecoregions, as well as in the 11 EDUs covered by the assessment. Occurrence data for these species were incorporated into the assessment process and used to assist with the identification of areas that significantly contribute to overall species conservation, thus biodiversity, at the ecoregional scale. See Appendix 4I for details on the Fish subteam methodology.

The freshwater fish team utilized the fine-filter selection criteria outlined in Groves et al. (2000), yet also had the ability to expand these criteria to meet any special circumstances of regional species that were deemed in need of protection. Freshwater species targets were limited to those species which spend their entire life history in the aquatic realm, and for which freshwater is essential to their life history. For this effort, taxa considered were only freshwater and anadromous fishes. Other aquatic animals, such as mollusks, are found in the invertebrate target list (Appendix 4G), while freshwater plants can be found in the plants target list (Appendix 4D). The invertebrates and plant species that were considered aquatic species for the MARXAN analyses and site summaries can be found in the freshwater categories of the Targets and Goals Appendices, as well as the Site Summaries. While we acknowledge that numerous mammals, birds, amphibians and insects rely on freshwater for all, or portions, of their life history, we have chosen to include those groups of species as terrestrial fine filter targets.

4.5.2 Data Sources

Our fine filter target fish species list was developed by consulting a number of relevant databases and assessments that focused on at risk species, including:

- Washington, Oregon and California Natural Heritage Program - species data lists
- WDFW - priority habitats and species
- BLM - freshwater species of concern list
- USFS- NW Forest Plan special status species
- Shasta -Trinity National Forest - list of aquatic species of concern
- Fine-filter target species lists from all adjacent ecoregions
- USFWS - list of native fish of the Klamath Basin and bull trout distribution data
- National Oceanographic and Atmospheric Association - anadromous salmonid ecologically significant unit data

We also used several scientific publications, notably *Inland Fishes of California* (Moyle 2002) and *Inland Fishes of Washington* (Wydoski and Whitney 2003), to obtain conservation status and distribution information on many species.

We consulted with a number of regional fisheries experts to review the initial species list. We asked these experts to review the list for omission and commission errors based on target selection criteria as well as their knowledge and understanding of species conservation status and needs. Reviewers were encouraged to provide justifications for any changes to the list and, if possible, provide specific data sources for species occurrences. All comments were considered, and most incorporated, into the target species list. In some cases, recent genetic research had elucidated some of the taxonomic similarities or differences between related species. As much as possible, this new information was taken into consideration and included in the analysis.

4.5.3 Fish Target List

As a first step in the assessment, the fish species target list was developed only within the boundaries of the ecoregion. In 2004, the fish target species list was expanded to include information for all 11 EDUs that were a part of the freshwater assessment. This expansion resulted in the inclusion of 12 at-risk species that were present within the EDUs, yet did not occur in the East or West Cascades. The final fish target species list for the East and West Cascades Ecoregions, including selection criteria, distribution, and other information is presented in Appendices 4I and 4J.

Eighty-nine species of fish were selected as targets for both ecoregions, 37 of which are endemic (Table 4.6). Eight species are listed as federally endangered or threatened. The West and East Cascades Ecoregions were represented by 42 and 60 species, respectively, and 13 species occurred in both ecoregions. The Salmonidae comprised over half of the list, represented by 46 targets, and accounted for 74% and 38% of the total for the West and East Cascades, respectively. The completed species list, spanning the 11 EDUs, comprised 109 species (Appendix 4J) and was also dominated by salmonids. The portion of the Great Basin EDU included in this assessment contained five species that did not occur within the ecoregions, the most of any EDU. Nearly half of the additional species were endemic to a region, while the remainder were primarily anadromous forms that utilize spawning and rearing habitat beyond the ecoregional boundaries.

Table 4.6. Fish family representation, degree of endemism and conservation status from species included in East and West Cascades ecoregional assessment.

Family	Number of Species	Number of endemics	Number federally or state listed T&E
Accipenseridae	1	0	0
Catostomidae	9	7	3
Cottidae	6	6	1
Cyprinidae	16	11	1
Percopsidae	1	0	0
Petromyzontidae	9	6	1
Salmonidae	46	5	2
Umbridae	1	0	0
Total	89	35	8

Chapter 5 – Protected Areas

5.1 Protected Areas Defined

Significant acreages in the Cascades are currently protected by federal or state land management agencies. These protected areas fall into two broad categories; lands protected by an act of Congress or state legislature (Wilderness Areas, National Parks, State Parks, Wild and Scenic Rivers, etc.), and lands set aside by agency administrative rules (Areas of Critical Environmental Concern, Research Natural Areas, etc.). These lands are generally classified as Protection Levels 1 and 2 by the USGS Gap Analysis Program (Christ 1996, Edwards et al. 1994). Federal lands with administrative designations under the Northwest Forest Plan (late successional reserves, riparian reserve lands and adaptive management areas) were not considered protected, although they did have a separate category and weighting in our suitability index (Chapter 6). Additionally, some private parcels are considered protected if they were acquired by a land trust or other non-profit with the express goal of managing the land to maintain its natural characteristics. Note that some lands currently in GAP 1 or 2 status may not be managed adequately for the biodiversity contained on them, and visa-versa, some lands not currently 'protected' may already be under suitable management practices. We identified a total of 1,629,100 ha in 377 protected areas, covering 13.4% of the two ecoregions (Map 5.1 and Table 5.1). While the two ecoregions have a similar percentage of protected areas, the different sections of each ecoregion vary dramatically, with only 3.4% of the Modoc Plateau in GAP 1 or 2 status and 35.5% of the Wenatchee section currently protected. Appendix 5A lists all the areas by name, section, and state.

Table 5.1. Number of protected (GAP 1 and 2) hectares in the East and West Cascades Ecoregions.

Sections and Ecoregions	Protected Ha	Total Ha	% Protected
Eastside Oak	75,600	845,300	8.9
Modoc Plateau	70,900	2,096,300	3.4
Pumice and Pine	122,600	1,341,600	9.1
Upper Klamath Basin	251,600	2,017,800	12.5
Wenatchee	317,400	895,000	35.5
Yakima	171,900	716,000	24.0
East Cascades-Modoc Plateau Ecoregion	***1,010,000***	***7,912,000***	***12.8***
Columbian Cascades	136,300	1,227,400	11.1
Middle Oregon Cascades	170,700	1,279,700	13.3
Mount Rainier	201,600	812,300	24.8
Umpqua Cascades	110,500	920,000	12.0
West Cascades Ecoregion	***619,100***	***4,239,400***	***14.6***

5.2 Protected Areas Analysis

To assess the contribution to biodiversity conservation by the existing protected areas network, all terrestrial data for the biodiversity targets used in our assessment was intersected with the protected areas. This analysis was restricted to the terrestrial realm because it only included areas protected within the two ecoregions, and did not extend throughout the 11 EDUs which covered the aquatic data.

As much of the data is polygonal and includes buffers to represent spatial uncertainty, rules were established to decide if a particular target was protected. Protected targets include: buffered species locations with their centroid within a protected area, or with more than

50% of the total polygon within a protected area, and all vegetation targets within the boundaries of a protected area.

5.2.1 Results for Terrestrial Ecological Systems

There were 32 terrestrial ecological systems which met a goal of at least 30% currently protected (Table 5.2) and 18 system types which are currently under 5% protected. Those that are well protected tend to be system types found in higher elevations, and those that are unprotected tend to be in lower elevations, especially in the drier portions of the ecoregions.

Table 5.2. Terrestrial Ecological Systems that are at least 30% protected (with at least 100 ha of mapped habitat).

Common Name	Element Code	Ecoregion	Total Amount mapped (ha)	% Protected
Columbia Plateau Steppe and Grassland	CES304.083	East	7,828	31
Columbia Plateau Vernal Pool	CES304.057	East	2,103	37
Mediterranean California Alpine Dry Tundra	CES206.939	East	6,250	64
Mediterranean California Subalpine Meadow	CES206.940	East	2,984	38
North Pacific Avalanche Chute Shrubland	CES204.854	East	5,820	49
North Pacific Dry and Mesic Alpine Dwarf-Shrubland, fellfield and Meadow	CES204.862	East	10,431	57
North Pacific Hardwood - Conifer Swamp	CES204.090	East	17,452	35
North Pacific Hypermaritime Shrub and Herbaceous Headland	CES204.088	East	168	50
North Pacific Maritime Dry-Mesic Douglas-fir-Western Hemlock Forest	CES204.001	East	129,412	34
North Pacific Montane Riparian Woodland and Shrubland	CES204.869	East	382	58
North Pacific Montane Riparian Woodland and Shrubland	CES204.866	East	19,931	31
North Pacific Montane, Massive Bedrock, Cliff and Talus	CES204.093	East	54,531	43
North Pacific Mountain Hemlock Forest	CES204.838	East	302,760	47
Northern Rocky Mountain Montane Grassland	CES306.836	East	11,631	36
Northern Rocky Mountain Subalpine Dry Parkland	CES306.807	East	81,111	51
Rocky Mountain Alpine Dwarf-Shrubland	CES306.810	East	488	52
Rocky Mountain Subalpine Mesic Spruce-Fir Forest and Woodland	CES306.830	East	28,880	33
Rocky Mountain Subalpine-Montane Limber-Bristlecone Pine Woodland	CES306.819	East	3,296	54
Temperate Pacific Freshwater Emergent Marsh	CES200.877	East	20,407	47
Columbia Plateau Ash and Tuff Badland	CES304.081	West	5,468	100
Inter-Mountain Basins Montane Sagebrush Steppe	CES304.785	West	2,227	50
Mediterranean California Subalpine Meadow	CES206.940	West	2,939	94
North Pacific Avalanche Chute Shrubland	CES204.854	West	635	97
North Pacific Dry and Mesic Alpine Dwarf-Shrubland, fellfield and Meadow	CES204.862	West	5,145	92
North Pacific Montane, Massive Bedrock, Cliff and Talus	CES204.093	West	31,321	30
North Pacific Mountain Hemlock Forest	CES204.838	West	352,934	46

Common Name	Element Code	Ecoregion	Total Amount mapped (ha)	% Protected
North Pacific Wooded Lava Flows	CES204.883	West	18,478	81
Northern California Mesic Subalpine Woodland	CES206.911	West	7,678	66
Northern Rocky Mountain Subalpine Dry Parkland	CES306.807	West	38,418	92
Rocky Mountain Lodgepole Pine Forest	CES306.820	West	23,536	48
Rocky Mountain Subalpine Mesic Spruce-Fir Forest and Woodland	CES306.830	West	1,377	68
Temperate Pacific Freshwater Emergent Marsh	CES200.877	West	582	100

Table 5.3. Terrestrial Ecological systems that are 0-5% protected (with at least 100 ha of mapped habitat).

Common Name	Element Code	Ecoregion	Total Amount mapped (ha)	% Protected
California Central Valley Mixed Oak Savanna	CES206.935	East	2,702	2
California Lower Montane Pine-Oak Woodland and Savanna	CES206.936	East	594	4
California Montane Woodland and Chaparral	CES206.925	East	78,497	5
Columbia Plateau Low Sagebrush Steppe	CES304.080	East	117,139	2
Columbia Plateau Scabland Shrubland	CES304.770	East	17,402	0
Inter-Mountain Basins Semi-Desert Shrub-Steppe	CES304.788	East	6,614	3
Northern and Central California Dry-Mesic Chaparral	CES206.931	East	868	2
Northern Rocky Mountain Dry-Mesic Montane Mixed Conifer Forest and Woodland	CES306.805	East	432,385	4
Northern Rocky Mountain Western Larch Woodland	CES306.837	East	104	1
Rocky Mountain Dry-Mesic Montane Mixed Conifer Forest and Woodland	CES306.823	East	13,152	4
East Cascades Oak-Pine Forest and Woodland	CES204.085	West	227	0
Inter-Mountain Basins Big Sagebrush Steppe	CES304.778	West	196	0
Klamath-Siskiyou Lower Montane Serpentine Mixed Conifer Woodland	CES206.917	West	342	0
Mediterranean California Dry-Mesic Mixed Conifer Forest and Woodland	CES206.916	West	168,432	4
North Pacific Montane Grassland	CES204.100	West	999	0
North Pacific Montane Riparian Woodland and Shrubland	CES204.866	West	7,263	3
Northern Rocky Mountain Dry-Mesic Montane Mixed Conifer Forest and Woodland	CES306.805	West	28,862	3
Northern Rocky Mountain Ponderosa Pine Woodland and Savanna	CES306.030	West	665	2

5.2.2 Results for Terrestrial Species

There were 29 species that had 100% of their EOs within the ecoregions protected (Table 5.4), but 23 of those only had one or two EOs, meaning that we either had incomplete data (only tracked in one state, no data on private lands, etc.), the species is on the edge of its range, or the species is extremely rare and its habitat is in need of restoration. None of those species met their conservation goals as set in the assessment (Chapter 8).

Table 5.4. Species with 100% of their Element Occurrences protected.

Common Name	Scientific Name	Grank	Ecoregion	# of EOs	Relative Distribution	Conservation Goal
A non-vascular plant	*Nardia japonica*	GQ	East	1	disjunct	13
A non-vascular plant	*Lecanora pringlei*	GNR	East	1	peripheral	7
Black Swift	*Cypseloides niger*	G4	East	1	widespread	13
Coyote Thistle	*Eryngium petiolatum*	G4	East	2	limited	25
Crater Lake Rockcress	*Arabis suffrutescens var. horizontalis*	G5T1	East	7	endemic	25
Felwort	*Swertia perennis*	G5	East	1	disjunct	13
Klamath Rim Pebblesnail	*Fluminicola sp. 6*	GQ	East	1	endemic	50
Northern Waterthrush	*Seiurus noveboracensis*	G5	East	1	disjunct	13
Obscure Indian-paintbrush	*Castilleja cryptantha*	G2	East	2	endemic	25
Ross' Avens	*Geum rossii var. depressum*	G5T1	East	2	endemic	50
Sierra Cliff-brake	*Pellaea brachyptera*	G4G5	East	5	disjunct	13
Smoky Mountain Sedge	*Carex proposita*	G4	East	7	disjunct	13
Western Ridged Mussel	*Gonidea angulata*	G3	East	2	widespread	13
Western Snowy Plover	*Charadrius alexandrinus nivosus*	G4T3	East	2	peripheral	7
A Liverwort	*Scapania gymnostomophila*	G3G4	West	1	peripheral	7
A non-vascular plant	*Chiloscyphus gemmiparus*	G1	West	1	disjunct	13
A non-vascular plant	*Scapania obscura*	G3Q	West	1	peripheral	7
A non-vascular plant	*Schofieldia monticola*	G3	West	2	disjunct	13
A non-vascular plant	*Bruchia bolanderi*	G2	West	4	disjunct	13
A non-vascular plant	*Trematodon boasii*	G1	West	1	disjunct	13
A non-vascular plant	*Umbilicaria lambii*	G2G4	West	1	disjunct	13
A non-vascular plant	*Stereocaulon spathuliferum*	G4G5	West	1	disjunct	13
Alpine Gentian	*Gentiana newberryi*	G4	West	1	endemic	25
Beller's Ground Beetle	*Agonum belleri*	G3	West	1	limited	25
Brewer Reedgrass	*Calamagrostis breweri*	G4	West	2	limited	25
Cliff Indian-paintbrush	*Castilleja rupicola*	G2G3	West	2	endemic	50
Golden Alpine Draba	*Draba aureola*	G4	West	4	endemic	50
Obscure Indian-paintbrush	*Castilleja cryptantha*	G2	West	20	endemic	25
Strickland's Tauschia	*Tauschia stricklandii*	G4	West	2	endemic	50

There were also approximately 30 species that met at least 50% of their conservation goal (Chapter 8). The more common amphibians tended to come out the best of any group. This is because they had relatively modest goals (usually seven or 13 EOs), they are widespread, and many protected areas include existing wetlands and riparian zones. The ones at the top of the list included: Cascades frog (East and West Cascades), western toad (West Cascades), Oregon spotted frog (*Rana pretiosa*; West Cascades), red-legged frog (*Rana draytonii*; East and West Cascades), and coastal tailed frog (*Ascaphus truei*; West Cascades). Other species doing well include bird species that are fairly widespread, have relatively low goals, and for which there is an abundance of good data. These were sandhill crane (*Grus canadensis*; East Cascades), yellow rail (*Coturnicops noveboracensis*; East Cascades, for percent of currently occupied habitat protected, not for number of EOs), northern goshawk (East Cascades), peregrine falcon (*Accipiter gentilis;* East and West Cascades), and marbled murrelet (West Cascades). The top three plants protected in terms of conservation goals are: Mount Rainier Lousewort (*Pedicularis rainierensis*), Obscure Indian-paintbrush (*Castilleja cryptantha*), and Mt. Mazama Collomia (*Collomia mazama*), all in the West Cascades. Obscure Indian-paint brush was the only species that had 100% of its EOs protected, as well as almost meeting its conservation goal within existing protected areas (80% of the goal of 25 EOs).

Out of the 280 terrestrial species targets with useable data, 95 targets had data, but less than 5% of their EOs fell in areas that are currently listed as GAP 1 or 2 protected areas. Out of those 95 targets, 48 are either endemic or have a G or T rank of three or less. This large number of species that are at risk and are currently under-protected speaks both to the lack of protection in some habitats, and to the lack of survey effort on private lands and in some protected areas such as Wilderness.

Table 5.5. Terrestrial species in the East and West Cascades which have less than 5% of their EOs located on protected lands and which are either endemic or have a G or T rank of 1-3.

Common Name	Scientific Name	GRANK	Ecoregion	Total # of EOs	Distribution	% Protected
A Terrestrial Slug	*Prophysaon sp. 1*	GQ	East	6	endemic	0
Ames Milk-vetch	*Astragalus pulsiferae var. suksdorfii*	G4T3	East	35	disjunct	3
Ash Creek ivesia	*Ivesia paniculata*	G2	East	19	endemic	0
Ash Valley milk-vetch	*Astragalus anxius*	G1	East	6	endemic	0
Broad-seeded Rockcress	*Arabis platysperma var. platysperma*	G5T3?	East	2	limited	0
Cascade Torrent Salamander	*Rhyacotriton cascadae*	G3	East	5	peripheral	0
Ephemeral Monkeyflower	*Mimulus evanescens*	G2	East	11	widespread	0
Green Wild Buckwheat	*Eriogonum umbellatum var. glaberrimum*	G5T2?	East	3	endemic	0
Hall Sedge	*Carex halliana*	G4G5	East	7	endemic	0
Hatch's Scaphinotus	*Scaphinotus hatchi*	G3	East	1	limited	0
Hoover's Desert-parsley	*Lomatium tuberosum*	G2G3	East	1	peripheral	0
Hoover's Tauschia	*Tauschia hooveri*	G2	East	7	disjunct	0
Howell's Thelypody	*Thelypodium howellii ssp. howellii*	G2T2	East	2	limited	0
Newberry Cinquefoil	*Potentilla newberryi*	G3G4	East	10	limited	0
Oregon Checker-mallow	*Sidalcea oregana var. calva*	G5T1	East	4	endemic	0
Pale Blue-eyed Grass	*Sisyrinchium sarmentosum*	G1G2	East	7	endemic	0
Peculiar Moonwort	*Botrychium paradoxum*	G2	East	2	widespread	0
Profuse-flowered Pogogyne	*Pogogyne floribunda*	G3	East	54	endemic	2
Red-Root Yampah	*Perideridia erythrorhiza*	G1	East	1	endemic	0
Sierra Nevada Red Fox	*Vulpes vulpes necator*	G5T3	East	3	limited	0

Common Name	**Scientific Name**	**GRANK**	**Ecoregion**	**Total # of EOs**	**Distribution**	**% Protected**
Siskiyou False Hellebore	*Veratrum insolitum*	G3	East	1	disjunct	0
Soldier Meadow Cinquefoil	*Potentilla basaltica*	G1	East	2	endemic	0
Talus Collomia	*Collomia debilis var. larsenii*	G5T4	East	2	endemic	0
Thompson's Pincushion	Chaenactis thompsonii	G2G3	East	30	endemic	3
Tiny-flower Phacelia	Phacelia minutissima	G3	East	1	disjunct	0
Ute Ladies' Tresses	Spiranthes diluvialis	G2	East	3	disjunct	0
Warner Mountain Bedstraw	Galium serpenticum ssp. warnerense	G4G5T2	East	17	endemic	0
Wenatchee Larkspur	Delphinium viridescens	G2	East	12	endemic	0
A non-vascular plant	Brachydontium olympicum	G2G3	West	1	disjunct	0
Bristly-stemmed Sidalcea	Sidalcea hirtipes	G2	West	3	limited	0
Broad-fruit Mariposa	Calochortus nitidus	G3	West	1	limited	0
California Globe-mallow	Iliamna latibracteata	G3	West	16	limited	0
Clouded Salamander	Aneides ferreus	G3	West	16	widespread	0
Columbia Oregonian	Cryptomastix hendersoni	G2	West	3	limited	0
Crater Lake Tightcoil	Pristiloma arcticum crateris	GQ	West	3	limited	0
Fringed Grass-of-parnassus	Parnassia fimbriata var. hoodiana	G5T3	West	2	endemic	0
Greene's Hawkweed	Hieracium greenei	G3G4	West	7	limited	0
Hatch's Scaphinotus	Scaphinotus hatchi	G3	West	4	limited	0
Klamath Gooseberry	Ribes inerme var. klamathense	G5T3?	West	5	limited	0
Merriam Alumroot	Heuchera merriamii	G2?	West	1	limited	0
Mountain Moonwort	Botrychium montanum	G3	West	4	widespread	0
Oregon Megomphix	Megomphix hemphilli	G2	West	191	limited	2
Oregon Red Tree Vole	Arborimus longicaudus	G3G4	West	244	limited	2
Pacific Sideband	Monadenia fidelis celeuthia	G4G5T1	West	2	endemic	0
Sickle-pod Rockcress	Arabis sparsiflora var. atrorubens	G5T3	West	1	limited	0
Thompson Mistmaiden	Romanzoffia thompsonii	G3	West	60	endemic	2
Umpqua Mariposa-lily	Calochortus umpquaensis	G1	West	13	endemic	0
Willamette Valley Larkspur	Delphinium oreganum	G1Q	West	6	peripheral	0

Chapter 6 – Suitability Indices

6.1 General Overview

Optimal site selection analyzes the trade-off between conservation values and conservation costs to arrive at an efficient set of conservation areas that satisfies conservation goals (Possingham et al. 2000, Cabeza and Moilanen 2001). The optimization algorithm (MARXAN) searches for the lowest "cost" set of assessment units that will meet goals for all conservation targets. Because determining the monetary cost of conservation for every assessment unit would be an extremely demanding task, we used a surrogate measure for cost called a *suitability index*. A place with a high "cost" for maintaining or restoring biodiversity has low suitability for conservation. Suitability indicates the relative likelihood of successful conservation within each assessment unit.

Land use suitability is a well-established concept amongst land use planners (see Hopkins 1977, Collins et al. 2001 for reviews), and there are many different methods for constructing an index (Banai-Kashini 1989, Carver 1991, Miller et al. 1998, Stoms et al. 2002). The suitability indices we used were based in part on the effects of fragmentation (by roads) and habitat conversion, which leads to smaller areas of existing habitat (Diamond 1975, Forman 1995).

An additional principle which guided the development of our suitability index was that existing public land is generally more suitable for conservation than private land. This assumption was based on the work of the Gap Analysis Program (Cassidy et al. 1997, Kagan et al. 1999). Both the Oregon and Washington GAP projects rated most public lands as better managed for biodiversity than most private lands. Furthermore, eminent conservation biologists have noted that existing public lands are the logical core of large multiple-use landscapes where biodiversity is a major management goal (Dwyer et al. 1995). By focusing conservation on lands already set aside for public purposes the overall cost of conservation would be less than if public and private lands were treated equally. We readily admit that our index cannot account for the many complex local situations that influence successful conservation, but we believe that some reasonable generalities are useful for assessing conservation opportunities across an entire ecoregion or EDU.

As our ecoregional analysis maintained separate terrestrial and aquatic planning unit layers, suitability indices were also developed independently for each realm. The factors considered for each suitability index varied slightly. We will describe the data collected for each factor used in any suitability equation and then describe the calculations for each index separately (see Appendix 6A for details).

6.2 Factors Used in the Terrestrial or Aquatic Suitability Indices

All data was compiled from the best available information for each state within the broader planning area. The following spatial data was used in one or more of the suitability indices:

Land Ownership/Management – Each parcel was assigned a GAP status and a land-use designation. GAP 3 lands were divided into six subcategories: State, State with a Habitat Conservation Plan (HCP), General Federal, Riparian Matrix, Adaptive Management Area, and Late Successional Reserve (LSR). GAP 4 lands were divided into two categories: Private and Private with HCP. If multiple designations applied (an LSR within a General Federal, for example) the highest protection level designation was used in assigning a weight for the suitability index.

Land Use/Converted Lands – Land use data characterizes the type and degree of man-made conversions to the landscape, from minor (Natural/Semi-Natural) to major conversions (High Intensity Commercial). Sub-categories used were Urban and Agriculture.

Roads – As this information was only used to generate road densities within assessment units, no attempt was made at edge matching, routing, or categorizing the roads by type (highway, two-lane County, etc.).

Seral Stage – Early seral stage (early shrub tree/recent clearcut) information was compiled from the QMD data developed by the Interagency Vegetation Mapping Project. This data was not continuous over the full extent of the East Cascades, and therefore was only used for suitability in some of the Western EDUs, and only areas within 150 meters of riparian areas were considered for the aquatic suitability indices.

Dams – In addition to the number of dams present in each assessment unit, we also considered impoundment area and dam height.

Mines – Only mines within 150 meters of riparian areas were considered for the aquatic suitability indices.

6.3 Calculation of Terrestrial and Aquatic Suitability Indices

An additional level of refinement was achieved for the aquatic suitability indices by querying experts independently for groups of EDUs, and tailoring the factors and weightings accordingly. Using the Analytic Hierarchy Process (Saaty 1980, Banai-Kashini 1989), experts were solicited for their relative weightings of the factors selected for use in the indices. A series of terms were weighted against each other for their relative impact to biodiversity, and sub-terms within each term were also weighted. Each management subtype was assigned a weighting relative to the other subtypes, and the percentage of the assessment unit under each management subtype was multiplied by its weighting. A sum was then calculated for each AU for all management subtypes within it. These values were then normalized on a 1-1,000 scale for each AU within an ecoregion or EDU, and then weighted against the other normalized main terms of the suitability index. All final suitability values for each EDU or ecoregion were then normalized on a 0-10,000 scale for use within the MARXAN portfolio assembly tool.

The equations for the suitability indices are listed here for the terrestrial ecoregions (Map 6.1) and freshwater EDUs (Map 6.2). See Appendix 6A for the calculations related to the suitability (S) indices and for the values assigned to the weighting factors (A-E and subfactors).

East and West Cascades Terrestrial Ecoregions

S = A * Land Management + B *% Converted Land + C * Road Density

Subfactors:
Land Management = g_1 * Gap4% + g_2 * GAP4 HCP% + g_3 * GAP3 State% + g_4 * GAP3 Fed%+ g_5 * GAP3 State HCP% + g_6 * GAP3 Riparian Matrix%+ g_7 * GAP3 Adaptive Management Area% + g_8 * GAP3 Late Successional Reserve% + g_9 * GAP2% + g_{10} *GAP1%

% Converted Land = h_1 * urban% + h_2 * agriculture%

Rogue-Umpqua, Willamette EDUs and Oregon Portion of the Lower Columbia

S = A * Land Management + B *% Converted Land + C * Road Density + D* Dams + E * Early Shrub/tree hectares within 150 meters of stream + F * Mines within 150 meters of stream

Deschutes, Great Basin (partial), Honey Lake, Pit, and Upper Klamath Basin EDUs

S = A * Land Management + B *% Converted Land + C * Road Density + D* Dams + E * Mines within 150 meters of stream

Puget Sound EDU and the Washington portion of the Lower Columbia

S = A *% Converted Land + B * Dams/ha + C * Road kms/Stream kms

Yakima/Palouse EDU

S = A *% Converted Land excluding riparian zone + B *% Converted Land within riparian zone + C * Dams/Stream km + D *% Private Land + E *% Irrigated agriculture

Okanagan EDU

S = A * Land Management + B *% Converted Land + C * Road Density + D * Dams

Chapter 7 – Prioritization of Assessment Units

7.1 Introduction

The prioritization of potential conservation areas is an essential element of conservation planning (Margules and Pressey 2000). The importance of prioritization is made evident by the extensive research conducted to develop better prioritization techniques (e.g., Margules and Usher 1981, Anselin et al. 1989, Kershaw et al. 1995, Pressey et al. 1996, Freitag and Van Jaarsveld 1997, Benayas et al. 2003). Consequently, many different techniques are available for addressing the prioritization problem. None are obviously better than the rest. We used an optimal site selection algorithm called MARXAN (Ball and Possingham 2000) to assign a relative priority to every assessment unit (AU) in the ecoregion. Assigning a relative priority to all AUs in the ecoregion will help planners explore options for conservation. The relative priorities were expressed as two indices – irreplaceability and conservation utility.

Irreplaceability is an index that indicates the relative biodiversity value of a place (i.e., an assessment unit). The number of targets and the abundance or rarity of a target within any given AU is used to represent that AU's biodiversity value. The biodiversity data consisting of the targets described in Chapter 4 were attributed to each AU and goals were set as described in Chapter 8. Conservation utility is a function of both biodiversity value and the likelihood of successful conservation as represented by the suitability index (Chapter 6). This value or index consists of a set of weighted factors (e.g., road density, conversion) that influence the relative likelihood of successful conservation at any given unit. These suitability values were also attributed to each AU.

A conservation portfolio could serve as a conservation plan to be implemented over time by nongovernmental organizations, government agencies and private land owners. In reality, however, an entire portfolio cannot be protected immediately and some conservation areas in the portfolio may never be protected (Meir et al. 2004). Limited resources and other social or economic considerations may make protection of the entire portfolio impractical. This inescapable situation can be addressed two ways. First, we should narrow our immediate attention to the most important conservation areas within the portfolio. This can be facilitated by prioritizing conservation areas. Second, we should provide organizations, agencies and land owners with the flexibility to pursue other options when portions of the portfolio are too difficult to protect. Assigning a relative priority to all AUs in the ecoregion will help planners explore different options for conservation.

AUs were prioritized for the terrestrial and aquatic realms. A more extensive analysis was done for the terrestrial realm because: (1) the terrestrial data have a greater influence on the portfolio than the freshwater data; (2) terrestrial environments and species have been more thoroughly studied, and therefore, our assumptions about terrestrial biodiversity are more robust than for freshwater biodiversity; and (3) the terrestrial portfolio has the greatest potential influence on land use planning and policy decisions affecting private lands.

The results of our prioritization should not be the only information used to direct conservation action. Unforeseen opportunities have had, and should continue to have, a major influence on conservation decisions. Local attitudes toward conservation can hinder or enhance conservation action. Considerations such as these are difficult to incorporate into long-range priority setting but must be dealt with on a case-by-case basis. Additional details on AU prioritization methods can be found in Appendix 7A.

7.2 Methods

7.2.1 Irreplaceability

Irreplaceability is an index that indicates the relative conservation value of a place. Irreplaceability has been defined a number of different ways (Pressey et al. 1994, Ferrier et al. 2000, Noss et al. 2002, Leslie et al. 2003, Stewart et al. 2003). However, the original operational definition was given by Pressey at al. (1994). They defined the irreplaceability of a site as the percentage of alternative reserve systems in which it occurs. Following this definition, Andelman and Willig (2002) and Leslie et al. (2003) each exploited the stochastic nature of the simulated annealing algorithm to calculate an irreplaceability index.

The number of simulated annealing solutions that include a particular AU is a good indication of that AU's irreplaceability. This is the assumption made by Andelman and Willig (2002) and Leslie et al. (2003) for their irreplaceability index. The index of Andelman and Willig (2002) was:

$$H_j = (1/n) \sum_{i=1}^{n} s_i \qquad (1)$$

where H is relative irreplaceability, n is the number of solutions, and s_i is a binary variable that equals 1 when AU_j is selected but 0 otherwise. H_j have values between 0 and 1, and are obtained from a running the simulated annealing algorithm n times at a single representation level.

Irreplaceability is a function of the desired representation (or goal) level (Pressey et al. 1994, Warman et al. 2004). Changing the representation level for target species often changes the number of AUs needed for the solution. For instance, low representation levels typically yield a small number of AUs with high irreplaceability and many AUs with zero irreplaceability, but as the representation level increases, some AUs attain higher irreplaceability values. The fact that some AUs go from zero irreplaceability to a positive irreplaceability demonstrates that Willig and Andelman's index is somewhat misleading – at low representation levels, some AUs are shown to have no value for biodiversity conservation when they actually do. We created an index for relative irreplaceability that addresses this shortcoming. Our comprehensive irreplaceability index for AU_j was defined as:

$$I_j = (1/m) \sum_{k=1}^{m} H_{jk} \qquad (2)$$

where H_{jk} are relative irreplaceability values as defined in equation (2) and m is the number of representation levels used in the site selection algorithm. I_j have values between 0 and 1. Each H_{jk} is relative irreplaceability at a particular representation level. We ran MARXAN at ten representation levels for coarse- and fine-filter targets. At the highest representation level nearly all AUs attained a positive irreplaceability.

Many applications of irreplaceability have implicitly subsumed some type of conservation efficiency (e.g., Andelman and Willig 2002, Noss et al. 2002, Leslie et al. 2003, Stewart et al. 2003). Efficiency is usually achieved by minimizing the total area needed to satisfy the desired representation level. Our watershed AUs ranged in size from 54 to 153,000 ha. However, the size of watersheds between the 10th and 90th percentiles ranged 1,700 to 8,900 ha, roughly the same order of magnitude. Hence, for the purposes of calculating the irreplaceability index, we choose to ignore AU area and the optimization simply minimized the total number of AUs.

7.2.2 Conservation Utility

We extended upon the concept of irreplaceability with *conservation utility*, a term coined by Rumsey et al. (2004). Conservation utility is defined by equation (2), but the optimization algorithm is run with the AU costs incorporating a suitability index. To create a map of conservation utility values, AU "cost" reflects practical aspects of conservation – current land uses, current management practices, habitat condition, etc. In effect, conservation utility is a function of both biodiversity value and the likelihood (cost) of successful conservation, represented by the suitability index (Chapter 6).

AU area should also influence AU selection because the 'cost' or effort of protecting a conservation site is related to its area. Larger areas are more costly to protect and maintain. To account for area, we combined suitability and AU area with the weighted geometric mean:

$$\text{COST} = [N(\text{suitability})^{X} * N(\text{AU area})^{Y}]^{[1/(X+Y)]} \qquad (3)$$

where the function N(•) normalizes the values. If X + Y = 1, then the equation simplifies to:

$$\text{COST} = N(\text{suitability})^{X} * N(\text{AU area})^{Y} \qquad (4)$$

We used the geometric mean for two reasons. First, if the suitability of an AU equals zero, then that AU is highly desirable and its overall cost should be zero regardless of area. Second, suitability and area are grossly incommensurate, and therefore, should not be summed. The values of X and Y for the final cost equation were set to 0.75 and 0.25, respectively.

7.2.3 Representation Levels

Each representation level corresponds to a different degree of risk for species extinction. Although we cannot estimate the actual degree of risk, we do know that risk is not a linear function of representation. It is roughly logarithmic.

7.2.3.1 Coarse-Filter

It was assumed that there is a logarithmic relationship between the risk of species extinction and the amount of habitat, based on the species-area curve. The species-area curve is arguably the most thoroughly established quantitative relationship in all of ecology (Conner and McCoy 1979, Rosenzweig 1995). The curve is defined by the equation $S=cA^{z}$, where S is the number of species in a particular area, A is the given area, c and z are constants. The equation says that the number of species (S) found in a particular area increases as the habitat area (A) increases. The parameter z takes on a wide range of values depending on the taxa, region of the earth, and landscape setting of the study. Most values lie between 0.15 and 0.35 (Wilson 1992). An oft cited rule-of-thumb for the z's value is called Darlington's Rule (MacArthur and Wilson 1967, Morrison et al. 1998). The rule states that a doubling of species occurs for every tenfold increase in area, hence $z = \log(2)$ or 0.301. We used this relationship to derive representation levels that roughly correspond to equal increments of biodiversity – i.e., each increase in coarse-filter area captured an additional 10% of species.

We used the species-area relationship to create representation levels that correspond to equal increments of risk. The coarse filter representation levels did not increase linearly but rather according to a power function: $S = A^{z}$. To derive the coarse-filter levels, the desired amount of biodiversity was increased linearly (10, 20, 30, . . ., 100%) and the corresponding area was calculated for each (Table 7.1).

Table 7.1. Coarse filter representation levels derived from the species-area curve with z = 0.301.

	Percent of species									
	10	**20**	**30**	**40**	**50**	**60**	**70**	**80**	**90**	**100**
Representation Level (percent extant area)	0.05	0.5	1.8	4.8	10	18	31	48	70	100

7.2.3.2 Fine-Filter

Fine-filter representation levels specify the number of species occurrences to be captured within a set of conservation areas. The relationship between species survival and number of isolated populations is also a power function:

$$\text{Species Persistence Probability} = 1 - [\, 1 - pr(P)\,]^{n} \qquad (5)$$

where pr(P) is the persistence probability of each isolated population and n is the number of populations. This equation says, in effect, that the first population (i.e., occurrence) is more important than the second population and much more important than the tenth population. That is, the function exhibits diminishing returns as the number of occurrences increases. According to this relationship, if we want representation levels to correspond to equal degrees of risk, then fine-filter representation levels should not increase linearly, but logarithmically. However, the above equation won't work for our purposes. We don't know pr(P), but even if we did, pr(P) is not equal across all populations.

Luckily, other relationships were available to us. The Natural Heritage Programs use many criteria to determine G and S ranks. These criteria indicate the degree of imperilment, i.e., the risk of extinction. One such criterion relates the number of occurrences to degree of imperilment (Table 7.2) (Master et al. 2003)[1]. This system expresses the idea that the first five occurrences make about the same contribution toward species rank as the next six to 20 occurrences.

If we assume equal imperilment intervals and equate A, B, C (a nominal scale) with 1, 2, 3 (an ordinal scale), then the relationship in the above table can be modeled as a power function. We used the function to interpolate between 1, 2, and 3 to yield multiple regularly spaced steps for the fine-filter levels. We did this to give 10 representation levels; the same number as for the coarse-filter. More details are presented in Appendix 7A.

Table 7.2. Categories for the known occurrence ranking criterion used by NatureServe and Natural Heritage programs to assign species S ranks and G ranks.

Condition Status	Number of Known Occurrences
A	1 to 5
B	6 to 20
C	21 to 80
D	81 to 300
E	>300

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[1] Table 7.2 is a modification of the older system (Master 1994) for species ranking, where G1/S1 equaled 1 to 5 occurrences, G2/S2 equaled 6 to 20 occurrences, and G3/S3 equaled 21 to 100 occurrences.

7.2.4 Running the Selection Algorithm

MARXAN produces an output that is equivalent to nH_j, i.e., the number of times an AU was selected out of n replicates. We ran 25 replicates at each representation level. Hence, the product m•n equaled 250 for both irreplaceability and conservation utility. The irreplaceability and conservation utility values were normalized such that 250 equaled 100. For the terrestrial and freshwater analyses, the boundary length modifier parameter (BM) was set to zero. When BM is set to zero, neighboring AUs have no influence on the selection frequency of an AU. More details are presented in Appendix 7A.

7.2.5 Aquatic Analyses

The aquatic analyses were done separately from the terrestrial analyses. Analyses for conservation of aquatic biodiversity are typically organized by EDUs not ecoregions. The East and West Cascades Ecoregions intersect 13 EDUs. However, the overlap with two of those EDUs (Olympic-Chehalis and John Day-Umatilla) is relatively insignificant and we did not include data from these EDUs in the analysis. Some EDUs have been analyzed in conjunction with other ecoregional assessments, e.g., the Okanogan EDU was associated with the Okanagan Ecoregion and the Puget Sound EDU was associated with the North Cascades Ecoregion. Other EDUs, such as the Lower Columbia and Yakima-Palouse, have been analyzed in advance of this ecoregional assessment because salmon recovery planning created a critical need for such information. Two EDUs, the partial Great Basin and Honey Lake, did not have a complete classification and mapping of aquatic systems. For these reasons the aquatic analyses done for this ecoregional assessment should not be used as “stand alone” analyses. The aquatic analyses were done only to guide efficient integration of terrestrial and aquatic conservation priorities. When establishing priorities for aquatic conservation only, such as planning associated with salmon recovery, the more thorough aquatic assessments should be used.

The generation of terrestrial utility and irreplaceability maps followed similar methods. The few exceptions are presented in Appendix 7A.

7.2.6 Integrating Terrestrial and Aquatic Analyses

Conserving both aquatic and terrestrial biodiversity in the same set of places will enhance the efficiency of conservation actions. We averaged the aquatic and terrestrial irreplaceability scores and the aquatic and terrestrial conservation utility scores to yield an “integrated” score. While the averages were unweighted, a case could be made for assigning a greater weight to the terrestrial scores because the terrestrial data density was much greater than the aquatic.

Greater efficiency may have been attained with the technique of vertical integration (see Appendix 8A). This technique was not used, however, because it requires that the BM equal a value greater than zero. If the BM is used, then neighboring AUs influence the selection frequency of an AU, and this is undesirable for determining irreplaceability.

7.3 Results

7.3.1 Terrestrial and Aquatic Analyses

The irreplaceability and utility maps for the terrestrial only analysis are shown in Maps 7.1 and 7.2. The categories on these maps correspond to deciles. That is, the statistical distribution of utility and irreplaceability scores were each divided into 10% quantiles. The decile map indicates where the AUs with a score (or selection frequency) in the top 10% of all AUs are. The 90th percentile scores for both replaceability and utility equaled 99 out of 100. Additionally, for both ecoregions combined, the percentage of AUs with a score greater than 90 was 13.3% and 14.2% for irreplaceability and utility, respectively (Figure 7.1).

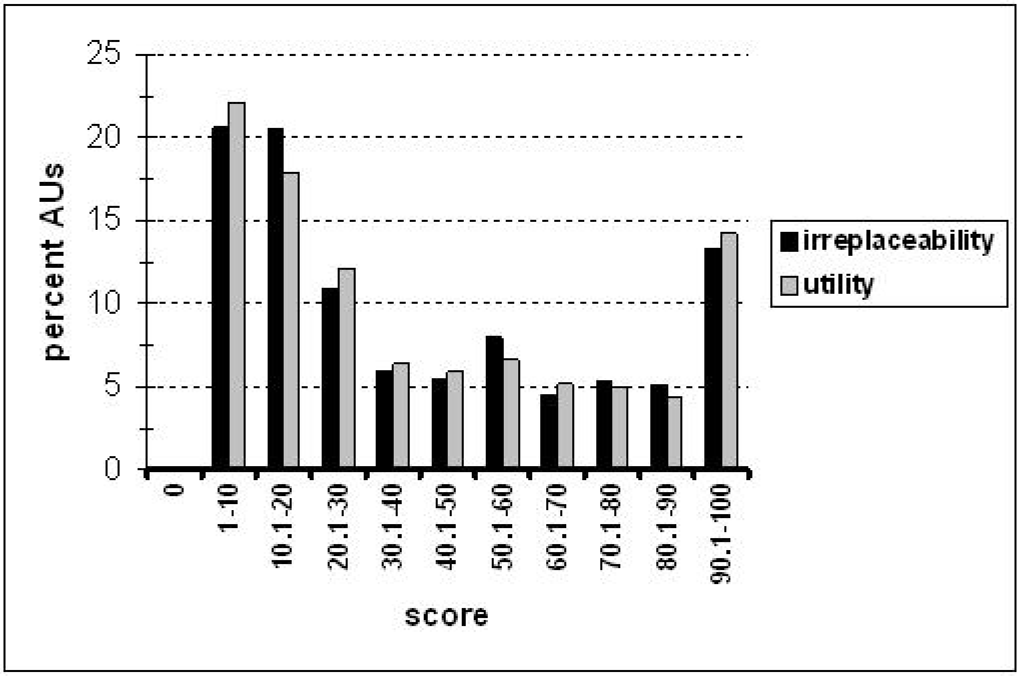

Figure 7.1. Distribution of irreplaceability and conservation utility scores for the terrestrial only analysis.

AUs with scores equal to 100 are those selected in every replicate at every representation level. For both ecoregions combined, 9.7% of AUs had irreplaceability equal to 100, 10.8% had utility equal to 100, and 9.6% of AUs had both scores equal to 100.

At the lowest representation level, the best solutions for irreplaceability and utility consisted of 13.9% and 14.5% of AUs, respectively. Perfect scores (equal to 100) were attained by 70% of AUs in the irreplaceability best solution and by 79% of AUs in utility best solution, which demonstrates that few options existed for meeting the lowest representation level. That is, rare targets could only be captured at the high scoring AUs. This also shows how incorporating suitability into the analysis narrows the number of options. Results were similar for the freshwater analyses (Maps 7.3 and 7.4).

7.3.2 Integrated Analysis

The irreplaceability and utility maps for the integrated analysis are shown in Maps 7.5 and 7.6. A score greater than 90 was attained by 0.8% of AUs for irreplaceability and 1.7% of AUs for utility (Figure 7.2). Twelve AUs had an irreplaceability score of 100, 15 had a utility score of 100, and 12 AUs had both scores equal to 100 (Appendix 7A). The number of AUs attaining perfect utility scores is greater than the number attaining perfect irreplaceability scores because when the optimization involved suitability, the higher suitability scores of some AUs caused them to be selected in every replicate.

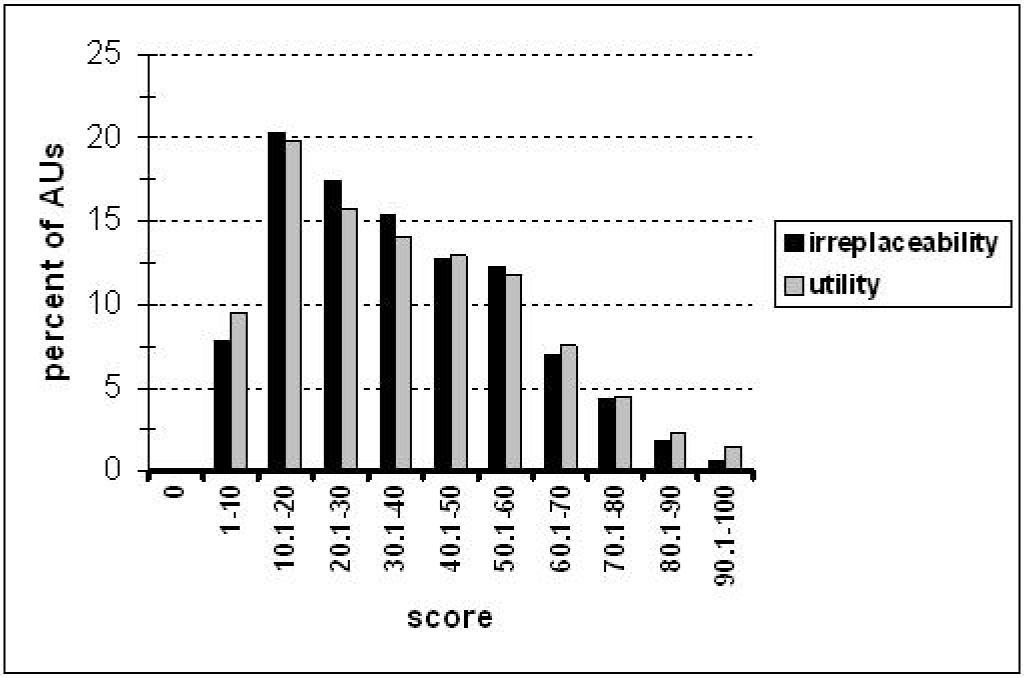

Figure 7.2. Distribution of irreplaceability and conservation utility scores for the integrated analysis

7.4 Discussion

How should our irreplaceability and conservation utility indices be interpreted? These indices were constructed by running MARXAN at ten representation or goal levels. The first level captured a very small amount of each target and the last level captured everything, i.e., all known occurrences of all targets. Think of the first representation level as the amount of biodiversity to be captured in an initial set of reserves, the second level as an additional amount to be captured by an enlarged set of reserves, the third level as an even greater additional amount, and so on. At each level, MARXAN's output indicates the relative necessity of each AU for efficiently capturing that particular amount of biodiversity. When the outputs from each level are summed together, the result specifies the most efficient sequence of AU protection that will eventually capture all biodiversity. The sequence in which AUs should be protected is one way to gauge their relative importance. AUs that have the highest irreplaceability or utility scores should be protected first, and therefore, are the most important AUs for biodiversity conservation.

The selection algorithm generates a set of AUs that serve to minimize the objective function. Therefore, AUs with high irreplaceability or high utility scores are those that contain one or more rare targets and/or contain a large number of target occurrences. High utility scores are also attained by AUs with low unsuitability (i.e., high suitability). AUs with scores of 100 are those that were selected in every replicate at every representation level. Those AUs contained target occurrences that were found in no other AU, contained a substantially larger number of occurrences than other AUs, or contained targets and had a substantially lower unsuitability than other AUs.

Utility and irreplaceability scores are different ways to prioritize places for conservation. Irreplaceability has been the most commonly used index (e.g., Andelman and Willig 2002, Noss et al. 2002, Leslie et al. 2003, Stewart et al. 2003), and our index assumes that the number of places (i.e., AUs) is the sole consideration for efficient conservation. Utility incorporates other factors that can affect efficient conservation such as land management status and current condition. In our analysis, many AUs attained scores of 100 for both utility and irreplaceability. These results demonstrate that for scores at or near 100, the cost had little influence on selection frequency; occurrence data drove the results. More importantly, it demonstrated that the results are robust; under these two different assumptions about efficiency (number of AUs versus unsuitability), the highest priority AUs were very similar.

Utility and irreplaceability scores were significantly different for many individual AUs at the middle and low end of the utility score range. This is useful information for prioritization. AUs at the low end of utility (or irreplaceability) typically are unremarkable in terms of biodiversity value. They contribute habitat or target occurrences, but they are interchangeable with other AUs. For these AUs, prioritizing on the basis of suitability rather than biodiversity value makes most sense. If a distinguishing feature of an AU is that conservation can be conducted there more successfully and inexpensively than in other AUs, that AU should be a priority for action. For these AUs, the utility score should be used for prioritization.

7.4.1 Uncertainty

There were two major sources of uncertainty in our analysis. First, there were errors in the biological data. The target occurrence data undoubtedly had both errors of omission and commission but the error rates were unknown. The accuracy of the ecological systems/land cover data was also unknown. Second, the suitability index was not an empirical model as variable selection and parameter estimates for the index were based on professional judgment. The index "model" was validated through expert opinion, but it was not verified with data. In addition, the various GIS data used to compute the suitability index had errors, and the error rates for these were unknown as well. We would like to express the uncertainty of the irreplaceability or utility values by calculating confidence limits around them, but no technique for doing so currently exists. Even if such a technique were available, it would probably require some knowledge of the input data error rates.

Other ecoregional assessments (Vander Schaaf et al. 2006, Pryce et al. 2006, Iachetti et al. 2006) have explored the sensitivity of the utility indices to changes in the suitability index. Each analysis found that AU utility and rank change in response to changes in the suitability index. Similarity measures that compared "before" and "after" utility maps of the entire ecoregion indicated that the overall map was relatively insensitive to changes in suitability index parameters. That is, the average change over all AUs was small. However, the utility and rank of some individual AUs did change significantly. The number of AUs that changed significantly depended of which index parameter was changed and the amount of change to that parameter. These findings are similar to our comparisons of the irreplaceability and utility values.

Before we can explore the sensitivity of our results to errors in the biological data, we need to understand the potential errors. For occurrence data, error rates were target-specific (or taxon-specific) and a function of several factors: data age, survey methods, survey interval, survey intensity, survey extent, and the nature of the species and its habitat. To complicate the analysis further, error rates for a single target could have been uneven across the ecoregion. To obtain meaningful results from a sensitivity analysis, we needed, at the very least, a set of target-specific (or taxon-specific) error rates or error rate models. Error rates were also needed for the ecological systems/land cover data – ideally, omission and commission rates by land cover category. All this suggested a level of complexity that was beyond the capacity of this ecoregional assessment. Therefore, we were forced to assume the error rates in the biological data were minimal and did not have a significant influence on the irreplaceability and utility scores.

Chapter 8 – Portfolio of Conservation Areas

Successful conservation will involve making choices about where limited resources should be expended (Ando et al. 1998; Pressey and Cowling 2001). Portfolio creation is a major step toward making informed choices about where conservation areas or reserves should be located. Selecting a set of sites that efficiently captures multiple occurrences of hundreds of targets from thousands of potential sites is a task that cannot be accomplished by expert judgment alone. For this reason, MARXAN was used to help create the portfolio. Further explanation of MARXAN can be found in Appendix 8A. Optimal reserve selection analyzes the trade-offs between conservation values and conservation costs to create an efficient set of conservation areas that satisfies conservation goals (Possingham et al. 2000; Cabeza and Moilanen 2001). The conservation value of a site is represented by the presence of target species, habitats, and ecological communities. The number, condition, and rarity of targets present at a particular site determine the conservation value of that place.

The portfolio design process for the East and West Cascades Ecoregions resulted in the creation of an integrated terrestrial and freshwater portfolio. Portfolio creation was an iterative process that balanced the use of the optimal reserve selection algorithm with expert knowledge about important places for biodiversity conservation.

8.1 Goals for Portfolio Construction

The analytical tool, MARXAN requires a numerical conservation objective for each target. These conservation objectives, or goals, are expressed as a number of occurrences or land area, and they largely determine the number of assessment units or the amount of land included in the portfolio. Conservation goals are established at the ecoregion section level for terrestrial targets, and at the Ecological Drainage Unit (EDU) level of stratification for freshwater targets. This is to insure that targets are represented across their natural distribution in the ecoregion.

The intent of the analysis was to capture sufficient occurrences to meet conservation goals in the most efficient way possible, while also preferentially choosing occurrences with the least human impacts, according to the suitability index (Chapter 6). For this ecoregional assessment, conservation goals were set that reflected a high likelihood of target species survival and functioning ecological systems. However, there is much uncertainty, for example, regarding threats like future land conversion and climate change and little information regarding the number of occurrences or the area of an ecological system necessary to maintain all species within an ecoregion (Soule and Sanjayan 1998). In short, we had no scientifically established method for setting conservation goals for the vast majority of coarse- and fine-filter targets. Where we lacked better information, we adopted a set of generic conservation goals developed by ecologists from The Nature Conservancy and NatureServe (Marshall et al. 2000; Neely et al. 2001; Rumsey et al. 2003; Floberg et al. 2004).

While the goals cannot be treated as conditions for ensuring long-term survival of species, they are an important device for assembling a portfolio of conservation areas that captures multiple examples of the ecoregion's biodiversity (Tear et al. 2005). These goals also provide a metric for gauging the contribution of different portions of the ecoregion to the conservation of its biodiversity, as well as measuring the progress of conservation in the ecoregion over time.

8.1.1 Terrestrial and Freshwater Ecological Systems Goals

Based on the species-area curve (Figure 8.1), an initial goal of 30% would result in the retention of between 70 and 85% of the species occurring within these ecological systems.

Using that assumption, we selected an initial goal of 30% of current extent for each terrestrial and freshwater ecological system (Table 8.1).

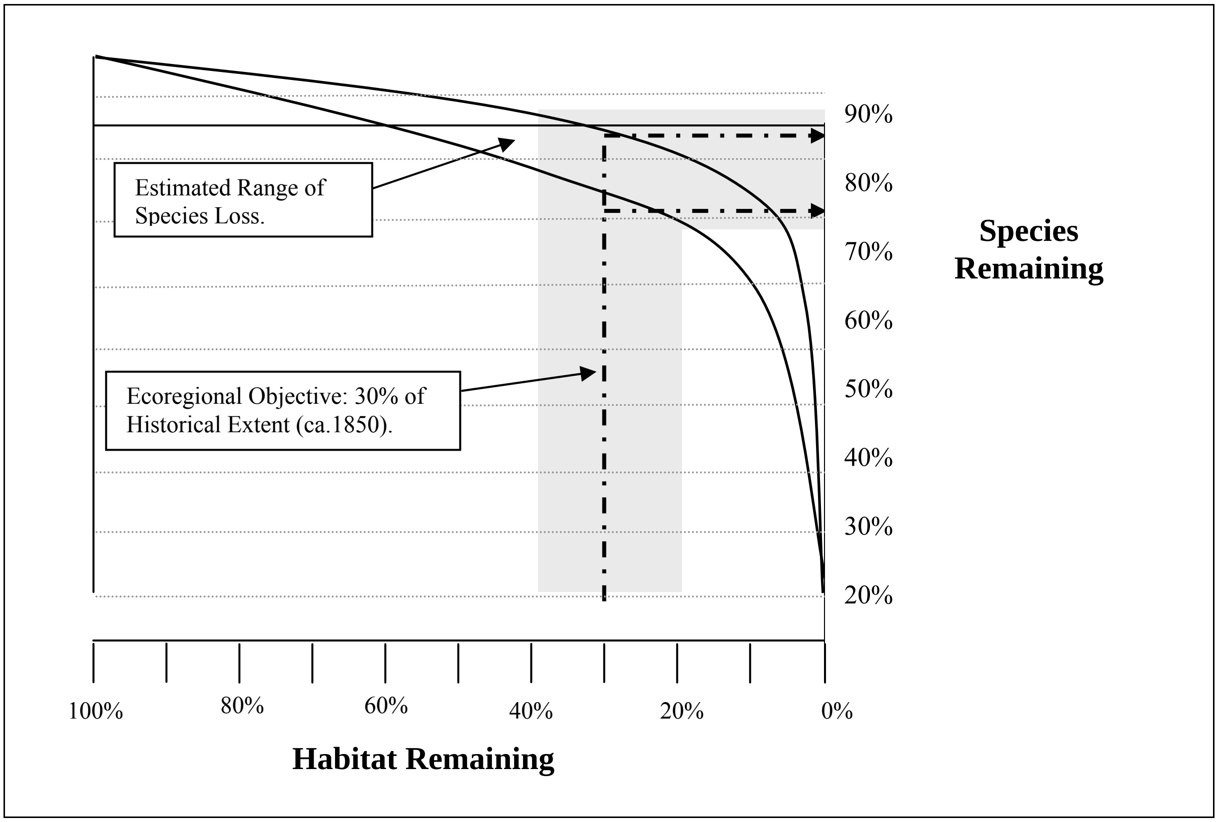

Figure 8.1. Estimated species remaining with percent area of habitat remaining over time. (Comer 2001)

8.1.2 Freshwater and Terrestrial Fine Filter Goals

Default conservation goals for terrestrial and some freshwater species were set for the ecoregion, section and EDU following goal recommendations from Comer (2003, see Table 8.2). Species distributions were defined as following:

Endemic = >90% of global distribution in ecoregion,
Limited = global distribution in 2-3 ecoregions,
Disjunct = distribution in ecoregion likely reflects significant genetic differentiation from main range due to historic isolation
Widespread = global distribution >3 ecoregions,
Peripheral = <10% of global distribution in ecoregion

Table 8.1. Default Ecoregional Goals for targets based on distribution, spatial pattern, and risk scenario.
(Based on Comer 2003)

	Default Goals for Scenarios					
	Small Patch Ecological Systems and Fine Filter Species Targets			Matrix, Large Patch and Linear Ecological Systems		
	Default Number of Occurrences*			Default Area or Length, per Section or Ecological Drainage Unit		
Distribution Relative to Ecoregion	**"High Risk" Scenario**	**"Middle Risk" Scenario (Portfolio)**	**"Low Risk" Scenario**	**"High Risk" Scenario**	**"Middle Risk" Scenario (Portfolio)**	**"Low Risk" Scenario**
Endemic	P: 25 N: 63	P: 50 N: 125	P: 75 N: 188	18%	30%	48%
Limited	P: 13 N: 34	P: 25 N: 67	P: 38 N: 101			
Widespread/ Disjunct	P: 7 N: 19	P: 13 N: 38	P: 20 N: 57			
Peripheral	P: 4 N: 12	P: 7 N: 23	P: 11 N: 35			

*for Occurrences: P = population EOs; N= nest EOs (based on z = 0.3).

If there was sufficient reason and agreement among team members, goals were adjusted for individual species. Recovery goals provided in federal recovery plans were used for the bald eagle and peregrine falcon. For some other listed species, such as the northern spotted owl, we set goals at 50% of element occurrences (EOs) (Appendices 4D and 4E). Given that this assessment is on the watershed scale, it is not meant to be a species specific recovery plan, although it can be used in conjunction with such plans. As with system goals, the goals for fine-filter targets were set for both ecoregional and section levels. The sectional goals were set based on a species distribution within the ecoregion to ensure stratification across its range.

For freshwater fish species targets, methodologies for the development of conservation goals differed slightly between EDUs. In all EDUs, goals for all anadromous salmonids were set at 50% of occupied habitat due to their high degree of vulnerability and status as indicator species. Where EDT data were used, the conservation goal for salmon in the integrated portfolio was 50% of the product of length of spawning habitat and the EDT habitat-quality score. In Washington EDUs (Okanogan, Yakima-Palouse, Lower Columbia and Puget Sound), conservation goals for resident fishes in the stand alone EDU freshwater portfolios were determined following "moderate risk" guidelines proposed by Comer (2003) and Table 8.1 (above) for the number of occurrences, or populations, for species with a limited distribution, and as a percentage of available reproductive and rearing habitat for mobile and wide-ranging species.

In Oregon and California EDUs (Deschutes, Willamette, Rogue-Umpqua, Upper Klamath, Pit, Honey Lake and Great Basin), and in the final integrated analyses, goals for resident fishes were based on a percentage of total observations for individual species (Appendices 4I and 4H). For these EDUs, goals for MARXAN runs were initially set at 30% of the total occurrences for a particular species or population. Additionally, goals for some at-risk and all listed freshwater species were increased to 50%. In all cases where available target data were expressed as point data, points were assumed to be populations.

Conservation goals are a general estimate of how much of a target may be required for its long-term persistence (Tear et al. 2005). Unfortunately, many species have become so rare, or are so data poor, that only a fraction of the occurrences necessary to meet their conservation goal exist in the ecoregion. MARXAN, our portfolio assembly tool, requires specific goals for each target based upon current distributions. However, it cannot meet a goal that exceeds the known amount of occurrences for any given target. Therefore, we created a separate MARXAN goal to address targets with an abundance that is less than that of the conservation goal. For targets with a total abundance equal to, or in excess of their conservation goal, the MARXAN goal equals the conservation goals. For targets whose total abundance is less than their conservation goal, the MARXAN goal was set at 90% of all available occurrences. MARXAN goals were not set at 100% in order to avoid forcing the selection of some of the most degraded sites.

8.2 Assessment Units

MARXAN requires that all data be attributed to assessment units (AUs). These AUs represent a wall-to-wall coverage of similar sized polygons that cover the entire planning area. For the East and West Cascades assessments, it was determined that watersheds would be the most ecologically relevant AU, and would allow us to use the same AUs for the terrestrial and freshwater realms.

The USGS has delineated watersheds across the nation (Seaber et al. 1987). These watersheds, termed “hydrologic units”, subdivide the major river drainages of the country into successively smaller watersheds. The 6th division, or HUC6, is the finest level of division the USGS has systematically developed. HUC6s within the Cascadian ecoregions have a mean area of approximately 5,000 ha and a large standard deviation. These HUC6s were used as the AUs to contain all the freshwater information for those portions of EDUs outside the two ecoregions. Within the East and West Cascade Ecoregions, we further subdivided the watersheds to decrease their size and variability. Using watershed delineation tools developed by the Conservancy’s Freshwater Initiative (Fitzhugh 2005), most HUC6s within the two ecoregions were subdivided into watershed AUs with a mean size of 2,600 ha, and a standard deviation of 1,050 ha (Map 3.1). Within the two ecoregions, all terrestrial data, and most of the freshwater data, were attributed to each of these AUs. Additional layers of larger assessment units were used to hold the large freshwater systems data (Class 2 and 3, or Medium and Large rivers) to avoid splitting them into small pieces (Map 4.3). These larger watersheds are represented by buffered mainstem river corridors in the final integrated portfolio.

Each AU was assigned a value of conservation suitability (described in Chapter 6). This value or index consists of a set of weighted factors (e.g., road density, conversion) that influence the relative likelihood of successful conservation at any given AU.

8.3 MARXAN and Portfolio Selection

The MARXAN program strives to minimize the “objective function”, or the sum of: the suitability values for all selected AUs, the penalties for not meeting target representation goals, and the length of boundaries defining the extent of the conservation portfolio. It begins by adding a random set of AUs to create a first iteration conservation portfolio. The algorithm then iteratively explores improvements to this initial portfolio by randomly adding or removing AUs, literally millions of times (i.e., iterations) per MARXAN run. Selected AUs are scored for how well they meet target goals, the total cost of the solution, and total length of the portfolio boundary. At each iteration the new portfolio is compared with the previous portfolio and the better one is accepted. The algorithm uses a method called simulated annealing (Kirkpatrick et al. 1983) to reject sub-optimal portfolios, thus greatly increasing the chances of converging on a very efficient portfolio. Typically, we used five million iterations of the algorithm for each version of the draft portfolios. Appendix 8A contains details on the MARXAN site selection algorithm.

Though an integrated (aquatic and terrestrial) conservation portfolio is the ultimate goal of our analyses, separate stand-alone analyses for the terrestrial and aquatic realms can also be valuable. They reveal patterns of biodiversity, possible conservation opportunities for targets, and help identify threats to those same resources. The first step in our integrated portfolio construction is to identify draft stand-alone terrestrial and aquatic portfolios, and then overlap those portfolios to form the 'core' of the integrated portfolio.

8.4 Freshwater Aquatic Analysis and Draft Portfolio

Aquatic analyses evaluate entire EDUs. An EDU is an aquatic unit akin to a terrestrial ecoregion; an area of relatively homogenous biota and physical habitats on a scale suitable for ecoregional assessment. There are a total of 11 EDUs that intersect the Cascadian ecoregions. Most of these EDUs extend far beyond the terrestrial planning boundary. The combined area of these EDUs is 32.5 million ha, more than 2.5 times the area of the combined East and West Cascades terrestrial ecoregions. HUC6s were used for aquatic AUs within EDUs where they extended beyond the boundaries of the terrestrial ecoregions, and our subdivided HUC6s were used as AUs within the ecoregional boundaries (Table 8.2). Integration is vastly simplified by using spatially identical AUs for the freshwater and terrestrial layers within the ecoregional boundaries.

Table 8.2. Summary of EDUs by area and number of AUs

EDU Name	Area (Hectares)	AU count
Deschutes	2,778,723	708
Great Basin (partial)	1,360,888	445
Honey Lake	725,258	159
Lower Columbia	2,816,707	966
Okanagan	6,384,544	992
Pit	1,992,758	619
Puget Sound	4,274,824	949
Rogue-Umpqua	2,550,003	635
Upper Klamath Basin	2,096,339	741
Willamette	2,609,999	743
Yakima-Palouse	4,904,407	743
Total	**32,494,450**	**7700**

For the aquatic realm, all aquatic target and suitability information was attributed to each AU within each EDU. Every EDU had the suitability values for the AUs normalized to a 0 – 10,000 scale, so each had a most and least suitable AU. Every biological target was stratified by EDUs; any target that straddled multiple EDUs was considered a separate target within each and goals were set based upon its abundance within that EDU. This ensured that the assessment was sensitive to wide-ranging species and widespread habitats that could occur across multiple EDUs. Using target and suitability data, MARXAN produced a draft aquatic portfolio that consisted of 2,120 AUs out of the total 7,700 within the 11 EDUs (Map 8.1). This assessment was then peer-reviewed prior to integration with the draft terrestrial portfolio.

8.5 Terrestrial Analysis and Draft Portfolio

The terrestrial targets and suitability data were attributed to each terrestrial AU within each ecoregion, using similar methods as the freshwater analysis. Each ecoregion had suitability values normalized to a 0 – 10,000 scale, so each had a most and least suitable AU. Targets that straddled both ecoregions were treated as separate targets within each ecoregion, and goals were set based upon their abundance. An additional level of stratification was achieved by subdividing each ecoregion into sections, four for the West Cascades and six for the East Cascades (Tables 8.3 and 8.4). Species had goals established for their full ecoregional and sectional distributions, while coarse filter habitats only had sectional goals. The draft terrestrial portfolio developed with MARXAN consisted of 1,352 AUs in the East Cascades and 619 AUs in the West Cascades (Map 8.2). This assessment was then peer reviewed prior to integration with the draft freshwater portfolio.

Table 8.3. Terrestrial Sections summary for the West Cascades Ecoregion

Section Name	Area (Hectares)	AU count
Columbian Cascades	1,227,353	472
Middle Oregon Cascades	1,279,667	472
Mount Rainier	812,348	306
Umpqua Cascades	920,040	358
Total	**4,239,408**	**1608**

Table 8.4. Terrestrial Sections summary for the East Cascades Ecoregion

Section Name	Area (Hectares)	AU count
Eastside Oak	845,322	329
Modoc Plateau	2,096,274	774
Pumice and Pine	1,341,582	532
Upper Klamath Basin	2,017,783	712
Wenatchee	895,009	329
Yakima	716,017	255
Total	**7,911,987**	**2931**

8.6 Integration Methodology

One of the biggest challenges in planning is how to incorporate aquatic and terrestrial targets into a single suite of conservation areas. Some plans have analyzed terrestrial and aquatic species and systems separately and then attempted to merge the results manually. Others have analyzed both target types together in one layer of AUs and used a site selection computer program to find an optimal solution. A third approach is to simply overlay the outputs of a terrestrial and aquatic assessment. Each of these three approaches have serious shortcomings. The manual integration may be feasible for small areas, but large-scale planning efforts can involve millions of hectares. It is simply impossible for humans to synthesize enough information to ensure reasonable outcomes. Analyzing both aquatic and terrestrial realms with the one-layer approach pushes a large portion of the solution into sub-optimal territory for both aquatic and terrestrial targets. An index crafted for an aquatic species will have little relevance for terrestrial systems. Similarly, an index crafted for both realms will tend to mask impacts specific to a single realm. The simple overlay of the independent assessments is perhaps the most straight-forward method, but often leads to larger conservation area designs, and opportunities for efficiency will be overlooked.

However, the intersection of the aquatic and terrestrial stand-alone portfolios does represent a very good starting point for an integrated portfolio. Taking the overlap as the "core" of the integrated portfolio ensures that many priorities identified within each realm, independent of any influence from the other realm, are maintained in the final conservation area design. This also ensures some continuity with the stand-alone outputs, a huge gain in efficiency from the perspective of peer review, which can be a very time consuming element of the planning process. To complete the draft automated integrated portfolio we used the vertical integration technique developed by the Oregon Chapter of The Nature Conservancy (Schindel 2005). This technique utilizes the component of MARXAN's objective function that attempts to minimize fragmentation.

In vertical integration, the boundary relations between AUs are used to allow the model to recognize that two or more polygons stacked upon each other are also adjacent. In these situations the model attempts to minimize the length of the total solution boundary by clustering vertically through a stack of AUs. As the boundary modifier is increased, the importance of clustering, horizontally as well as vertically, is increased. This three-dimensional approach mimics GIS analysis though no spatial analysis is involved in the MARXAN algorithm (Figure 8.2).

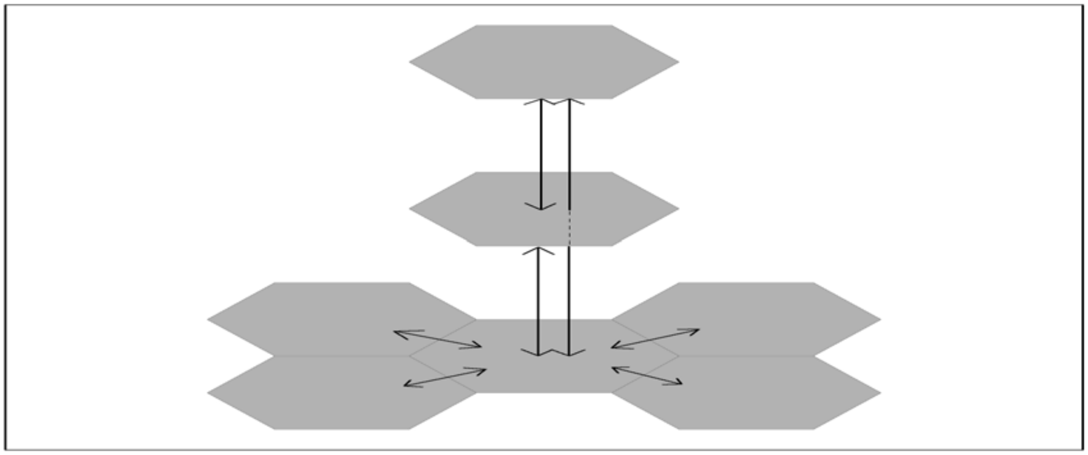

Figure 8.2. A schematic demonstrating the boundary relations between stacked and horizontally adjacent AUs.

(Each AU may relate to AUs above or below it, as well as from side to side.)

In this ecoregional assessment, because the primary aquatic and terrestrial AUs were spatially identical, they could be stacked to facilitate a straight-forward, integrated analysis. The length of their shared boundaries could be measured as the area of the polygons. We initially set all of the aquatic-terrestrial boundaries at the mean of the terrestrial-to-terrestrial boundaries, so the model was generally as likely to clump upwards through the stack between aquatic and terrestrial AUs, as from side to side within a layer. A big advantage of this analytical technique is that the inputs from the stand-alone analysis can be used with little modification in the integrated analysis.

A final component of the analysis involved the small to medium river drainages. The aquatic habitats are typically represented by three classes of nested polygonal watersheds: tributary and headwater drainages less than 100 km² (Class 1), small to medium river drainages between 100 – 1,000 km² (Class 2), and large river drainages more than 1000 km² (Class 3). Only Class 1 and 2 polygons were analyzed in our MARXAN runs. The Class 3 polygons are very large, with only a few examples identified in each EDU. Their selection was done manually with expert input, using the final integrated portfolio as a guide. For our analysis, the Class 1 drainages were attributed to their best fit aquatic AU subwatershed, and the larger Class 2 polygons were related to all the aquatic AUs below them using boundary relations. Three components were then part of the complete boundary relations file; the traditional boundary relations between the terrestrial AUs, the relations of the aquatic AUs to the terrestrial AUs they overlapped, and the relations between the aquatic AUs and the Class 2 polygons they overlapped.

Integrated portfolio solutions which maximize the overlap between the terrestrial and freshwater AU layers (minimizing the boundary) will be favored by the algorithm. However, the algorithm is not forced to select overlapping AUs. If the costs of an AU are prohibitive, or if the conservation targets in an AU are no longer required to meet goals, the algorithm may not select that AU even when the AU above or below it has been selected.

We tested this methodology against the standard practice of attributing all biological information to a single set of AUs with a suitability index blended to address impacts to both realms. In this case, when an AU is selected, then both freshwater and terrestrial sets of targets are always selected. Using the same boundary modifier, the same scale of suitability indices (by averaging the two values to derive a blended index), the same goals, and the same boundary values for horizontal adjacency, head-to-head comparisons were done between the two methods. Both selected very similar numbers of AUs (857 for the vertical method, 852 for the single-layer), and had similar areas (2,365,980 ha vertical, 2,328,306 ha single). However, the mean AU cost (calculated from the suitability index) for the vertical method was about 20% lower for the single-layer method, and goal attainment was higher (94.7% vs. 92.5%). Also, the amount that goals were exceeded was 13% lower in the vertical solution. The vertically integrated solution was more discriminating in its selection of conservation priorities within each realm. See Appendix 8A for more details.

8.7 Draft Integrated Portfolios and Expert Review

The integrated portfolio analysis began with a core of "locked in" AUs that consisted of the overlap of the stand-alone aquatic and terrestrial portfolios (Map 8.3). This overlap or core consisted of 424 AUs in the East Cascades and 204 AUs in the much smaller West Cascades.

MARXAN was then run again with goals set for each layer (terrestrial HUCs, freshwater HUCS, and Class 2 freshwater system polygons) and 10 runs were performed for each ecoregion, each using five million iterations and a boundary modifier of 0.1. Each of the runs was scored on how well it met goals, its total size, how much overlap existed between the selected aquatic and terrestrial AUs, and total cost. The output with the best score for each ecoregion became the draft integrated portfolio which was then reviewed and modified by experts. The draft integrated portfolio for the East Cascades consisted of 255 AUs chosen only for freshwater targets, 391 chosen only for terrestrial targets, and 701 selected for both sets of targets. An additional 95 AUs which were not selected but were at least 50% protected (GAP Status 1 or 2) were added to this draft portfolio. The West Cascades draft integrated analysis, produced 237 AUs selected for aquatic targets, 253 for terrestrial, and 395 AUs were selected for both sets of targets. This draft portfolio included an additional 60 AUs which are already at least 50% protected.

These two draft integrated portfolios were then peer reviewed by over 200 biologists and ecologists from the organizations and agencies involved in the assessment, as well as additional state and federal agencies and nonprofit organizations. In addition to informal sessions within our own organizations, we held four review sessions in Washington and five in Oregon. The Klamath Falls session included participants that reviewed the California segment of the portfolio. All sessions were well attended by experts that possessed a variety of relevant qualifications. In all, these review sessions had over 120 participants representing 38 organizations (Appendix 8B). The main goal of these sessions was to evaluate our portfolio as well as the data that went into the analysis. Reviewers verified results, identified omissions of areas with rare or high quality conservation targets, noted invalid inclusions, and informed us of poor quality data as well as data we failed to use.

We recorded and linked each comment to the relevant AU identification number(s). Most of the comments were “ground-truthing,” verifying or negating the automated outcome based on first-hand knowledge of the area in question. These comments aided in our subsequent reevaluation of the portfolio. Most of the remaining comments questioned the validity of AUs that were included in or omitted from the portfolio. Members of the core team reviewed each comment and made final changes to the portfolio. Experts made comments on everything from base layers to locations and condition of targets and additional datasets available. Some of the major issues that were identified and subsequently resolved include the following:

- Experts in both Oregon and Washington noted significant problems with the set of bull trout data that we used in the analysis.
- In both Oregon and Washington, the ownership layer included a number of areas that were misidentified. Problems were primarily associated with USFS and WDNR properties.
- In Oregon, experts identified a general lack of salmon data above dams where the presence of salmon had been verified.

A total of 776 comments received resulted in 75 AUs being added for terrestrial or freshwater targets (most of which had already been selected for one set of targets) and 133 AUs being dropped, for a net loss of 58 AUs. Reasons for dropping AUs included identification of better places to conserve the targets, and a few AUs had apparently been selected by MARXAN purely to reduce the total boundary length of the portfolio by blocking up AUs.

An additional step we conducted with freshwater experts was to review the medium river Class 2 systems which had been selected as part of the vertical portfolio integration, as well as the larger Class 3 systems which were manually picked to identify important aquatic linkages between and among integrated portfolio sites. In the final portfolio, these sites are represented by mainstem river corridors.

8.8 Final Integrated Portfolios

The final integrated portfolio selects approximately 46% of the number of AUs and area originally identified for the East Cascades, and approximately 54% of the West Cascades (Table 8.5). The difference in percentages between the two ecoregions is probably due to the fact that the West Cascades had over twice as many target species EOs per ha (0.0022) compared to the East Cascades (0.00095). This is likely a function of the large amount of data we had for certain species (eg. spotted owls, salmon) that are not as widespread on the east as compared to the west side of the crest, but it may also be a function of survey effort.

Table 8.5. Summary of East and West Cascades Integrated Portfolios by Assessment Units

Ecoregion	Final Portfolio Status	# of AUs in Final Portfolio	% of AUs in Ecoregion	Final Portfolio area (ha)	% of Ecoregion
East Cascades	Freshwater only	186	6.35	523,259	6.61
East Cascades	Terrestrial only	355	12.11	994,120	12.56
East Cascades	Both fw and terr.	687	23.44	2,023,803	25.58
East Cascades	Additional protected AUs	95	3.24	237,435	3.00
East Cascades	*All selected AUs*	*1323*	*45.14*	*3,778,616*	*47.76*
West Cascades	Freshwater only	160	9.95	451,426	10.65
West Cascades	Terrestrial only	252	15.67	695,522	16.41
West Cascades	Both fw and terr.	395	24.56	1,081,855	25.52
West Cascades	Additional protected AUs	60	3.73	137,083	3.23
West Cascades	*All selected AUs*	*867*	*53.92*	*2,365,887*	*55.81*
Both Ecoregions	All selected AUs	2190	48.25	6,144,503	50.57

Although the mid-risk portfolio identifies approximately half of each ecoregion for possible conservation action, 24% of each portfolio is permanently protected (Table 8.6), and many other areas are currently in management which is beneficial for the conservation targets. We also emphasize that these assessments do not advocate complete protection (GAP1 or 2 status) of all areas identified in the portfolios. Rather, they identify areas which should be protected or managed according to the requirements of the conservation targets contained at those sites.

Table 8.6. Summary of East and West Cascades Integrated Portfolios by amount currently protected
(GAP status 1 or 2)

Ecoregion	Section	Final Portfolio area (ha)	Currently Protected Portfolio area (ha)	% of Portfolio Currently Protected
East Cascades	Eastside Oak	424,632	67,633	15.93
East Cascades	Modoc Plateau	842,859	50,543	6.00
East Cascades	Pumice and Pine	571,676	104,604	18.30
East Cascades	Upper Klamath Basin	926,085	218,864	23.63
East Cascades	Wenatchee	630,963	312,774	49.57
East Cascades	Yakima	382,400	160,609	42.00
East Cascades	*Full Ecoregion*	*3,778,616*	*915,027*	*24.22*
West Cascades	Columbian Cascades	687,829	122,965	17.88
West Cascades	Middle Oregon Cascades	721,330	151,635	21.02
West Cascades	Mount Rainier	460,304	187,800	40.80
West Cascades	Umpqua Cascades	496,424	89,324	17.99
West Cascades	*Full Ecoregion*	*2,365,888*	*551,724*	*23.32*
Both Ecoregions	All sections	6,144,504	1,466,751	23.87

The percent area selected was similar for the four sections of the West Cascades Ecoregion but varied considerably among the sections of the East Cascades from 40% of the Modoc Plateau to 70% of the Wenatchee section (Tables 8.7 and 8.8). The reason for this is that the Wenatchee section has more data than the Modoc Plateau section, and also had the most AUs (45) added to the portfolio, based on protected status (50%). This is consistent with the fact that 35.5% of the Wenatchee section is already protected (GAP 1 or 2) while only 3.4% of the Modoc Plateau section falls into those categories (Chapter 5).

These assessments were completed at the HUC watershed assessment unit scale and did not identify just portions of any particular assessment unit which contained the biodiversity that it was selected for. That level of planning needs to be done at the local scale, with local stakeholders involved in land management decisions.

Table 8.7. Summary of Final Integrated Portfolio by Terrestrial Section for the East Cascades Ecoregion

Terrestrial Section	Final Portfolio Status	# of AUs in Final Portfolio	% of AUs in Section	Hectares in Final Portfolio	% of Section area
Eastside Oak	Freshwater only	14	4.3	35,267	4.2
Eastside Oak	Terrestrial only	43	13.1	118,099	14.0
Eastside Oak	Both FW and Terr.	104	31.6	268,370	31.8
Eastside Oak	Additional protected AUs	1	0.3	2,896	0.3
Eastside Oak	All selected AUs	162	49.2	424,632	50.2
Modoc Plateau	Freshwater only	45	5.8	125,186	6.0
Modoc Plateau	Terrestrial only	104	13.4	281,306	13.4
Modoc Plateau	Both FW and Terr.	134	17.3	428,867	20.5
Modoc Plateau	Additional protected AUs	3	0.4	7,500	0.4
Modoc Plateau	All selected AUs	286	37.0	842,859	40.2
Pumice and Pine	Freshwater only	29	5.5	81,432	6.1
Pumice and Pine	Terrestrial only	68	12.8	172,381	12.9
Pumice and Pine	Both FW and Terr.	110	20.7	294,966	22.0
Pumice and Pine	Additional protected AUs	9	1.7	22,897	1.7
Pumice and Pine	All selected AUs	216	40.6	571,676	42.6
Upper Klamath Basin	Freshwater only	40	5.6	115,268	5.7
Upper Klamath Basin	Terrestrial only	79	11.1	240,674	11.9
Upper Klamath Basin	Both FW and Terr.	162	22.8	527,570	26.2
Upper Klamath Basin	Additional protected AUs	19	2.7	42,574	2.1
Upper Klamath Basin	All selected AUs	300	42.1	926,085	45.9
Wenatchee	Freshwater only	36	10.9	102,563	11.5
Wenatchee	Terrestrial only	47	14.3	138,664	15.5
Wenatchee	Both FW and Terr.	102	31.0	272,854	30.5
Wenatchee	Additional protected AUs	45	13.7	116,883	13.1
Wenatchee	All selected AUs	230	69.9	630,963	70.5
Yakima	Freshwater only	22	8.6	63,544	8.9
Yakima	Terrestrial only	14	5.5	42,996	6.0
Yakima	Both FW and Terr.	75	29.4	231,176	32.3
Yakima	Additional protected AUs	18	7.1	44,685	6.2
Yakima	All selected AUs	129	50.6	382,400	53.4

Table 8.8. Summary of Final Integrated Portfolio by Terrestrial Section for the West Cascades Ecoregion

Terrestrial Section	Final Portfolio Status	# of AUs in Final Portfolio	% of AUs in Section	Hectares in Final Portfolio	% of Section area
Columbian Cascades	Freshwater only	57	12.1	158,177	12.9
Columbian Cascades	Terrestrial only	65	13.8	178,958	14.6
Columbian Cascades	Both FW and Terr.	114	24.2	306,320	25.0
Columbian Cascades	Additional protected AUs	19	4.0	44,374	3.6
Columbian Cascades	All selected AUs	255	54.0	687,829	56.0
Middle Oregon Cascades	Freshwater only	51	10.8	146,171	11.4
Middle Oregon Cascades	Terrestrial only	92	19.5	258,959	20.2
Middle Oregon Cascades	Both FW and Terr.	109	23.1	303,159	23.7
Middle Oregon Cascades	Additional protected AUs	6	1.3	13,041	1.0
Middle Oregon Cascades	All selected AUs	258	54.7	721,330	56.4
Mount Rainier	Freshwater only	32	10.5	95,066	11.7
Mount Rainier	Terrestrial only	41	13.4	119,989	14.8
Mount Rainier	Both FW and Terr.	70	22.9	191,352	23.6
Mount Rainier	Additional protected AUs	24	7.8	53,897	6.6
Mount Rainier	All selected AUs	167	54.6	460,304	56.7
Umpqua Cascades	Freshwater only	20	5.6	52,012	5.7
Umpqua Cascades	Terrestrial only	54	15.1	137,616	15.0
Umpqua Cascades	Both FW and Terr.	102	28.5	281,024	30.5
Umpqua Cascades	Additional protected AUs	11	3.1	25,772	2.8
Umpqua Cascades	All selected AUs	187	52.2	496,424	54.0

8.8.1 Portfolio Sites

In order to move beyond AUs and plan on a landscape scale, the AUs selected in the final integrated portfolio were then grouped together into Priority Conservation Areas or Portfolio Sites, primarily on a larger watershed scale and named after the main river in that watershed.

In the East Cascades, the 1,323 selected AUs were grouped into 143 integrated sites, and the 867 AUs in the West Cascades portfolio were made into 107 integrated sites, with an average size of 25,000 ha. (Maps 8.4, 8.5, 8.6 and Appendix 8C). These sites were connected and intersected by an additional 57 mainstem Class 2 (medium river) and 20 mainstem Class 3 (large river) sites represented by river corridor sites (Maps 8.4, 8.5, 8.6 and Appendix 8D). See poster-sized Maps A-D on the CD for details of the Portfolio Sites.

Summaries of the conservation targets, land management, and ownership at each Portfolio Site can be found in Appendix 8E (West Cascades) and 8F (East Cascades and Modoc Plateau) or the separately bound Site Summaries available for each state.

8.9 Conservation Goal Assessment

As The Nature Conservancy and other organizations and agencies have been completing large-scale ecoregional assessments, goals set for the conservation portfolios have varied, with the more recent assessments calling for higher conservation goals (Andelman et al.

1999, Vander Schaaf et al. 2006, Iachetti et al. 2006). This has resulted in more area identified for future conservation as scientists realize that targets and complex ecological relationships often require more than an “island” of protected habitat to survive in the long term (Comer 2003, Tear et al. 2005). However, this also means that fewer targets can meet their conservation goals.

The results for the general target groups for each ecoregion are summarized below (Tables 8.9 and 8.10). The specifics for each target by section or EDU are in Appendices 8G and 8H.

Targets which have conservation goals based on percentage of available habitat are more likely to meet those goals than targets that were largely represented by occurrence data and have numerical goals (primarily terrestrial species). Accordingly, in the two ecoregions, goal attainment for the groups with percentage goals was approximately 97% for terrestrial systems, 93% for Class 1 freshwater systems (which are comprised of larger polygons and so are less likely to reach goals), and 93% for fish (which were rated on their full EDU conservation goals and attainment including the freshwater portfolio outside the ecoregions).

Targets that had numerical goals (terrestrial species) only met their sectional conservation goals about 35% of the time. The rare and elusive species which have not received a lot of survey effort, such as invertebrates, plants and reptiles fared the worst. Two major reasons for that are a lack of comprehensive survey effort and relatively high goals, since many of these species are endemic. Birds met a relatively high percentage of their goals, around 50%. This is generally due to better survey efforts, and because they are often wide ranging, are not endemic, and thus have lower goals. This is also true of the mammals, which met their goals about 65% of the time. Finally, the terrestrial species group that had the highest rate of goal attainment was amphibians. They tend to be relatively sedentary, are often endemic to one ecoregion, and are rare enough that they garner attention, but not so rare that they are impossible to survey. A similar pattern of how well targets met conservation goals was seen in the Pacific Northwest Coast Ecoregional Assessment (Vander Schaaf et al. 2006).

Table 8.9. East Cascades sectional targets with data captured in the integrated conservation portfolio.

Target Group	# of targets analyzed by section or EDU	# meeting sectional conservation goals	% meeting sectional conservation goals
Terr. Ecological Systems	205	196	96
Freshwater Class 1 Systems	127	118	93
Vascular Plants	229	37	16
Nonvascular Plants	6	0	0
Mammals	38	20	53
Birds	113	56	50
Amphibians	34	29	85
Reptiles	6	1	17
Fish	82	75	91
Insects	2	0	0
Mollusks, Crustacean	39	2	5

Table 8.10. West Cascades sectional targets with data captured in the integrated conservation portfolio.

Target Group	# of targets analyzed by section or EDU	# meeting sectional conservation goals	% meeting sectional conservation goals
Terr. Ecological Systems	96	94	98
Freshwater Class 1 Systems	66	62	94
Vascular Plants	137	31	23
Nonvascular Plants	40	1	3
Mammals	30	24	80
Birds	59	32	54
Amphibians	44	35	80
Reptiles	7	3	43
Fish	53	51	96
Insects	10	0	0
Mollusks	15	6	40

8.10 Alternative Portfolios

The size of the conservation portfolio is mainly determined by the goals – the larger the goals, the larger the portfolio. For this reason, goal setting is possibly the most critical step in creating a portfolio. Hence, we created additional portfolios with higher and lower goals to demonstrate how changing goals changes the total size and configuration of the portfolio.

8.10.1 Methods

Risk is inversely related to the amount of habitat or the number of occurrences that are protected in the portfolio. More habitat and occurrences that are protected yields less risk. The goals for the lower-risk and higher-risk portfolios were based on the goals of the mid-risk portfolio. For the higher-risk portfolio, our goals were reduced by simply multiplying all mid-risk coarse-filter goals by 0.6 and fine-filter goals by 0.5. However, goals could not be less than one for targets represented by the number of occurrences. For the lower-risk, the goals were increased by simply multiplying mid-risk coarse-filter goals by 1.6 and fine-filter goals by 1.5. The low-risk goals could not exceed the maximum available.

Using the process described above, we created higher- and lower-risk alternative portfolios. The alternative portfolios are nested. That is, all the AUs in the higher-risk portfolio belong to the mid-risk portfolio and all AUs in the mid-risk portfolio belong to the lower-risk portfolio. MARXAN has a feature for locking AUs into or out of the optimal solution. To create a nested higher-risk portfolio, we locked out all AUs that were not in the mid-risk portfolio. This limited the algorithm's selection space to only the mid-risk portfolio. To create a nested lower-risk portfolio, we locked in all AUs that were in the mid-risk portfolio. The low-risk portfolio started with these locked-in AUs, only allowing the algorithm to add AUs. AUs in the portfolio may be selected for terrestrial targets only, aquatic targets only, or for both terrestrial and aquatic targets.

The target conservation goals were the only element altered for the lower- and higher-risk portfolios. All other variables and parameters in the optimization were the same as those used for the mid-risk portfolio (e.g., penalty factors, boundary modifier, number of iterations, etc.)

8.10.2 Results

The alternative portfolios are depicted on Map 8.7. The integrated mid-risk portfolio is the set of final Portfolio Sites discussed in Chapter 8.8. This integrated portfolio included 48% of AUs (Table 8.11). However, only 27% of AUs were selected for both terrestrial and aquatic targets in this mid-risk portfolio. AUs selected for either terrestrial or aquatic targets only account for the difference between these percentages. In terms of land area, the percentage captured by the mid-risk portfolio was quite similar to the percentage of AUs selected, 50% (Table 8.12).

The relative size of each portfolio was largely determined by the relative size of the conservation goals. The size of the higher-risk portfolio was 0.53 times the size of the mid-risk portfolio in terms of AU number and 0.56 times the size of the mid-risk portfolio in terms of land area. The same ratios comparing the lower-risk and mid-risk portfolios were 1.49 and 1.46, respectively. These four ratios are very close in magnitude to the factors used to alter the mid-risk conservation goals.

For the lower- and mid-risk portfolios, AUs selected for both terrestrial and aquatic targets comprised 50 to 60% of the portfolio. About 30% of the higher-risk portfolio was comprised of AUs selected for both types of targets. As goals are decreased, the model has more latitude in its selection of AUs to conserve any given target. By selecting the most suitable (or least costly) suite of AUs to meet these lowered goals, a greater reduction in the value of the objective function can be achieved than by maximizing the overlap between the layers. Therefore, lowered goals also lead to a decrease in overlap among selected terrestrial and aquatic AUs.

Table 8.11. Percent of AUs in ecoregion captured by each of the integrated alternative portfolios.

Ecoregion	lower risk		mid-risk		higher risk		total AUs available
	both*	all*	both	all	both	all	
East Cascades	36.3	64.3	26.7	45.1	7.1	23.6	2931
West Cascades	45.8	85.6	28.3	54.0	8.8	29.9	1608
East and West combined	39.7	71.8	27.3	48.3	7.7	25.8	4539

* "Both" is the percent of AUs selected for both the terrestrial and aquatic analyses. "All" is the percent of AUs selected for terrestrial only, aquatic only, and for both terrestrial and aquatic.

Table 8.12. Percent of land area in ecoregion captured by each of the integrated alternative portfolios.

Ecoregion	lower risk		mid-risk		higher risk		total area available (ha)
	both*	all*	both	all	both	all	
East Cascades	38.8	66.7	28.6	47.8	7.8	26.3	7,912,000
West Cascades	46.5	86.8	28.8	56.0	9.6	32.3	4,239,400
East and West combined	41.5	73.7	28.6	50.6	8.5	28.4	12,151,400

* "Both" is the percent of land captured for both the terrestrial and aquatic analyses. "All" is the percent of land captured for terrestrial only, aquatic only, and for both terrestrial and aquatic.

8.10.3 Discussion

The three alternative portfolios represent different tolerances of risk to biodiversity loss, with the low-risk portfolio covering the largest geographic area and the high-risk protecting the smallest. The three risk levels also acknowledge the uncertainty of how much is enough to conserve for the survival of biodiversity. Finally, the three levels illustrate that there are a range of policy options for biodiversity conservation. Lower risk options will be more costly because of the larger land area needed. It is important to realize that because of our uncertainty, any portfolio's absolute risk to the loss of biodiversity is unknown. However, the mid-risk portfolio is the best effort by those experts involved in this assessment to produce a map of priority conservation areas.

Chapter 9 – Prioritization of Portfolios

9.1 Introduction

Ecoregional assessments typically identify a large number of conservation areas or portfolio sites (Rumsey et al. 2003, Floberg et al. 2004, Vander Schaaf et al. 2006). By virtue of its selection, each portfolio site should be considered for action, however not all areas are of equal conservation value or in need of attention with the same degree of urgency. The challenge of conserving all of the identified areas in an ecoregional assessment is overwhelming if not impossible for any single organization or agency. Through a practical approach to priority setting, this challenge can be focused down to an ambitious set of objectives, which if undertaken by the conservation community as a whole, is within our collective reach (Groves 2003).

9.2 Methods

The integrated portfolios for the East and West Cascades Ecoregional Assessment identified a very large proportion of the ecoregions as being critical for conservation. With approximately 50% of each ecoregion identified, it is necessary to apply a prioritization scheme to help distinguish which portfolio sites need conservation action more immediately than others. The two most commonly used criteria in setting conservation priorities are conservation value (or biodiversity) and vulnerability (threat).

The method below uses data previously described in the assessment to produce a ranking of each site based on one measure of its conservation score compared with its vulnerability score. This work was based on criteria established in Geography of Hope (Groves et al. 2000) and methods applied by Noss et al. (2002) in the Utah-Wyoming Rocky Mountains Ecoregional Plan. A more thorough evaluation of priorities is required and will need to build on the quantitative summary presented here with more subjective qualitative measures related to conservation feasibility, opportunity and leverage.

9.2.1 Irreplaceability versus Vulnerability Scatterplot

One approach to prioritization is to plot biodiversity value of a portfolio site against the degree of threat to that site. The irreplaceability versus vulnerability scatterplot was first used by Pressey et al. (1996, as described by Margules and Pressey 2000) and was also recently used by Noss et al. (2002) and Lawler et al. (2003). We plotted irreplaceability versus vulnerability for the sites in both the terrestrial and freshwater conservation portfolios. Irreplaceability has been defined a number of different ways (Pressey et al. 1994, Ferrier et al. 2000, Noss et al. 2002, Leslie et al. 2003, Stewart et al. 2003). Our definition of irreplaceability (Section 7.2.1) is a measure of how often the AUs that compose up a portfolio site were selected during MARXAN runs to meet the goals set for each target.

Margules and Pressey (2000) defined vulnerability as the risk of an area being transformed by any process which degrades its biodiversity value. The broader definition encompasses adverse impacts from additional factors such as invasive species and fire suppression. Vulnerability could also be defined from the perspective of target species – the relative likelihood that target species will be lost from an area. Since target persistence depends on habitat, a vulnerability index would be a function of current and likely future habitat conditions. Future habitat conditions are generally determined by the management practices and policies associated with an area. Our suitability index incorporated factors that reflected both current habitat conditions and management (Chapter 6). Therefore, for the purposes of prioritization, we assumed that our suitability index (or the inverse of it) could also be used as a vulnerability index.

Margules and Pressey (2000) and Noss et al. (2002) divided their scatterplots into four quadrants which correspond to priority categories (Figure 9.1): high irreplaceability, high vulnerability (Q1); high irreplaceability, low vulnerability (Q2); low irreplaceability, high vulnerability (Q3) and low irreplaceability, low vulnerability (Q4). Potential conservation areas in Q1 could be considered the highest priority, although some might also prioritize areas in Q2 that are high value and less vulnerable because these areas tend to be in better condition and have a high likelihood of successful conservation (Pyke 2005).

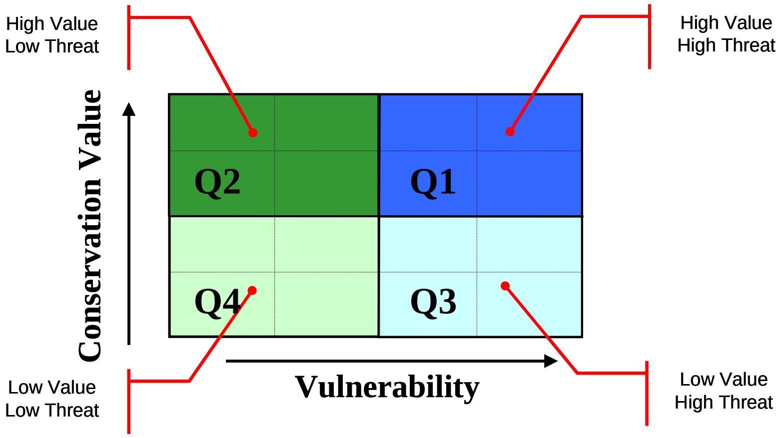

Figure 9.1. Graphing Relative Conservation Value and Vulnerability Scores

The purpose of dividing the scatterplot into quadrants is to assign conservation areas or portfolio sites to priority categories. Utilizing methodology from Lawler et al. (2003), we further divided the scatterplot into 16 sub-quadrants using the quartile values for irreplaceability and vulnerability. Each sub-quadrant corresponds to a priority category (Figure 9.1).

Terrestrial and freshwater portfolios were prioritized separately using identical methodology. The first step was to define our measures of conservation value and vulnerability. For this analysis, our measures were a function of readily available GIS data compiled through the ecoregional assessment process. We based conservation value on the irreplaceability score, an output from running the MARXAN model (Chapter 7); vulnerability was equivalent to the suitability index that was an input to our model (Chapter 6). We populated this data into a custom Microsoft Excel spreadsheet and weighted each of the factors equally.

9.3 Results

The following three products resulted from the prioritization for each ecoregional portfolio:

- Scatterplots showing the relative position of portfolio sites for conservation value and vulnerability (Figures 9.2 and 9.3).
- A color-coded map of the East and West Cascades integrated portfolios, combining the conservation value sub-quartiles with the vulnerability sub-quartiles results in 16 possible bins categories (Map 9.1).
- A table of portfolio sites that corresponds to the map and scatterplots, organized by sub-quartile position in the scatter plot (Map 9.1, Table 1).

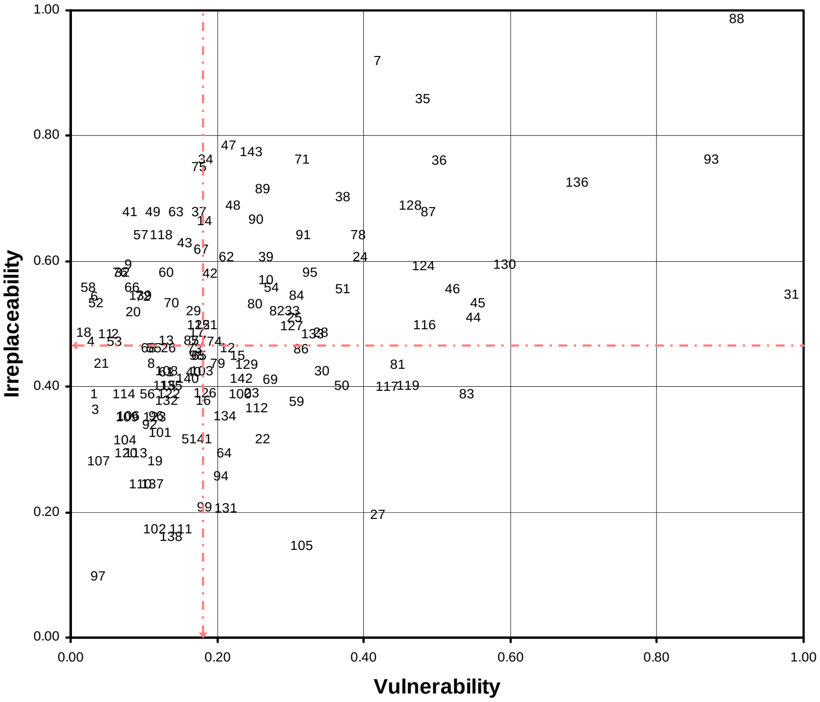

Figure 9.2 East Cascades Portfolio Prioritization Scatterplot.
Numbers represent portfolio sites and dotted lines separate priority quadrants (see site list in Appendix 8C, Map 9.1 and 9.1, Table 1)

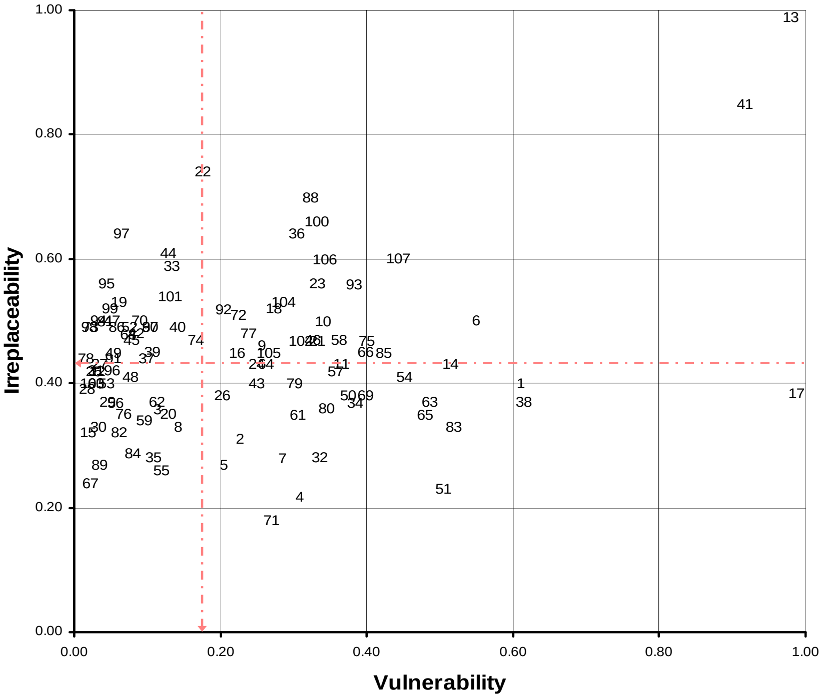

Figure 9.3. West Cascades Portfolio Prioritization Scatterplot.
Numbers represent portfolio sites and dotted lines separate priority quadrants (see site list in Appendix 8C, Map 9.1 and 9.1, Table 1)

9.4 Discussion

For planners working at an ecoregional scale, this exercise allows potential conservation sites to be sorted according to level of biodiversity as well as those that are facing threats. It is important to remember that this is a portfolio of conservation areas which have already been selected for their biodiversity significance, and therefore a relatively low ranking on one or both scores does not mean that the site is not important for conservation.

In this exercise, the measures of conservation value and vulnerability were weighted equally, as were the relative importance and confidence weightings for each factor. By varying the value weights of the factors used above, or by bringing in other useful variables (e.g., species richness, utility scores, specific threats) to the Excel spreadsheet, this prioritization process can provide users with a practical level of flexibility. Consequently, future analysis could allow various user groups to experiment with an assortment of prioritization scenarios.

The ability to quantify the relationship of conservation value and vulnerability provides a basis for strategic planning, and fosters debate around conservation needs. Some conservation practitioners would argue that the highest priority sites should be those that have the highest conservation (or irreplaceability) value, and the lowest vulnerability (or least threatened). Others would agree that we must take action at those sites which are most irreplaceable, but should focus on sites which are the most vulnerable, as those are the sites which may be the most exposed to threats such as conversion, invasives, or resource extraction. Even though a larger site may contain an area currently managed for conservation (such as a preserve or a wildlife area) the suitability for the extent of all the AUs in that site is used for this prioritization analysis.

Because this prioritization is an automated process, it is especially important to examine the site summaries (Appendices 8E and 8F) to put these results in perspective. Specifically, site summaries will include information about the conservation targets at a site, including rarity and contribution to the portfolio, explaining a relatively high or low irreplaceability score. This information, along with the suitability information contained in the AU GIS file can help the user consider a site’s current opportunities and future threats.

Chapter 10 – Population Threat

10.1 Methods

The Western US has seen dramatic human population growth over the last several decades. This trend will probably continue well into the future. In order to gauge the threat from population growth on our portfolio of conservation areas, we compared our AUs against growth forecasts provided by Western Futures (Theobald 2001, 2003). Using population and housing densities, road densities and typical patterns of land conversion, these forecasts provide a prediction of land conversions from 2000 to 2050.

We confined our analysis to the 2000 – 2020 time span to avoid the unknowns inherent in forecasting further out into the future and to highlight more imminent threats. Using the population density grids from Western Futures for 2000 and 2020, the change between them was calculated on a grid-cell by grid-cell basis. Each cell was then assigned to an AU, and the average population density change was calculated for the AU.

10.2 Results

None of the highest scoring AUs for human population growth in the two ecoregions were selected in our final integrated conservation portfolio (Map 10.1). This was not surprising, as our suitability index would have influenced the model away from those highly-fragmented and converted areas. Population growth scores for all AUs are located in the Assessment Unit GIS coverage on the accompanying CD.

We identified and evaluated those conservation areas in the final portfolio with the greatest potential (i.e., top 25%) for human population growth through the year 2020, looking at the average score for the whole site, as well as the highest AU score for each site.

In the West Cascades, the portfolio site with the highest single AU score for human population growth, as well as the highest average score was Issaquah Creek in Washington. The site in Oregon identified as likely to have the largest population increase was the Sandy River (Table 10.1).

In the East Cascades, the portfolio site with both the highest single AU score and the highest average score for population growth was the Upper Deschutes in Oregon. It was closely followed by the Columbia Rocky Reach site in Washington. There were no sites in California (Modoc Plateau section) which showed a high level of population increase (Table 10.2).

Table 10.1. West Cascade Portfolio Sites with the largest projected population increase

Site Name	Average Score	Highest AU Score	State
Issaquah Creek	130.58	203.29	WA
Sandy River - Cascades	84.46	94.88	OR
Carbon River	73.86	73.86	WA
Kalama River	70.30	70.30	WA
Scatter Creek - Cascades	65.83	65.83	WA
Boise Ridge	43.97	54.14	WA
Deschutes (WA)	51.51	51.51	WA
Mashel / Ohop	43.27	48.97	WA
Kanaskat	45.16	45.16	WA
Coast Fork Willamette	43.59	43.59	OR
Salmon – Huckleberry	36.00	36.00	OR
Columbia Gorge - West	35.01	35.01	WA
East Fork Lewis River	33.92	33.92	WA
Raging River	31.31	31.31	WA

Table 10.2. East Cascade Portfolio Sites with the largest projected population increase

Site Name	Average Score	Highest AU Score	State
Upper Deschutes	57.22	120.87	OR
Columbia Rocky Reach	47.55	109.12	WA
Lower Wenatchee	16.96	39.02	WA
Three Creek / Tumalo	32.10	32.10	OR
White Salmon River	22.56	22.56	WA
Chelan	18.12	18.12	WA
Miller Island	16.10	16.10	OR
Icicle Creek	14.51	14.51	WA
Indian Ford Creek	13.38	14.29	OR
Upper Yakima	12.17	12.17	WA
Columbia Gorge - East	10.07	10.31	WA
Chelan Butte	7.60	7.96	WA
Poe Valley / Bonanza	7.08	7.08	OR
Middle Wenatchee	6.69	6.69	WA

10.3 Discussion

The East and West Cascades Ecoregional Assessment team had hoped to complete GIS threats assessments for a variety of existing and future threats, but we were restricted by the lack of existing datasets which were comprehensive across the ecoregions. This included threats such as invasives (plant and animal), logging, hatcheries, dams, future mineral extraction, second home development, recreation, land conversion, climate change, and fire suppression. Analysis of some of these threats was attempted in the PNW Coast Ecoregional Assessment (Appendix 8H in Vander Schaaf et al. 2006) with mixed results.

Some of these threats had datasets for the East and West Cascades which existed ecoregion-wide, but were at too coarse of a level to be useful for this assessment. This included hatcheries (data specific to each hatchery to determine its level of threat was too inconsistent), invasives (data could only be found to county-level for the ecoregions), climate change (data was too coarse, but better datasets should be available in 2007), and fire suppression.

We attempted to examine fire suppression through the rapid assessment (RA) products released by the Landfire partnership in May of 2005. The three datasets we used were: the RA potential natural vegetation (PNV) map, the RA Succession Classes, and the reference condition descriptions. Using the “similarity and departure” formula developed by the fire regime condition class (FRCC) effort, a value for “departure from reference conditions” was calculated for each Site/PNV combination. Although we felt our methods were sound (Appendix 10A), the feedback from experts after the draft analysis convinced us to abandon further efforts until Landfire and FRCC come out with an updated dataset and their own analyses in 2007.

Some of the current threats in the Cascades (dams, land conversion) were addressed by our suitability analysis and index (Chapter 6) and influenced our portfolio selection. Additional threats are correlated with this population growth analysis: second home development, land conversion, invasives (which often accompany human expansion), and recreation (Hansen et al. 2001). Some estimates show population in the Western US increasing by 65% between 2000 and 2040 (Travis et al. 2005). This ecoregional assessment and the population growth analysis can be used to help identify those areas rich in biodiversity which are most at-risk from human encroachment and the associated development-related threats.

Chapter 11 – Recommendations for Future Iterations

11.1 Targets and Data

The East and West Cascades Assessments relied on a complex analysis of 450 species, 68 terrestrial systems, and over 300 freshwater system targets. This huge number of targets created a massive data management challenge. The simultaneous analysis of the two ecoregions was possible given their shared boundary, alleviating some common problems faced by previous assessment efforts.

11.1.1 Terrestrial Ecological Systems

The terrestrial systems data was a new layer compiled of various datasets. In most cases we could rely upon USFS datasets. In some cases we had to fill in gaps with more coarse datasets that presented problems in certain situations. For instance, wetland and grassland systems were not handled well by coarse-scale systems data and imagery.

We had seral stage data for all of the West Cascades and higher elevational portions of the East Cascades, however we did not have time to crosscheck this data against current aerial photos. Consequently, we were unable to verify which late seral stands were still present and we could not confirm data consistency across all forest system types. Future iterations should gather more recent data.

11.1.2 Plants

Out of the 182 plants targets, 85% were vascular plants. Although non-vascular plants were underrepresented, this probably did not greatly affect the assessment. However, incomplete data sets on private lands and wilderness areas significantly impacted the assessment. We had no data for 23 of 123 plants in the East Cascades, and 18 of 92 targets for the West Cascades and only met goals for 20% of plant targets. This same problem was observed for the wildlife dataset (Chapter 8.9). This low goal attainment was partially due to relatively high goals, but if the protected areas were more thoroughly surveyed, we would have been able to assess our conservation goals with greater accuracy.

Data for plant communities (i.e., plant associations) in Oregon and California were also in short supply. The Heritage programs for both states do not track plant associations and we relied almost exclusively on species and systems data in California and Oregon. Wetlands were the one exception, as all states had wetland data. However, wetland data were incomplete and a crosswalk of wetland types from state to state was also problematic and left until late in the assessment. In future assessments, gathering a full wetland data set should be a priority.

11.1.3 Terrestrial Wildlife

We encountered a complete lack of data for a number of fine-filter targets. For other targets, gaps existed only within certain ecosections. At least one valid element occurrence was available for 97 of 193 fine filter wildlife targets (Appendices 4E and 4F). Gaps in the invertebrate dataset were most striking, especially in Washington. With the exception of woodpeckers, raptors, and some wetland-associated species, little data was available for most birds and a number of mammals and reptiles. Noticeable gaps were often the result of differences in survey effort from state to state. In the future, as distribution models become more habitat specific, those should be considered for inclusion early on in the process. It is too difficult data-wise to input them into MARXAN at the end of the assessment process. Similarly, data on species guilds, such as bats, shorebirds, waterfowl, and wide ranging mammals should be included early in the process, rather than left for post-assessment analysis.

Given that there is no data available for many targets, it may not be necessary to spend a lot of effort getting the target list "just right". The priority should be to make sure species are identified that are endemic, severely declining, or are not likely to be captured by the coarse filters. We developed a separate invertebrate "watch list" to identify species that require more monitoring and are lacking information to assess their status. In the future, a watch list should be considered for other taxa, especially for those where only partial data is available, rather than putting a lot of species that do not have data on a target list.

11.1.4 Fish and other Freshwater Species

Freshwater species in general are largely undocumented and understudied. Species status is unknown for the vast majority. With the notable exception of salmon species, we simply don't know all of the native, or non-native, freshwater species that exist in the Pacific Northwest, where they are, and what the trends are in their population status. This includes not just fish, but most aquatic invertebrates, as well as many amphibians. For species which we do have information, their presence and distribution data are managed by multiple agencies with little standardization.

There were a total of 89 fish species represented in this assessment. However, much of the data available pertained only to salmonids. Although an effort was made to use consistent data and methods for analysis of all 11 EDUs, this proved difficult. EDT (Ecosystem Diagnosis and Treatment, Mobrand Biometrics Inc.) data was used in Washington EDUs for all salmonids. These EDT data were not given in km, therefore they were not in the same unit of measurement as the Oregon data. Oregon generally did not have salmonid EDT data but we modified the state's data to correspond with the Washington data (Appendix 4I).

This proved especially challenging in the Lower Columbia EDU, which includes both states and required modification of both the species data as well as the suitability indices. In the future, we recommend re-evaluating the Lower Columbia EDU evenly across both states. Also, the AU boundaries with this EDU should be adjusted to meet in the Columbia River, rather than crossing into terrestrial habitats in both states. Finally, the fact that this EDU is the only one which exists in both ecoregions made data management even more difficult.

The largest gap for fish was with non-game fish. Non-game fish have not been extensively studied or documented, and should be a higher priority for tracking by state and federal agencies. Expert input was invaluable for enhancing the resident fish information used in this assessment, but this type of data is inconsistent and time intensive to compile. Efforts to develop a central database for freshwater species, for example through Streamnet (www.streamnet.org), should be supported and improved.

For aquatic species other than fish, the East and West Cascades assessment included aquatic mollusks (primarily information from the Klamath Basin) and a few aquatic plants. Otherwise, invertebrates, amphibians, and birds that rely upon springs, lakes, rivers and wetlands were not identified as freshwater targets, but were run as part of the terrestrial analysis, if data existed for them. In the future, these data should be included in the aquatic analyses, incorporating the habitats they depend on as well.

11.1.5 Freshwater Systems

Freshwater systems data were developed using various combinations of key macrohabitat characteristics (e.g., geology, stream gradient, etc.). These systems were developed for all EDUs touching the Cascades except those in which only a small portion of the EDU was contained within the two ecoregions (i.e., Great Basin, Honey Lake, John Day-Umatilla, and Olympic-Chehalis) (Map 4.3). Macrohabitats and Aquatic Ecological Systems were not developed for the Great Basin and Honey Lake EDUs. Instead, priority areas for the portions of these two EDUs within the East Cascades were developed through expert interviews. The John Day-Umatilla and Olympic-Chehalis EDUs barely crossed into the

Cascades and were not considered in the aquatic analysis. These decisions later created problems when we integrated the freshwater and terrestrial layers. Although we used expert knowledge (in the Great Basin and Honey Lake) and past assessments (in the John Day–Umatilla and Olympic-Chehalis) to inform the portfolio, the integrated utility and irreplaceability analyses suffered because these AUs had fewer data compared to equivalent AUs in other EDUs. Also, because the Okanogan EDU classification methodology was not consistent with the remainder of the EDUs, the integration of that EDU with the terrestrial East Cascades data was more difficult. In the future, we recommend that freshwater systems be included evenly across all AUs in an assessment.

Some team members felt the freshwater systems data should have been weighted less heavily in comparison to the species data, especially in Oregon and California where peer review was limited. It may have been better to use the macrohabitats than summarize them to systems (especially if the systems are not ground truthed) because the macrohabitats are more tied to a specific stream reach, whereas systems are generalized to a watershed. This was especially true for Class 2 and 3 systems. The Yakima EDU attempted to include lakes, springs, and ephemeral creeks (Class 0 freshwater systems), and this effort should be expanded in future assessments.

11.2 Conservation Goals

Setting conservation goals is one of the most difficult portions of an ecoregional assessment. We set goals using the best available information in the time available, but there is always room to improve. Although the goals cannot ensure the long-term persistence of species and habitats, they move conservation action in that direction. They also allow us to prioritize portions of the ecoregion for conservation action.

This assessment used an adapted version of methods for setting conservation goals derived by Comer (2003) (Table 8.1, Chapter 8). The team agreed that the backbone of the assessment, the terrestrial and freshwater systems, had reasonable goals (a default 30% for the medium-risk scenario) and until there is evidence to the contrary, those goals will result in a meaningful conservation portfolio.

The goals for terrestrial species were set relatively high compared to past assessments (Vander Schaaf et al. 2006, Andelman et al. 1999). This decision was made to conserve biodiversity over a longer time period in the face of natural and human-caused disturbances. This resulted in a medium-risk portfolio with goals of 50 EOs for many endemic species. This goal was often unrealistic given that this threshold usually exceeded the number of EOs for most species. In future assessments, we believe varied goals for species that have different levels of mobility, as in Comer's older (2001) recommendations, along with the low, medium, and high-risk goals is most appropriate. Thus, a species with a low level of mobility would have relatively high goals compared to one with more mobility and more ability to respond to threats and environmental changes.

Goals for fish targets do not fit well with Comer's (2003) methodology. Having some fish species goals set on a percentage basis (salmonids) allowed those goals to be met much more easily than goals set for resident fishes (often set as a straight number of EOs similar to terrestrial species). Although most of the salmonids had goals of 50%, that still was a lower bar than the goals set for some resident fishes in the draft freshwater portfolio and many terrestrial species. In summary, the goals for targets set by percentages were probably appropriate, while those set by numbers of EOs were sometimes unrealistically high.

11.3 Suitability and Threats Analyses

The suitability indices relied on relatively coarse region-wide datasets. Use of this index was not intended for scales finer than the AU level. Data for suitability factors related to freshwater targets and habitats were not easily accessible or evenly spread across the

EDUs. Effects of dams, water withdrawls, and pollution were not easily tied to upstream or downstream AUs. Factors that were used to measure suitability (e.g., road density, urban land cover) were weighted using expert opinion. Although the team used best professional judgment to weigh each factor, decisions were ultimately made using imperfect knowledge, and expert opinion can sometimes be biased (Tversky and Kahneman 1974).

Although our initial intention was to develop multiple region-wide layers to address multiple threats, ultimately there was only a single dataset we were confident in using. This was the census data used by Western Futures to predict which areas would be most affected by human population expansion. We attempted to address fire suppression through the rapid assessment products released by the Landfire partnership, but the scale of the data was too coarse to use at the scale of our sub-HUC6 watershed AUs. However, the Ecological Integrity methods in Appendix 10A could prove useful as better data sets become available.

Despite rapidly improving satellite imagery, developing other threat layers at the AU scale was beyond our ability. We ultimately relied upon our suitability index to prioritize our portfolio. However, we believe additional threat layers (especially vulnerability to climate change) would be useful in portfolio prioritization. In future updates of ecoregional assessments, variables associated with threats deserve greater attention.

11.4 Integration of Terrestrial and Freshwater

A strong point of this assessment was the true integration of the terrestrial and freshwater datasets, both for targets and suitability. It is clear that a robust and resilient conservation portfolio must consider the interaction of these two environments to adequately conserve all species. We therefore encourage a continuation of this integration protocol for future ecoregional assessments.

This assessment was the first ecoregional assessment in the Pacific Northwest to use a “stacked” or “vertical integration” analysis (Appendix 8A), which allows AUs to be selected for either aquatic, terrestrial, or both sets of targets This did not result in significantly higher costs or larger conservation areas, but did allow more transparency in knowing why a particular AU was chosen to be part of the conservation portfolio. The status of individual AUs can be seen on the large portfolio maps or in the GIS AU shapefile on the CD. Also, the site summaries (Appendices 8E and 8F) list any freshwater or terrestrial targets which were not selected by MARXAN to meet goals, yet fall within the portfolio site as “additional targets occurring at the site.”

11.5 Connectivity and MARXAN

The draft portfolios produced by MARXAN identified a set of AUs meeting conservation goals with the maximum suitability (least human impacts). We directed MARXAN to pick large blocks of habitat by tying the output to a minimum dynamic area (MDA) based on natural disturbances in the region, as well as having MARXAN minimizing the boundary length or circumference of each portfolio site. An MDA is defined as the smallest area that is large enough to buffer against natural disturbance while maintaining ecological processes (Appendix 4C).

However, because MARXAN selects places where targets are known to occur, it did not adequately address connectivity between blocks of habitat. Expert review addressed this deficiency by explicitly adding corridors to maintain biological connectivity. Because important corridors may still have been missed, connectivity must be considered at the local planning scale and in subsequent ecoregional assessments. In the future, a more sophisticated modeling algorithm could be used to specifically address habitat connectivity.

Chapter 12 – Assessment Products and their Uses

12.1 Assessment Products

Three principal products emerged from this effort: (1) the underlying conservation data used in the assessment, (2) irreplaceability and conservation utility maps, and (3) a conservation portfolio with site summaries. A number of important ancillary products were also produced, such as suitability indices and the individual factors in them, that are of considerable interest to groups with specific questions regarding threats, freshwater conservation, policy alternatives and conservation site priorities in the East and West Cascades Ecoregions.

12.1.1 Underlying Data

The data that have been compiled specifically for this assessment have proven to be one of the most sought after products. Agencies and groups regularly request these data, especially because they are in a GIS format. One use of the data is to assess the biodiversity of an existing protected area. This assessment can use a GAP-style analysis to direct resources to elements of biodiversity where conservation is lacking. These underlying datasets, which cover the entire planning area, include all terrestrial and freshwater systems, species occurrences by assessment unit, land ownership, land management, road densities, human population densities, dams, mines, etc. In light of sensitive data policies, species occurring within each AU are given without revealing the precise location within the unit. Additional details about these datasets can be found in Chapters 4, 5 and 6. The following analyses are available as maps as well as GIS datasets on the CD.

12.1.2 Irreplaceability and Utility Maps

Irreplaceability indices represent the relative conservation value of all AUs in the ecoregion (Chapter 7, Maps 7.1 – 7.6). The irreplaceability analysis is solely driven by the available biological data, while the conservation utility analysis is a prioritization of all AUs based on the biological contents (irreplaceability) and the relative suitability of each AU. These maps can be used to guide ecoregion-level conservation action and can also inform finer-scale decisions.

12.1.3 Conservation Portfolios and Alternative Portfolios

The conservation portfolio maps depict areas that most efficiently meet our conservation goals (Chapter 8, Maps 8.4 – 8.7, and A-D on the CD). The conservation areas identified in each portfolio are important for a number of reasons. First, some represent the only places where a species or plant community is known to occur. Second, areas identified in the mid-risk portfolio include large, relatively intact landscapes that are protected as parks or wilderness. These areas are especially important to wide-ranging species such bears, wolves, wolverines, fishers and owls. Such areas contribute tremendously to ecoregional biodiversity and are essential to the maintenance of landscape-scale ecological processes. Third, additional areas can be used to link those larger protected areas either to ensure that movement of wide-ranging terrestrial species is not restricted, or to address fish that require cool, consistent water flows. These linkages will also benefit species and communities that may need to move as climate and precipitation patterns change. We do not advocate permanent protection of the entire conservation portfolio. Rather, we hope that with focused conservation planning, these lands and waters can be managed to ensure the future of all dependent organisms and communities. Appendices 8E and 8F summarize the biological and management data for each conservation area or portfolio site identified in the mid-risk ecoregional portfolios.

Alternative portfolios were also produced for this assessment as an acknowledgement of the uncertainty associated with goal setting and an illustration of different levels of risk associated with the loss of biodiversity (Map 8.7). Alternative portfolios represent a higher and lower risk to the loss of biodiversity, as compared with the mid-risk portfolio described above.

12.1.4 Suitability Indices

Wherever possible, the most promising areas for successful conservation were selected. To do this, a suitability index was created to map the relative likelihood of successful conservation across the ecoregion (Chapter 6). Two different suitability indices were developed for this assessment – one for terrestrial and one for freshwater environments (Maps 6.1 and 6.2). The suitability indices relied on two assumptions:

1) public land is more suitable for conservation than private land; and

2) unconverted areas are more suitable for conservation than converted and fragmented areas.

These principles and assumptions generally guided site selection toward public lands and away from private land, and toward rural areas with low habitat fragmentation and away from urban areas. However, in some instances, the portfolio includes areas of low suitability. For example, if a population of a rare species could only be captured in an urban area, then that area likely was selected. The scores for each factor in the suitability indices are available in the GIS AU shapefile on the CD.

12.2 Caveats for Users

This assessment has no regulatory authority. Rather, it is a guide to help inform conservation decision-making across the East and West Cascades Ecoregions. The sites described are approximate, and often are large and complex enough to allow (or require) a wide range of resource management approaches. Ultimately, the boundaries and management of any priority conservation area will incorporate those policies, values and decisions of the affected landowners, conservation organizations, governments and other community members. Many of the portfolio sites identified in this assessment may be managed using a range of strategies. While effective conservation can necessitate restricted use, it does not necessarily exclude all human activities.

Although restoration is often an important element of conservation, restoration potential was not directly evaluated through this assessment. Instead, this assessment selected sites based on the habitats and species that currently exist, and did not look at a site’s restoration potential. A reliable assessment of restoration priorities would require a different approach than the one we have presented. However, many high priority areas will contain lower-quality habitats in need of restoration that could greatly enhance the viability of these areas and the conservation targets they contain.

Users must be mindful of the large scale at which this assessment was prepared. The intended geographic scale of use of the analysis and much of its data is 1:100,000. For instance, the map of terrestrial systems is appropriate for use at the ecoregional level, but this information should be regarded as a coarse-scale representation of the potential distribution of existing vegetation. Also, many places deemed low priority at the ecoregional scale are nevertheless locally important for their natural beauty, educational value, ecosystem services and conservation of local biodiversity. These include many small wetlands, small patches of natural habitat and other important parts of our natural landscape. They should be managed to maintain their own special values. Furthermore, due to their large size, high priority assessment units and conservation portfolio sites may include areas unsuitable for conservation. We expect that local planners equipped with more complete information and higher resolution data will develop refined boundaries for these sites.

Users of this ecoregional assessment may need to ask policy-level questions before using this assessment in light of certain assumptions. For example, setting the suitability index to favor the selection of public over private land presumes a policy of using existing public lands to meet goals wherever possible, thereby lowering the involvement of private lands.

This assessment is one of many science-based tools that will assist conservation efforts by government agencies, non-governmental organizations, and individuals. It cannot replace, for example, recovery plans for endangered species, or the detailed planning required in designing a local conservation project. Similarly, it does not address the special considerations of game management, and cannot be used to ensure adequate populations for harvest.

Chapter 13 – Summary and Conclusion

13.1 Ecoregional Goals and the Conservation Portfolio

Establishing conservation goals is a crucial element of the ecoregional conservation assessment. These goals consider the number, area and distribution of species and habitats that might be required to maintain biodiversity. They are used to measure how well the portfolio performs in conserving the ecoregion's biodiversity, they provide a context for decisions and lend accountability and defensibility to the assessment (Pressey et al. 2003).

Setting conservation goals is one of the most difficult steps in the assessment. In addition, setting goals for conservation targets relies heavily on expert opinion and has a high likelihood of uncertainty (Groves et al. 2000). However, the consequence of delaying conservation until better information becomes available is too great given the demands on our natural resources (e.g., expanding human populations).

Although goals established for terrestrial and freshwater ecological systems (often 30-50%) were largely met, the goals of most species targets went unmet. The main reasons for this were a lack of data and an insufficient number of populations in the case of rare species. In particular, low-elevation areas dominated by private lands and high elevation wilderness areas tend to be less studied, leading to inadequate species data. Although rare species usually fell short of conservation goals, known occurrences were almost always captured in the portfolio. However, it is notable that the goals for ecological systems were met. This is important because the conservation of these systems may ultimately protect the majority of species that are unknown or poorly understood. With careful management the chances of success are greatly increased.

Future assessments will undoubtedly have more information available to set goals for individual targets. In the meantime, organizations can use the current goals as a starting place to address gaps in biodiversity knowledge and protection, and to track progress. However, it is important to realize that meeting goals only means that a specified number of occurrences of species and habitats have been identified in the ecoregional portfolios. It does not necessarily imply that these species and habitats are protected. Implementation of this assessment is required for conservation success.

13.2 Irreplaceability and Utility Sensitivity Analyses

High irreplaceability scores (i.e., greater than 85 to 90) are mostly independent of the suitability index. An AU achieves a high irreplaceability score primarily on the basis of its biological content. If targets located in a given AU are critical to satisfy set goals, then that AU will be selected almost every time. Lower scoring AUs (below 50) tend to be much more sensitive to the suitability index. Those receiving a lower score typically are unremarkable in terms of biodiversity. Although they contribute habitat or target occurrences, they are relatively interchangeable with other AUs. Prioritizing on the basis of suitability rather than biodiversity value makes more sense for low scoring AUs. If an AU can be distinguished from another because conservation will be cheaper or more successful, then that AU should be given higher priority for action. However, since the suitability index relies on the judgments of individuals, AUs with moderate and low irreplaceability scores should still be examined closely.

Software programs like MARXAN are often referred to as "decision support tools." MARXAN gives the user a way to explore the effect of various assumptions and perspectives. Davis et al. (1996) and Stoms et al. (1998) did the equivalent of a sensitivity analysis for their suitability indices. However, they referred to their different indices as "model variations" or "alternatives;" an implicit recognition that different sets of assumptions may have equal validity. To address uncertainties in suitability indices, AU priorities, especially for lower-ranked AUs, should be assessed using several different analyses that rely upon different indices (e.g., suitability vs. irreplaceability). This will enhance the robustness of analytical results and lead to more confident decision-making.

13.3 Alternative Portfolios

The alternative portfolios are intended to illustrate how the conservation area changes as goals are changed. Policy makers and land managers will ultimately decide which alternative is most appropriate, based on available science, input from local stakeholders, and the monitoring of biodiversity over time.

These alternatives are made up of higher and lower-risk portfolios. As higher-risk implies, if this portfolio were implemented, some species would likely vanish from the ecoregion. The lower-risk portfolio captures a large amount of area, but even under this alternative, not all land would be set aside for preservation. Undoubtedly, much habitat must be conserved in multiple-use landscapes where land uses, such as forestry, can be compatible with biodiversity conservation. The mid-risk portfolio strikes a balance between the risk of species loss and the impracticality of conserving extremely large areas. This portfolio is also supported by a set of largely agreed upon conservation goals, and underwent extensive expert review.

The higher-risk portfolio imposes a higher degree of risk than the mid-risk portfolio. The opposite would be true for the lower-risk portfolio. However, it is not known how much higher or lower the risk will be. In fact, the mid-risk portfolio could actually be high risk given that it might result in ecoregional extinction or extirpation for some species. Given the scale and scope of human-caused changes to the ecoregion now and in the future, the persistence of biodiversity cannot be guaranteed by meeting ecoregional goals. As much as possible, future ecoregional assessments should attempt to overcome this shortcoming.

13.4 Use of the Ecoregional Assessment

Biodiversity conservation in the ecoregion will attain its fullest potential if all conservation organizations, government agencies and private landowners coordinate their conservation strategies according to the priorities identified through this assessment. This seems especially valid given that conservation areas (portfolio sites) span a range of ownerships and jurisdictions, and therefore call for a suite of conservation strategies. The portfolio is not meant to be a blueprint for total protection, but it does identify those areas of opportunity for strategic collaboration amongst multiple stakeholders.

Although this assessment covers a large land area, the application of this tool will often occur at the local level. Specifically, this assessment represents a baseline to be built upon and refined through local planning efforts. It is intended to guide conservation to sites with high biodiversity and suitability values. The specifics necessary to delineate such a site, and to plan and manage for its conservation, requires local expertise.

The ultimate vision of the ecoregional assessment process is to facilitate the thoughtful coordination of current and future conservation efforts by the growing number of federal, provincial, state, local, private and non-governmental organizations engaged in this field. To that end, we encourage wide use of the data and products developed and welcome comments on how future updates to this assessment may be improved.

Glossary and Acronym List

Aquatic/freshwater ecological systems: dynamic spatial assemblages of biological communities that occur together in an aquatic landscape with similar geomorphological patterns, are tied together by similar ecological processes (e.g. hydrologic and nutrient regimes, access to floodplains) or environmental gradients (e.g. temperature, chemical, habitat volume), and form a robust, cohesive and distinguishable unit on a hydrography map.

Anadromous: fish that hatch in freshwater, migrate to saltwater, and then come back to freshwater to spawn

Assessment unit: the area-based polygon units used in the optimal site-selection algorithm and attributed with the conservation suitability and amount of all targets located within them. These units are non-overlapping and cover each ecoregion and EDU.

Automated portfolio: a data-driven portfolio created by the MARXAN site-selection algorithm operating on the watershed assessment unit level.

Base layer: a data layer in a GIS that contains basic information such as land ownership, rivers and streams, political boundaries, etc.

Biodiversity: the full range of natural variety and variability within and among organisms, and the ecological complexes in which they occur. This term encompasses multiple levels of organization, including genes, subspecies, species, communities, and ecological systems or ecosystems.

Candidate species: plants and animals that the U.S. Fish and Wildlife Service believe should be considered for status review. A status review may conclude that the species should be added to the federal list of threatened and endangered species.

Coarse-filter: refers to the biological communities or ecological systems, which if protected in sufficient quantity, should conserve the vast majority of species in the ecoregion.

Conservation area: *See Portfolio site*

Conservation target: See *Target*

Core team: the interdisciplinary group that is accountable for the completion of the ecoregional assessment.

Cost: a component of the MARXAN algorithm that encourages MARXAN to minimize the area of the portfolio by assigning a penalty to factors that negatively affect biodiversity, such as proximity to roads and development. In this assessment, terrestrial and freshwater costs were assigned to each assessment unit in the ecoregion. Used synonymously with “vulnerability” and “suitability,” which is actually the inverse of the cost.

Crosswalk: a comparison of two different vegetation classification systems and resolving the differences between them to form a common standard.

Declining: species that have exhibited significant, long-term reduction in habitat/and or numbers, and are subject to continuing threats in the ecoregion.

Disjunct: See *Distribution*

Distribution: In ecoregional assessments, distribution is thought of relative to the ecoregion and used as a guide to establish numeric differentials in goal setting (higher with endemic species, to lower with peripheral species).

Endemic = >90% of global distribution in ecoregion

Limited = <90% of global distribution is with in the ecoregion, and distribution is limited to 2-3 ecoregions

Disjunct = distribution in ecoregion quite likely reflects significant genetic differentiation from main range due to historic isolation; roughly >2 ecoregions separate this ecoregion from other more central parts of it's range

Widespread = global distribution >3 ecoregions

Peripheral = <10% of global distribution in ecoregion

Ecological drainage unit (EDU): aggregates of watersheds that share ecological characteristics. These watersheds have similar climate, hydrologic regime, physiography, and zoogeographic history.

Ecological integrity: the probability of an ecological community or ecological system to persist at a given site is partially a function of its integrity. The ecological integrity or viability of a community is governed primarily by three factors: demography of component species populations; internal processes and structures among these components; and intactness of landscape-level processes which sustain the community or system.

Ecological land unit (ELU): mapping units used in large-scale conservation assessment projects that are typically defined by two or more environmental variables such as elevation, geological type, and landform (e.g., cliff, valley bottom, summit). Biophysical or environmental analyses based on ELUs combined with land cover types and satellite imagery can be useful tools for predicting locations of communities or systems when field surveys are lacking.

Ecological system: see *terrestrial ecological system* or *aquatic/freshwater ecological system.*

Ecoregion: a relatively large area of land and water that contains geographically distinct assemblages of natural communities, with boundaries that are approximate. These communities share a large majority of their species, dynamics, and environmental conditions, and function together effectively as a conservation unit at global and continental scales.

Element code (EL Code): a unique 10-character alphanumeric code created and used by Heritage Programs and NatureServe to universally classify species, communities, and terrestrial systems. The Global Element ID code list is now being used by Natureserve, in addition to El Codes.

Element occurrence (EO): a term originating from the methodology of the Natural Heritage Network that refers to a unit of land or water on which a population of a species or example of an ecological community occurs. For communities, these EOs represent a defined area that contains a characteristic species composition and structure.

Endangered species: any species which is in danger of extinction throughout all of its range; a species that is listed as Endangered by the U.S. Fish and Wildlife Service under the Endangered Species Act.

Endemic: See *Distribution*

Evolutionarily Significant Unit (ESU): used to identify “distinct population segments” of Pacific salmon (*Oncorhynchus spp.*) stocks under the U.S. Endangered Species Act. The basic spatial unit used to help describe a species diversity within its range and aid in the recovery of a listed species.

Extirpation: the extinction of a species or a group of organisms in a particular local area.

Fine-filter: species of concern or aggregations that complement the coarse filter, helping to ensure that the coarse filter strategy adequately captures the range of viable, native species and biological communities. Endangered or threatened, declining, vulnerable, wide-ranging, very rare, endemic, and keystone species are some potential fine filter targets.

Focal group: a collection of organisms related by taxonomic or functional similarities.

Fragmentation: the process by which habitats are increasingly subdivided into smaller units, resulting in increased insularity as well as losses of total habitat area.

Functional landscapes: large areas (usually greater than 1,000 acres) where the natural ecological processes needed to conserve biodiversity can be maintained or potentially restored.

GAP (National Gap Analysis Program): Gap analysis is a scientific method for identifying the degree to which native animal species and natural communities are represented in our present-day mix of conservation lands. Those species and communities not adequately represented in the existing network of conservation lands constitute conservation “gaps.” The purpose of the Gap Analysis Program (GAP) is to provide broad geographic information on the status of ordinary species (those not threatened with extinction or naturally rare) and their habitats in order to provide land managers, planners, scientists, and policy makers with the information they need to make better-informed decisions. URL: http://gapanalysis.nbii.gov/portal/server.pt

GAP status: the classification scheme or category that describes the relative degree of management or protection of specific geographic areas for the purpose of maintaining biodiversity. The goal is to assign each mapped land unit with categories of management or protection status, ranging from 1 (highest protection for maintenance of biodiversity) to 4 (no or unknown amount of protection).

Biodiversity Management Status Categories of the GAP Analysis Program

Category	Description
Status 1	An area having permanent protection from conversion of natural land cover and a mandated management plan in operation to maintain a natural state within which disturbance events (of natural type, frequency, intensity, and legacy) are allowed to proceed without interference or are mimicked through management.
Status 2	An area having permanent protection from conversion of natural land cover and a mandated management plan in operation to maintain a primarily natural state, but which may receive uses or management practices that degrade the quality of existing natural communities, including suppression of natural disturbance.
Status 3	An area having permanent protection from conversion of natural land cover for the majority of the area, but subject to extractive uses of either a broad, low-intensity type (e.g., logging) or localized intense types (e.g., mining). It also confers protection to federally-listed endangered and threatened species throughout the area.
Status 4	There are no known public or private institutional mandates or legally recognized easements or deed restrictions held by the managing entity to prevent conversion of natural habitat types to anthropogenic habitat types. The area generally allows conversion to unnatural land cover throughout.

Geographic Information System (GIS): a computerized system of organizing and analyzing spatially-explicit data and information.

Global rank: an assessment of a biological element's (species or plant association) relative imperilment and conservation status across its geographic distribution. The ranks range from G1 (critically imperiled) to G5 (secure). These ranks are assigned by the Natural Heritage Network and are determined by the number of occurrences or total area of coverage (plant associations only), modified by other factors such as condition, historic trend in distribution or condition, vulnerability, and impacts.

G1	Critically Imperiled – Critically imperiled globally because of extreme rarity or because of some factor(s) making it especially vulnerable to extinction. Typically 5 or fewer occurrences or very few remaining individuals (<1,000) or acres (<2,000) or linear miles (>10).
G2	Imperiled – Imperiled globally because of rarity or because of some factor(s) making it very vulnerable to extinction or elimination. Typically 6-20 occurrences or few remaining individuals (1,000-3,000) or acres (2,000-10,000) or linear miles (10-50).
G3	Vulnerable – Vulnerable globally either because very rare and local throughout its range, found only in a restricted range, or because of other factors making it vulnerable to extinction or elimination. Typically 21-100 occurrences or between 3,000 and 10,000 individuals.
G4	Apparently Secure – Uncommon but not rare (although it may be rare in parts of its range) but possible cause for long-term concern. Typically more than 100 occurrences and more than 10,000 individuals.
G5	Secure – Common, widespread, and abundant (although it may be rare in parts of its range, particularly on the periphery). Not vulnerable in most of its range. Typically with considerably more than 100 occurrences and more than 10,000 individuals.

Goal: in ecoregional assessments, a numerical value associated with a species or system that describes how many populations (for species targets) or how much area (for systems targets) the portfolio should include to represent each target, and how those target occurrences should be distributed across the ecoregion to better represent genetic diversity and hedge against local extirpations.

Ground truthing: assessing the accuracy of GIS data through field verification.

Historic species: species that were known to occupy an area, but most likely no longer exist in that area.

Impact: the combined concept of ecological stresses to a target and the sources of that stress to the target. Impacts are described in terms of severity and urgency. Sometimes used synonymously with "threat."

Imperiled species: species that have a global rank of G1-G2 by Natural Heritage Programs. Regularly reviewed and updated by experts, these ranks take into account number of occurrences, quality and condition of occurrences, population size, range of distribution, impacts and protection status.

Integration: a portfolio assembly step whereby adjacent sites that contain high-quality occurrences of both freshwater and terrestrial targets are combined.

Irreplaceability: an index that indicates the conservation value of a potential conservation area based on the rarity and number of targets in a given assessment unit. It is operationally defied as the percentage of alternative reserve systems for which a particular assessment unit is chosen. When generating the irreplaceability values, a suitability index is not used.

Limited: See *Distribution*

Linear communities or systems: occur as linear strips and are often ecotonal between terrestrial and aquatic systems. Similar to small patch communities, linear communities occur in specific conditions, and the aggregate of all linear communities comprises only a small percentage of the natural vegetation of the ecoregion.

Macrohabitats: units of streams and lakes that are similar with respect to their size, thermal, chemical, and hydrological regimes. Each macrohabitat type represents a different physical setting that correlates with patterns in freshwater biodiversity.

MARXAN: Marine Reserve Design Using Spatially Explicit Annealing. Software consisting of computerized optimal site selection algorithms that select conservation sites based on their biological value and suitability for conservation.
URL: www.ecology.uq.edu.au/marxan.htm

Matrix-forming systems or Matrix communities: communities that form extensive and contiguous cover, occur on the most extensive landforms, and typically have wide ecological tolerances.

Minimum dynamic area (MDA): MDA is the smallest area needed to maintain a natural habitat, community, or population based on natural disturbance regimes and the ability of the biota to recolonize or restabilize component species. In this context, identification of a MDA for a particular conservation target is based on the size of patches created by various disturbances, the frequency of those disturbances, the longevity of the resulting patches, and the ability of the component species to disperse through the greater mosaic. More recent work in landscape ecology has expanded this definition to include not only issues related to species viability, but also the maintenance of the disturbance regime itself.

NatureServe: NatureServe is a non-profit conservation organization that provides the scientific information and tools needed to help guide effective conservation action. NatureServe and its network of natural heritage programs are the leading source for information about rare and endangered species and threatened ecosystems. NatureServe represents an international network of biological inventories—known as natural heritage programs or conservation data centers—operating in all 50 of the United States, Canada, Latin America and the Caribbean. URL: www.natureserve.org

Non-vascular plant: in this assessment, this term refers to lichens, mosses, and fungi.

Occurrence: spatially referenced locations of species, plant associations, or ecological systems. May be equivalent to Natural Heritage Program element occurrences, or may be more loosely defined locations delineated through the identification of areas by experts.

Peripheral: See *Distribution*

Partners in Flight: a cooperative program among U.S. federal, state, and local governments, philanthropic foundations, professional organizations, conservation groups, industry, the academic community, and private individuals, to foster conservation of migratory bird populations and their habitats in the Western hemisphere. URL: http://www.pwrc.usgs.gov/pif/

Plant association: a recurring plant community with a characteristic range in species composition, specific diagnostic species, and a defined range in habitat conditions and physiognomy or structure. Also referred to as communities.

Population: a group of individuals of a species living in a certain area that maintains some degree of reproductive isolation.

Portfolio: in this ecoregional assessment, the identified suite of priority conservation areas, or portfolio sites, that are considered the highest priorities for conservation in the ecoregion.

Portfolio site: areas of biodiversity concentration composed of assessment units that contain target species, plant associations, and ecological systems. Boundaries need to be refined during site conservation planning for adequate protection and to ensure supporting ecological processes are maintained for the targets within.

Priority conservation area: *see Portfolio site*

Relative Biodiversity Index (RBI): Abundance in query domain/abundance in area of interest) * 100.

Reach: the length of a stream channel that is uniform with respect to discharge, depth, area and slope.

Retro or Retrospective target: a large amount of habitat or modeled data can significantly influence the result of the site selection analysis. Rather than let one species dominate the result, some datasets can be used retrospectively to evaluate the portfolio as defined by the goals and data of other targets. Retrospective evaluation has the benefit of simplifying the analysis by reducing the amount of data being input, and by reducing the influence of a large quantity of data or the influence of a species with a very high goal associated with its data. If the goals met from other targets do not capture enough of these retro targets in the portfolio, then the goals can be adjusted appropriately to incorporate more of that species.

Sensitivity analysis: analysis done to determine what happens to model outputs in response to a systematic change of model inputs. Sensitivity analysis serves two main purposes: (1) to measure how much influence each parameter has on the model output; and (2) to evaluate the effects of poor parameter estimates or weak assumptions.

Seral: of, relating to, or constituting an ecological sere (a sere is a series of ecological communities formed in ecological succession).

Small patch systems: communities or systems that form small discrete areas of vegetation cover and that are dependent upon specific local environmental conditions, such as hydric soil.

Suitability: the likelihood of successful conservation at a particular place relative to other places in the ecoregion. The lower the suitability “value” the more suitable an assessment unit is for conservation. For this assessment, GIS layers which were part of the terrestrial and freshwater suitability indices included, management status, land use, road density, dams and mines. For this assessment the inverse of the suitability score was equal to the vulnerability. See *Cost* for further explanation.

T Rank (Infraspecific Taxon Conservation Status Rank): Infraspecific taxa refer to subspecies, varieties and other designations below the level of the species. Infraspecific taxon status ranks (T-ranks) apply to plants and animal species only; these T-ranks do not apply to ecological communities. The status of infraspecific taxa (subspecies or varieties) are indicated by a "T-rank" following the species' global rank. Rules for assigning T-ranks follow the same principles outlined above for global conservation status ranks. For example, the global rank of a critically imperiled subspecies of an otherwise widespread and common species would be G5T1. A T-rank cannot imply the subspecies or variety is more abundant than the species as a whole-for example, a G1T2 cannot occur. A vertebrate animal population, such as those listed as distinct population segments under the U.S. Endangered Species Act, may be considered an infraspecific taxon and assigned a T-rank; in such cases a Q is used after the T-rank to denote the taxon's informal taxonomic status. At this time, the T rank is not used for ecological communities.

Target: also called conservation target. An element of biodiversity selected as a focus for the conservation assessment. The three principle types of targets are species, communities, and ecological systems.

Terrestrial ecological systems/ecosystems: dynamic spatial assemblages of plant associations that 1) occur together on the landscape; 2) are tied together by similar ecological processes (e.g. fire, hydrology), underlying environmental features (e.g. soils, geology) or environmental gradients (e.g. elevation, hydrologically-related zones); and 3) form a robust, cohesive, and distinguishable unit on the ground. Ecological systems are characterized by both biotic and abiotic components. Ex: North Pacific Western Hemlock-Silver Fir Forest

Threatened species: any species that is likely to become an endangered species throughout all or a significant portion of its range; a species listed as Threatened by the U.S. Fish and Wildlife Service under the Endangered Species Act.

Umbrella species: species that by being protected may also protect the habitat and populations of other species.

Urban Growth Area (UGA): a designated area within which urban growth will be encouraged and outside of which growth can only occur if it is not urban in nature. In the United States, urban growth areas around cities are designated by the county in consultation with the cities; urban growth areas not associated with cities are designated by the county.

Utility (Conservation Utility): an index that indicates the conservation value of a potential conservation area. When generating conservation utility values, a suitability index is combined with the Irreplaceability score.

Viability: the ability of a species to persist for many generations or an ecological community or system to persist over some time period.

Vulnerability: an index which reflects the relative likelihood that target species will be lost from an area. In this assessment, equal to the inverse of suitability. See *Cost* for more details.

Vulnerable: vulnerable species are usually abundant, may or may not be declining, but some aspect of their life history makes them especially vulnerable (e.g., migratory concentration or rare/endemic habitat).

Widespread: See *Distribution*

Acronym List

ac	acres
AU	Assessment Unit
BLM	Bureau of Land Management
BM	Boundary Length Modifier Parameter
CD	Compact disc
CNDDB	California Natural Diversity Data Base
DBH	diameter at breast height
EDT	Ecosystem Diagnosis and Treatment
EDU	Ecological Drainage Unit
EL	Element
EO	Element Occurrence
EOR	Element Occurrence Record
FEMAT	Forest Ecosystem Management Assessment Team
FRCC	Fire Regime Condition Class
G rank	Global Status Ranks
GAP	Gap Analysis Program
GIS	Geographic Information System
ha	hectares
HCP	Habitat Conservation Plan
ISMS	Interagency Survey and Manage Species
IVC/NVC	International Vegetation Classification/National Vegetation Classification
LSR	Late Successional Reserve
MDA	Minimum Dynamic Area
NHD	National Hydrography Dataset
ODFW	Oregon Department of Fish and Wildlife
ORNHIC	Oregon Natural Heritage Information Center
PAG	Plant Association Group
PNV	Potential Natural Vegetation
QMD	quadratic mean diameter
RA	Rapid Assessment
SCWCS	State Comprehensive Wildlife Conservation Strategy
U.S.	United States
USDA	United States Department of Agriculture
USFS	United States Forest Service
USGS	United States Geological Survey
USFWS	United States Fish and Wildlife Service
WAU	Watershed Assessment Unit
WDFW	Washington Department of Fish and Wildlife
WNHP	Washington Natural Heritage Program
WRIA	Water Resource Inventory Area

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