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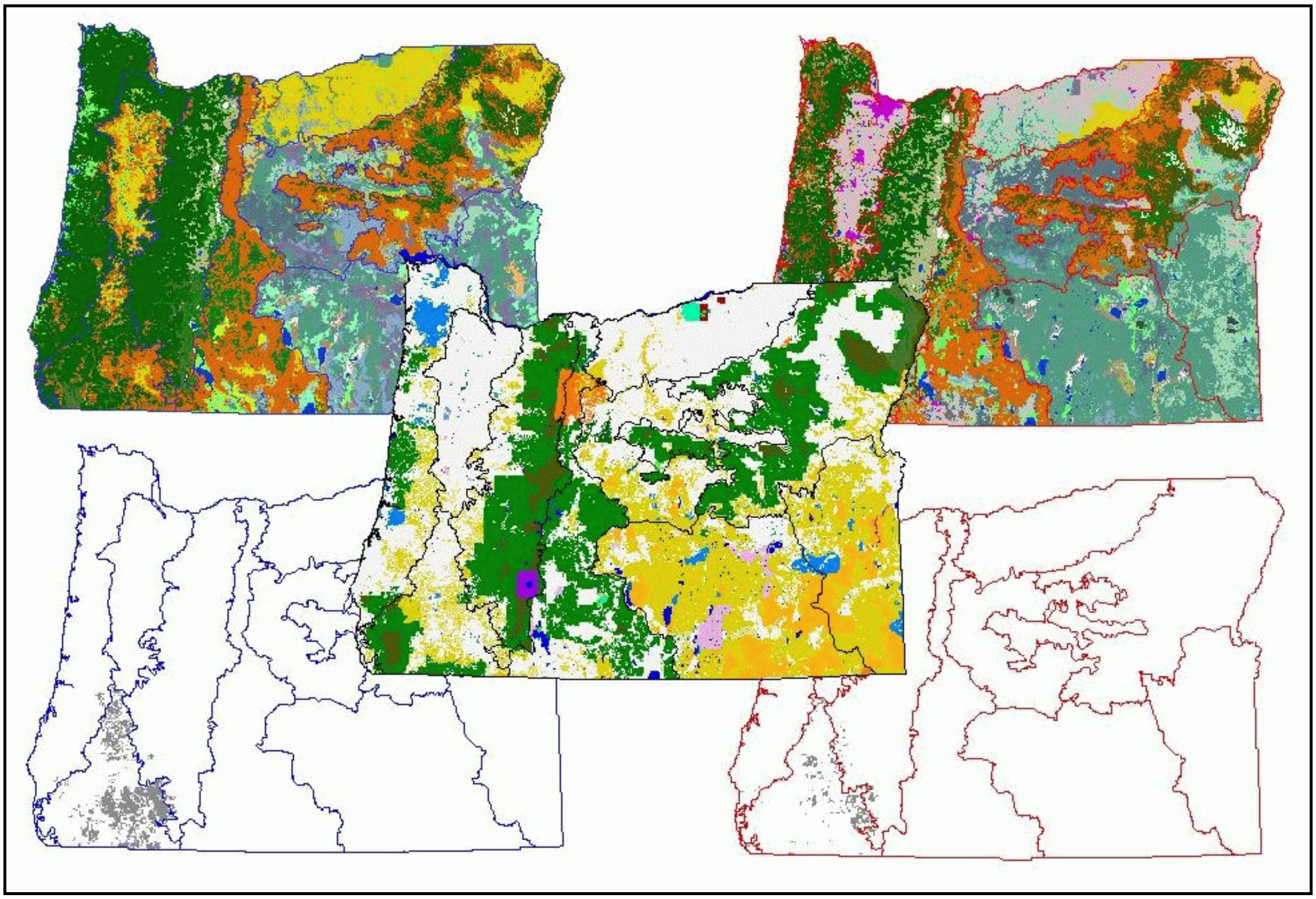
OREGON
GAP ANALYSIS PROJECT

A GEOGRAPHIC APPROACH TO PLANNING FOR BIOLOGICAL DIVERSITY



Oregon Natural Heritage Program

United States Geological Survey Biological Resources Division

Oregon Department of Fish and Wildlife

Biodiversity Research Consortium

Oregon Biodiversity Project

Oregon Gap Analysis Final State Report

1999

Oregon Natural Heritage Program
821 SE 14th Ave.
Portland, OR 97214
ph: 503-731-3070 fax: 503-230-9639
http://www.heritage.tnc.org/nhp/or/us
http://sscgis.state.or.us
http://dfw.state.or.us

THE OREGON GAP ANALYSIS PROJECT
FINAL REPORT
OCTOBER 1999

James S. Kagan, PI
Director / Ecologist, Oregon Natural Heritage Program

John C. Hak, Co-PI
GIS Program Manager, Oregon Natural Heritage Program

Blair Csuti
Conservation Program Coordinator, Oregon Zoo

Chris W. Kiilsgaard
Land Cover Analyst, NW Habitat Institute

Eleanor P. Gaines
Zoologist / Data Manager, Oregon Natural Heritage Program

Contract Administration Through:
Oregon Natural Heritage Program and the Oregon Field Office of The Nature Conservancy
821 SE 14th Ave., Portland, OR 97214

Submitted by:
James S. Kagan

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EXECUTIVE SUMMARY

The Oregon Gap Analysis project (OR-GAP) began work in 1988, as the second GAP program started, following only the original pilot project initiated in Idaho by Mike Scott of the Idaho Cooperative Fish and Wildlife Research Unit of the University of Idaho. OR-GAP was managed by Blair Csuti of the Idaho Cooperative Fish and Wildlife Research Unit until 1997 and was completed by the Oregon Natural Heritage Program (ORNHP). It has been a cooperative venture, with the initial vegetation map completed by contract staff and the ORNHP, and the initial wildlife distributions developed cooperatively by Oregon State University, the Biodiversity Research Consortium, ORNHP and the Oregon Department of Fish and Wildlife (ODFW). Oregon was also fortunate enough to have a separate statewide biodiversity assessment managed by the Northwest Office of the Defenders of Wildlife. This was the Oregon Biodiversity Project, which started as an effort to implement the results of the first Oregon Gap Analysis work, but wound up as an independent analysis. A second generation land cover map was developed by ODFW, and ORNHP developed updated species distribution maps based on the second generation land cover. Because we had access to an historical vegetation cover, we were able to model vertebrate species distributions prior to European settlement. This report outlines all of the work completed to-date.

The major objectives of the project were to (1) produce GIS-databases describing actual land cover type, historical land cover type, terrestrial vertebrate species distributions, land stewardship, and land management status at a scale of 1:100,000, (2) identify land cover types and terrestrial vertebrate species that currently are not represented or are under-represented in areas managed for long-term maintenance of biodiversity, i.e., "gaps," and (3) facilitate cooperative development and use of information so that institutions, agencies, and private land owners may be more effective stewards of Oregon's natural resources. The OR-GAP project is a step toward the more detailed efforts and studies needed for long-term planning for biodiversity conservation in Oregon. The final (Version 2) map of actual land cover used in this analysis included the distribution of 65 land cover types, mapped as polygons with a minimum mapping unit (MMU) of 100 hectares.

Individual distributions of 457 vertebrate species were predicted using habitat associations. Range limits of each species were delineated within a grid of 441 hexagons (635 km^2) based on published range maps, locality records and review by local experts. This hexagon database has been in existence at the Oregon Natural Heritage Program for the last 10 years, and has been updated based on continual reviews and inclusion of new data, and includes information both on species distributions, the source of information for each hexagon, and the confidence in the record. Within hexagons, species distributions were modeled based on species-land cover associations and the presence of riparian areas. Comparisons of predicted species to species lists maintained for eight wildlife refuges produced variable results since the tested areas often had incomplete lists.

The Gap Analysis Program (GAP) uses a scale of 1 through 4 to denote how well each tract of land is managed for biodiversity maintenance, with "1" being the highest, most permanent and best managed, and "4" being the lowest, or unknown status. Status codes were assigned by ORNHP staff following GAP guidelines with review by The Nature Conservancy's Public Lands Coordinator. A total of 17.2% of the state of Oregon is classified as status 1 and 2 lands, 95% of these found on federal ownership. Oregon has large portions of its public lands in the western portion of the state as Late Successional Reserves (LSR), and large portions of the eastern part in

Bureau of Land Management Wilderness Study Areas (BLM WSA). The designation of these LSRs and BLM WSAs as status 2 lands results in high proportion of Oregon found in protected areas (status 1 and status 2 lands), although these designations do not provide as much protection as do most other status 2 designations. This is a limitation of using only four land management classes to represent a complex array of management designations when examining protection patterns for individual species as well as species richness. Land management status was overlain with land cover and vertebrate species distributions to conduct a gap analysis of Oregon. We considered land cover types and vertebrate species as under-represented (i.e., "gaps") in management areas if < 1% of the land they occupied or their habitat in Oregon fell within status 1 and 2 lands.

Nine (14%) of 63 natural (non-anthropogenic) land cover types have < 1% of the area they occupy in status 1 and 2 lands. The highest priority for further protection is recommended for coastal strand and hawthorn-willow shrublands because their current protection is low and they are the most vulnerable to ongoing land management practices. Palustrine forest and south coast mixed conifer forest are also high priorities for protection if WSAs and LSRs are excluded from the analysis. Wetland and riparian types are not satisfactorily mapped at our current MMU, and further efforts are needed to provide an adequate spatial description of their location before long-term planning for their conservation can be accomplished.

Five (< 2%) of the 263 birds modeled had < 1% of their habitat protected in status 1 and 2 lands. When LSR lands are put in status 3, three additional species are added to this category. When historic distributions were compared to current status 1 and 2 lands, one fifth (57) of the birds modeled had substantial habitat loss or low habitat protection. Of these, nine are of current conservation concern. No native mammals had < 1% of its habitat in status 1 and 2 lands. When LSR lands are excluded from category 2, two mammals of conservation concern (California and Townsend's voles) fall into this category. Thirty one (24 %) mammals (including seven conservation targets) have had substantial habitat loss or low habitat protection when compared to historic distribution. There were no amphibians or reptiles with < 1% of their present distribution in status 1 and 2 lands. When LSR lands are dropped from the analysis, one reptile, the common kingsnake, is added to this group. Thirteen (22 %) of the amphibians and reptiles have had substantial habitat losses or low habitat protection compared to historic distributions.

Using some indices developed to look at how much habitat species have lost, and how well their current and historic distributions are protected, OR-GAP was able to compare species richness maps for all species, with a subset of those needing conservation action. The major centers of species richness (areas with very high species richness values) are the Klamath Basin in south-central Oregon, the Malheur Basin in east-central Oregon, and the Siskiyou Mountains in southwestern Oregon in both the all species and the priority species richness maps. However, areas of high to moderately high diversity change dramatically in the subset of needy species coverage, with priority areas highlighted in the western Columbia River Gorge, the Alvord Basin, and southeastern Wasco County that were not important in the overall species richness map.

In general, OR-GAP is hesitant to use the results of the analysis to make important statements about either diversity patterns in Oregon, or sites where best biodiversity most needs to be protected here. However, the development of the stewardship coverage and the species distribution databases has improved the ability for others to do statewide and local assessments. Both versions of the OR-GAP land cover are uneven, with detailed mapping and classification in some areas, and coarser mapping and classification in others, and neither have had accuracy assessments. The wildlife by habitat relationship models used in OR-GAP are in the process of being improved, but the new models were not available in time for this analysis. We believe that using higher resolution vegetation coverages with more detailed classifications, and the improved wildlife-habitat models would greatly improve the overall accuracy of the analysis. However, the OR-GAP version 2 species distribution maps are clearly the best wildlife distribution maps available and are quite useful for ecoregional, statewide and multi-state analyses.

OR-GAP has been most valuable as a focus to develop and integrate these important data sets. Using the species distribution databases and the managed area coverage with the new wildlife-habitat models and ecoregional or local vegetation maps which are currently being produced throughout the state, should provide much more accurate species lists and species distribution maps. OR-GAP intends to continually update the managed area cover, the species distribution databases, and to provide crosswalks between the new wildlife habitat models and any new vegetation or land cover maps which become available. We intend to try to aggregate a 1:24,000 vegetation coverage for Oregon, based on local mapping efforts, and to compare these to the coarser scale maps based on satellite imagery. And, we intend to remain a source of biodiversity information for anyone interested in studying or protecting biodiversity in Oregon.

ACKNOWLEDGMENTS

Thanks to Amos Eno and the staff of the National Fish and Wildlife Foundation, who funded the early development of the GAP concept. Thanks to John Mosesso and Doyle Frederick of the Biological Resource Division (BRD) Office of Inventory and Monitoring, for their support of the national GAP program, especially during its transition from the U.S. Fish and Wildlife Service to the National Biological Service and then to the U.S. Geological Survey Biological Resources Division. Thanks to Reid Goforth and the staff at the BRD Cooperative Research Units for administering GAP's research phase from headquarters. Without those mentioned above, there could not have been a Gap Analysis Program. Thanks also to the National Gap Analysis Program staff. We especially acknowledge contributions to this report by Chris Cogan, Patrick Crist, Tom Edwards, Michael Jennings, and J. Michael Scott.

Due to the long history (over 10 years) of this project in Oregon, many people have contributed to this program and effort here. For the first eight years, Blair Csuti managed the Oregon State Project, while working with Mike Scott and others to move the program from a local to a national scale. During this entire time, the project has been a cooperative venture, with participation from conservation organizations, researchers, and biologists throughout the state. While it is impossible to mention everyone who participated, a few people and organizations deserve special mention.

Sara Vickerman of the Northwest Office of the Defenders of Wildlife has been a constant supporter of both OR-GAP and the national program. She has helped with program funding and has been the primary driver of efforts to use the information developed and accumulated by OR-GAP to make conservation more efficient in Oregon. Her focus on GAP implementation led to the creation of the Oregon Biodiversity Project (OBP). OBP was the first statewide assessment of biodiversity in Oregon, and its final report, *Oregon's Living Landscape* provides a benchmark that will be hard to match. Sara, Bruce Taylor, Keith Hupperts, Lori Kleifgen, Andrew Briggs and other OBP staff have assisted in the production of many of the materials used in this report.

The Biodiversity Research Consortium has also been intimately involved in OR-GAP. Ross Kiester of the Pacific Northwest Research Station, Forestry Sciences Laboratory in Corvallis, Denis White of the Environmental Protection Agency (EPA) Lab in Corvallis, Eric Preston, currently retired but formerly with EPA, and Manuela Huso of Oregon State University deserve special mention here.

The Oregon Department of Fish and Wildlife has also been committed to and involved in OR-GAP since its inception in Oregon. The OR-GAP program certainly would not be where it is today without the persistence and energy of Tom O'Neil and Meg Shaughnessy. The assistance of Greg Seigletz, Milton Hill, Charlie Bruce and Jim Greer are also notable.

Finally, while only Jimmy Kagan, John Hak, and Eleanor Gaines from the Oregon Natural Heritage Program are authors of this report, other heritage staff provided significant help. Mary Finnerty made a number of the maps, Sue Vrilakas help edit the document, and Mark Stern, Ken Popper, Terry Campos and Eric Scheuering all provided important assistance in developing the vertebrate species distributions and habitat associations.

ORNHP would also like to thank ESRI for their donation of ARCINFO and ARCVIEW software which was critical to the production of this report.

CHAPTER 1: INTRODUCTION

How This Report is Organized

This report is a summation of a scientific - technical project. While we endeavor to make it understandable for as general an audience as practicable, it will reflect the complexity of the project it describes. A glossary of terms is provided to aid the reader in its understanding, and for those seeking a detailed understanding of the subjects, the cited literature should be helpful. The organization of this report follows the general chronology of project development, beginning with the production of the individual data layers and concluding with analysis of the data. It diverges from standard scientific reporting by embedding results and discussion sections within individual chapters. This was done to allow the individual data products to stand on their own as testable hypotheses and provide data users with a concise and complete report for each data and analysis product.

We begin with an overview of the Gap Analysis mission, concept, and limitations. We then present a synopsis of how the current biodiversity condition of the project area came to be, followed by land cover mapping, animal distribution prediction, species richness, and land stewardship mapping and categorization. Data development leads to the Analysis section which reports on the status of the elements of biodiversity (natural community alliances and terrestrial vertebrate species) for this state. Finally, we describe the management implications of the analysis results and provide information on how to acquire and use the data.

The Gap Analysis Program Mission

The mission of the Gap Analysis Program (GAP) is to prevent conservation crises by providing conservation assessments of native vertebrate species and their habitats and to facilitate the application of this information to land management activities.

This is accomplished through the following five objectives:

1. Map actual land cover as closely as possible to the Alliance level (FGDC 1997).
2. Map the predicted distribution of those terrestrial vertebrates that spend any substantial part of their life history in the project area and for which adequate distributional habitats, associations, and mapped habitats are available. Map other taxa as cooperative opportunities allow.
3. Document the representation of natural land cover types and animal species in areas managed for the long-term maintenance of biodiversity.
4. Make all GAP Project information available to the public and those charged with land use research, policy, planning, and management.
5. Build institutional cooperation in the application of this information to state and regional management activities.

To meet these objectives, it is necessary that GAP be operated at the state level but maintain consistency with national standards. Within the state, participation by a wide variety of cooperators is necessary and desirable to ensure understanding and acceptance of the data and forge relationships that will lead to cooperative conservation planning.

The Gap Analysis Concept

The Gap Analysis Program (GAP) brings together the problem-solving capabilities of federal, state, and private scientists to tackle the difficult issues of land cover mapping, vertebrate habitat characterization, assessment, and biodiversity conservation at the state, regional, and national levels. The program seeks to facilitate cooperative development and use of information. Throughout this report we use the terms "GAP" to describe the national program, "GAP Project" to refer to an individual state or regional project, "OR-GAP" to refer to the Oregon program, and "gap analysis" to refer to the gap analysis process or methodology.

Much of the following discussion was taken verbatim from Edwards *et al.* 1995, Scott *et al.* 1993, and Davis *et al.* 1995. The gap analysis process provides an overview of the distribution and conservation status of several components of biodiversity. It uses the distribution of actual vegetation and predicted distribution of terrestrial vertebrates and, when available, invertebrate taxa. Digital map overlays in a GIS are used to identify individual species, species-rich areas, and vegetation types that are unrepresented or under represented in existing management areas. It functions as a preliminary step to the more detailed studies needed to establish actual boundaries for potential biodiversity management areas. These data and results are then made available to the public so that institutions as well as individual land owners and managers may become more effective stewards through more complete knowledge of the management status of these elements of biodiversity. GAP, by focusing on higher levels of biological organization, is likely to be both cheaper and more likely to succeed than conservation programs focused on single species or populations (Scott *et al.* 1993).

Biodiversity inventories can be visualized as "filters" designed to capture elements of biodiversity at various levels of organization. The filter concept has been applied by The Nature Conservancy, which has established Natural Heritage Programs in all 50 states, most of which are now operated by state government agencies. The Nature Conservancy employs a fine filter of rare species inventory and protection and a coarse filter of community inventory and protection (Jenkins 1985, Noss 1987). It is postulated that 85-90% of species can be protected by the coarse filter, without having to inventory or plan reserves for those species individually. A fine filter is then applied to the remaining 15-10% of species to ensure their protection. Gap analysis is a coarse filter method because it can be used to quickly and cheaply assess the other 85-90% of species.

The intuitively appealing idea of conserving most biodiversity by maintaining examples of all natural community types has never been applied, although numerous approaches to the spatial identification of areas in which most biodiversity is represented have been described (Kirkpatrick 1983, Margules *et al.* 1988, Pressey and Nicholls 1989, Nicholls and Margules 1993). Furthermore, the spatial scale at which organisms use the environment differs tremendously among species and depends on body size, food habits, mobility, and other factors. Hence, no coarse filter will be a complete assessment of biodiversity protection status and needs. However, species that fall through the pores of the coarse filter, such as narrow endemics and wide-ranging mammals, can be captured by the safety net of the fine filter. Community-level (coarse-filter) protection is a complement to, not a substitute for, protection of individual rare species.

Gap analysis is essentially an expanded coarse-filter approach (Noss 1987) to biodiversity protection. The vegetation types mapped in GAP serve directly as a coarse filter, the goal being to assess representation of all types in biodiversity management areas. Landscapes with great vegetation diversity often are those with high edaphic variety or topographic relief. When elevational diversity is very great, a nearly complete spectrum of vegetation types known from a biological region may occur within a relatively small area. Such areas provide habitat for many species, including those that depend on multiple habitat types to meet life history needs (Diamond 1986, Noss 1987). By using landscape-sized samples (Forman and Godron 1986) as an expanded coarse filter, gap analysis searches for and identifies biological regions where unprotected or under represented vegetation types and vertebrate species occur.

More detailed analyses were not part of this project but are areas of research that GAP as a national program is pursuing. For example, a second filter could combine species distribution information to identify a set of areas in which all, or nearly all, mapped species are represented. There is a major difference between identifying the richest areas in a region (many of which are likely to be neighbors and share essentially the same list of species) and identifying areas in which all species are represented. The latter task is most efficiently accomplished by selecting areas whose species lists are most different or complementary. Areas with different environments tend to also have the most different species lists for a variety of taxa. As a result, a set of areas with complementary sets of species for one higher taxon (e.g. mammals) often will also do a good job representing most species of other higher taxa (e.g. trees, butterflies). Species with large home ranges, such as large carnivores, or species with very local distributions may require individual attention. Additional data layers can be used for a more holistic conservation evaluation. These include indicators of stress or risk (e.g. human population growth, road density, rate of habitat fragmentation, distribution of pollutants) and the locations of habitat corridors between wildlands that allow for natural movements of wide-ranging animals and the migration of species in response to climate change.

The Gap Analysis Project in Oregon

Because of the long history of OR-GAP, we have developed information which both follows national gap standards, and predates many of them. The first GAP land cover map was developed in 1990 using LANDSAT MSS false-color infrared positive prints. Species distribution maps were developed using species distribution data in EMAP (EPA's environmental monitoring and assessment program) hexagons. This database (species by hexagon) was developed in Oregon by ORNHP with funding from EPA, the Biodiversity Research Consortium and The Nature Conservancy. The first stewardship (ownership) map was drafted by ORNHP, digitized by the Idaho Department of Water Resources and quality controlled by ODFW. Species distributions were generated using the first land cover map, ORNHP hexagon distributions, and a wildlife habitat matrix developed by Blair Csuti and ODFW. A result of this work was the publication of the *Atlas of Oregon Wildlife* (Csuti *et al.*) in 1997.

OR-GAP was able to complete a gap analysis looking at historic distributions of Oregon wildlife species. We were able to update a statewide, historic vegetation cover developed by the Oregon Biodiversity Project. This cover allows a comparison of both how well vegetation alliances are protected in the statewide network of conservation lands, as well as how much they have declined over the last 150 years. Combined with excellent historic distribution maps of Oregon's vertebrate wildlife species, we were able to use standard techniques to assess how much habitat each species has lost since the advent of European settlement.

This final state report summarizes the project to-date, focusing on efforts by OR-GAP to meet national standards. It includes a new land cover map which used most of the new gap standards, a new stewardship cover, and newly created species distribution maps. All of the coverages, data, and products created by OR-GAP since its inception in 1988 are available and will be included on CD-ROM and the National GAP and OR-GAP web sites. The existence of first generation land cover and species cover maps provides the opportunity to compare methods. While we have not compared the methods in this report, we believe this is an opportunity for future study.

OR-GAP has become a critical part of ORNHP's overall objective to maintain and update all information on Oregon's biodiversity. For this report, final versions of the primary GAP coverages have been developed and used. All of the coverages used for this report are OR-GAP Version 2. ORNHP will continue to update each of these coverages. The ownership and stewardship coverage is continually updated as new areas are protected or designated, or as land ownership patterns change. ONRHP will release an updated ownership and stewardship cover each year. The OR-GAP Land Coverage developed by the Oregon Department of Fish and Wildlife will not be updated, but ORNHP is working to compile more detailed regional and statewide land use/land cover coverages. Version 2 species distribution coverages are included and analyzed in this report and will not change. But both the wildlife-habitat matrix and species distributions will be continually updated by ORNHP. As a result, we will have the capacity to generate updated species distributions coverages on a local, regional or statewide basis as higher resolution land covers become available.

Unfortunately, OR-GAP has not yet addressed aquatic biodiversity. In Oregon, aquatic habitats, anadromous fish, rivers and water quality are the primary drivers of environmental policy and restoration efforts. As a result, OR-GAP is committed to completing an aquatic gap analysis. Developing a macrohabitat or stream classification, attributing all of Oregon streams and lakes, and obtaining high quality distribution information for some of Oregon's aquatic biota (all fish and some key aquatic invertebrates) are high priority goals for OR-GAP and ORNHP over the next two years.

General Limitations

Limitations must be recognized so that additional studies can be implemented to supplement GAP. The following are general project limitations; specific limitations for the data are described in the sections that describe them:

1. GAP data are derived from remote sensing and modeling to make general assessments about conservation status. Any decisions based on the data must be supported by ground-truthing and more detailed analyses.

2. GAP is not a substitute for threatened and endangered species listing and recovery efforts. A primary argument in favor of gap analysis is that it is pro-active: it seeks to recognize and manage sites of high biodiversity value for the long-term maintenance of populations of native

species and natural ecosystems before individual species and plant communities become critically rare. Thus, it should help to reduce the rate at which species require listing as threatened or endangered. Those species that are already greatly imperiled still require individual efforts to assure their recovery.

3. GAP data products and assessments represent a snapshot in time generally representing the date of the satellite imagery. Updates are planned on a 5-10 year cycle, but users of the data must be aware of the static nature of the products.

4. GAP is not a substitute for a thorough national biological inventory. As a response to rapid habitat loss, gap analysis provides a quick assessment of the distribution of vegetation and associated species before they are lost, and provides focus and direction for local, regional, and national efforts to maintain biodiversity. The process of improving knowledge in systematics, taxonomy, and species distributions is lengthy and expensive. That process must be continued and expedited in order to provide the detailed information needed for a comprehensive assessment of our nation's biodiversity. Vegetation and species distribution maps developed for GAP can be used to make such surveys more cost-effective by stratifying sampling areas according to expected variation in biological attributes.

The Study Area

Oregon is the tenth largest of the United States, at 97,060 square miles (251,418 square km) (Keisling 1999, *Oregon Blue Book*). Ecologically, it is the most diverse state aside from California (based on the number of plant associations described in the National Vegetation Classification (NVCS) by the Oregon Natural Heritage Program). Oregon has coastal rainforests dominated by California and Alaska species (coast redwood and Sitka spruce), barren deserts receiving less than seven inches of rainfall a year, and mountain ranges associated with the Rocky Mountains, the Cascades, the Klamath Mountains and the Great Basin Ranges. The state is known for its forests, which include the world's tallest (Oregon is home to the champion big leaf maple, black cottonwood, white fir, Douglas-fir, ponderosa pine, Port Orford cedar and Sitka spruce trees) and the most productive, as well as extensive fire maintained ponderosa pine and Oregon white oak savannas and woodlands. The state's extensive sagebrush steppe, native prairies and grasslands, and rivers and lakes are less well known, but no less significant to wildlife and biodiversity.

Oregon is a crossroads for plants from many regions, with numerous species at or near the edge of their range. Many plants typically found in the Arctic dominate the high Cascades. Coastal Alaskan plants such as Sitka spruce dominate the north Coast Range, while the southern coast has a redwood belt that spills over from California. The Wallowa Mountains are the western edge of the Rocky Mountains and are home to many species common to central Colorado. Southeastern Oregon is the edge of the Great Basin and is characterized by plants found in the cool deserts of Nevada and Utah. In the Klamath Mountains, the flora of the Sierra Nevada, the Cascades, and the Great Basin come together to form unique combinations. A two-mile stretch of the Siskiyou Crest in southwestern Oregon supports plant communities as varied as old growth Douglas-fir forest, alpine meadows, western juniper steppe, Jeffrey pine savannas, red fir forests, and rigid sagebrush steppe.

Evidence of humans in Oregon goes back beyond 15,000 years, although there is continued debate as to the actual earliest settlements here. Native Americans were distributed around the state, with very different cultures in different areas, although most relied on hunting and fishing for subsistence. In northwest Oregon, native tribes use of fire played a critical role in establishing many patterns of natural habitats. Around the end of the Pleistocene, the drier climate had created open grasslands and oak savannas throughout much of the Willamette Valley supporting numerous prairie wildlife species, as well as a diverse endemic flora adapted to grasslands. As the climate got cooler and wetter and summer lightning almost disappeared, Native Americans frequently set fires in the Willamette Valley, maintaining the prairies and oak savannas which would otherwise have become conifer forests.

Currently, Oregon's population is relatively small, with just over 3.2 million people in 1998, most of whom are concentrated in the Willamette River Valley. This valley, between Eugene and Portland, was the final destination of the Oregon Trail because of its mild climate and very productive soils. The eastern half of the state supports a sparse population and a natural resource economy based mostly on dryland and irrigated farms, ranches and timber production. Southwestern Oregon is similar to northern California, with a mix of farmers, timber workers, fishermen and but with small but rapidly growing communities concentrated around Medford.

Many organizations now use ecoregions to organize biodiversity information and to develop conservation plans. Ecoregions are geographic areas with similar features, such as climate, vegetation, geology, geomorphology, soils, and ecosystem processes - which together support characteristic natural communities of plant and animal life. OR-GAP has recognized ten ecoregions which occur in Oregon.

Oregon's ecoregions include the Willamette Valley, Coast Range, Klamath Mountains, West Cascades, East Cascades, Columbia Basin, High Lava Plains, Northern Basin and Range, Blue Mountains and Owyhee Uplands (Figure 1.1). These ecoregions correspond to the ten Sections from Oregon in Bailey's (McNab and Avers 1994) U.S. Forest Service Ecoregional Framework, and for western Oregon were based on those developed by James Omernik of EPA (Pater *et al.* 1998). Descriptions of these ten ecoregions are included in Appendix 1.2. These ecoregions have been used as the basis for conservation planning by ODFW, ORNHP, the Oregon Biodiversity Project as well as in modified form by The Nature Conservancy and the U.S. Forest Service in the Interior Columbia Basin Management Plan.

For this report, OR-GAP completed the analysis primarily on a statewide basis. Ecoregional assessments are currently underway on the basis of these ecoregions, and some of the data included here is displayed on an ecoregional basis.

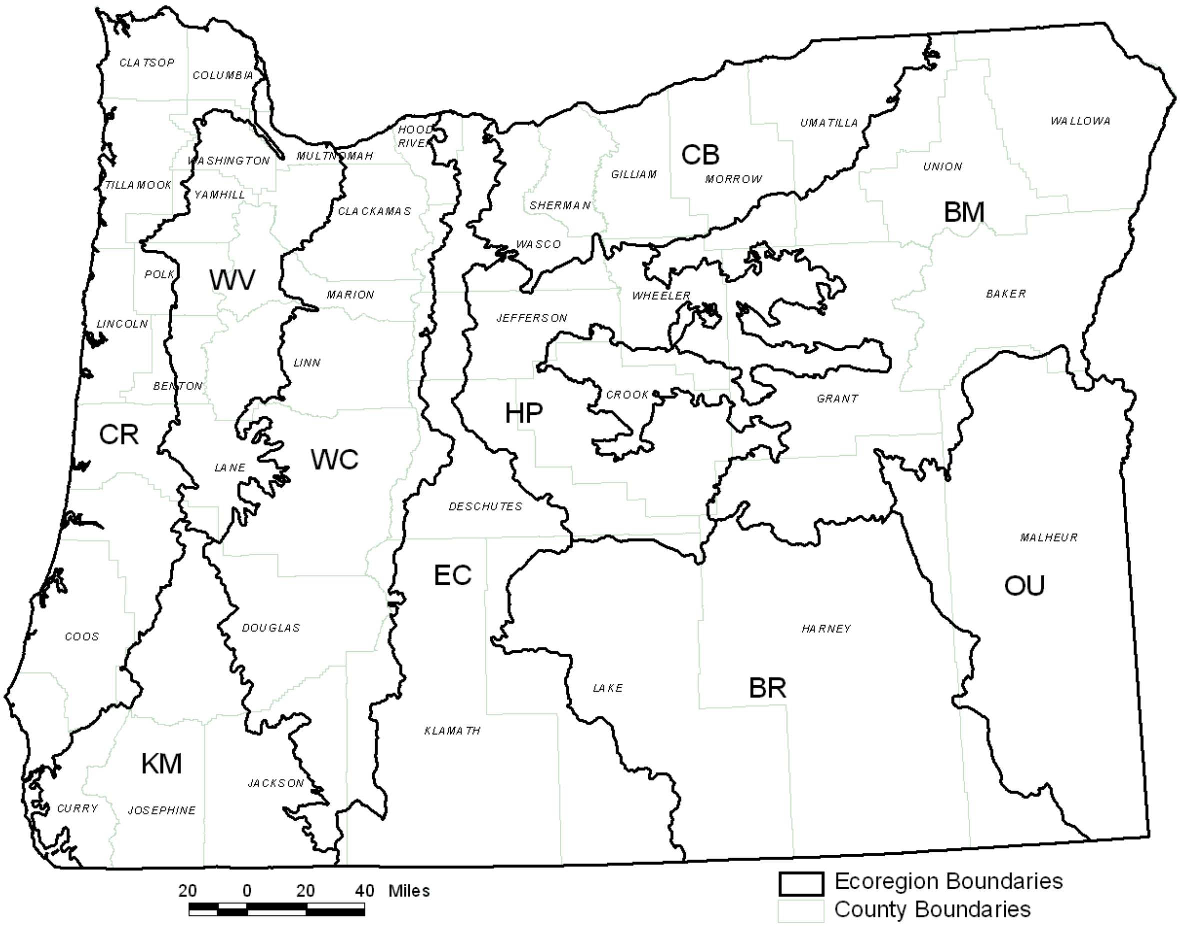

Figure 1.1. Map showing the 10 Ecoregions of Oregon. CR = Coast Range, WV = Willamette Valley, KM = Klamath Mountians, WC = West Cascades, EC = East Cascades, BR = Basin and Range, HP = High Lava Plains, CB = Columbia Basin, BM = Blue Mountains, and OU = Owyhee Uplands.

CHAPTER 2: EXISTING LAND COVER CLASSIFICATION AND MAPPING

Introduction

Mapping natural land cover requires a higher level of effort than the development of data for animal species, agency ownership, or land management, yet it is no more important for gap analysis than any other data layer. Generally, the mapping of land cover is done by adopting or developing a land cover classification system, delineating areas of relative homogeneity (basic cartographic "objects"), then labeling these areas using categories defined by the classification system. More detailed attributes of the individual areas are added as more information becomes available, and a process of validating both polygon pattern and labels is applied for editing and revising the map. This is done in an iterative fashion, with the results from one step causing re-evaluation of results from another step. Finally, an assessment of the overall accuracy of the data is conducted. The final assessment of accuracy will show where improvements should be made in the next update (Stoms *et al.*1994).

In its "coarse filter" approach to conservation biology (e.g., Jenkins 1985, Noss 1987), gap analysis relies on maps of dominant natural land cover types as the most fundamental spatial component of the analysis (Scott *et al.* 1993) for terrestrial environments. For the purposes of GAP, most of the land surface of interest (natural) can be characterized by its dominant vegetation.

Vegetation patterns are an integrated reflection of the physical and chemical factors that shape the environment of a given land area (Whittaker 1965). They also are determinants for overall biological diversity patterns (Franklin 1993, Levin 1981, Noss 1990), and they can be used as a currency for habitat types in conservation evaluations (Specht 1975, Austin 1991). As such, dominant vegetation types need to be recognized over their entire ranges of distribution (Bourgeron *et al.* 1994) for beta-scale *define* analysis (*sensu* Whittaker 1960, 1977). These patterns cannot be acceptably mapped from any single source of remotely sensed imagery, therefore, ancillary data, previous maps, and field surveys are used. The central concept is that the physiognomic and floristic characteristics of vegetation (and, in the absence of vegetation, other physical structures) across the land surface can be used to define biologically meaningful biogeographic patterns. There may be considerable variation in the floristics of subcanopy vegetation layers (community association) that are not resolved when mapping at the level of dominant canopy vegetation types (alliance), and there is a need to address this part of the diversity of nature. As information accumulates from field studies on patterns of variation in understory layers, it can be attributed to the mapped units of alliances.

Land Cover Classification

Land cover classifications must rely on specified attributes, such as the structural features of plants, their floristic composition, or environmental conditions, to consistently differentiate categories (Küchler and Zonneveld 1988). The criteria for a land cover classification system for GAP are: (a) an ability to distinguish areas of different actual dominant vegetation; (b) a utility for modeling vertebrate species habitats; (c) a suitability for use within and among biogeographic regions; (d) an applicability to Landsat Thematic Mapper (TM) imagery for both rendering a base map and from which to extract basic patterns (GAP relies on a wide array of information sources, TM offers a convenient meso-scale base map in addition to being one source of actual land cover information); (e) a framework that can interface with classification systems used by other organizations and nations to the greatest extent possible; and (f) a capability to fit, both categorically and spatially, with classifications of other themes such as agricultural and built environments.

For GAP, the system that fits best is referred to as the National Vegetation Classification System (NVCS) (FGDC 1997). The origin of this system was referred to as the UNESCO/TNC system (Lins and Kleckner in press) because it is based on the structural characteristics of vegetation derived by Mueller-Dombois and Ellenberg (1974), adopted by the United Nations Educational, Scientific, and Cultural Organization (UNESCO 1973) and later modified for application to the United States by Driscoll *et al.* (1983, 1984). The Nature Conservancy and the Natural Heritage Network (Grossman *et al.* 1994) have been improving upon this system in recent years with partial funding supplied by GAP. The basic assumptions and definitions for this system have been described by Jennings (1993).

In 1994, the NVCS classification system was not chosen by ODFW to use for the process of revising its classification scheme and mapping protocol from the Kagan and Caicco (1992) initial mapping effort. ODFW felt instead that vegetation physiognomy should be the primary criterion for the classification since the major purpose of the OR-GAP Version 2 was to map vegetation at a regional scale using remotely sensed data. A second purpose for the classification was to establish relationships between major environmental controls and the identified vegetation units. For this reason, floristic composition was chosen as a second criterion in combination with physiognomy. While ODFW was creating the classification a panel of Pacific Northwest resource agencies proposed another vegetation classification scheme (IRICC 1994). Their scheme was similar to the NVCS in that it utilized both floristic composition and physiognomy as key classification criteria. The appeal of the IRICC approach was that various mapping efforts would become generic in their utility on the basis of the common classification units. A second appeal to the IREC system is that label criteria is not restricted to species dominance and allows for more descriptive class types such as the Northeastern Oregon Mixed Conifer Forest. The IRICC approach was used as the basis for the ODFW, OR-GAP version 2 coverage.

To classify barren, or non-vegetated lands ODFW followed the classification approach described by the USGS (Anderson *et al.* 1976). The Anderson classification system is commonly used in remote sensing applications and uses a hierarchy that partitions regional landscapes into broad major land use/land cover categories such as agriculture, urban, forest, etc. Second level distinction separates the broad level I class into specific categories. For example, the Anderson level I class Barren Land is classified into dunes, exposed rock, salt flats in level II. We classified barren, or non-vegetated lands to Anderson level II in this mapping project. Agricultural lands were kept at Anderson level I in the interest of time, project finances and the general focus of GAP, which is to inventory natural ecosystems. Table 2.1 shows the types classified and mapped on the Version 2 landcover. Appendix 2.1 includes descriptions of each of these types.

Table 2.1 Landscape-level vegetation types and proportional area of land cover for Oregon.

FOREST AND WOODLAND COVER TYPES

Map Code #	*CLASS NAME*	*Area of Land Cover (acres)*	*% of State*
32	*Sitka Spruce-W. Hemlock Maritime Forest*	397521	0.631%
33	*Mountain Hemlock Montane Forest*	331700	0.527%
34	*True Fir-Hemlock Montane Forest*	1510010	2.398%
35	*Montane Mixed Conifer Forest*	83834	0.133%
37	*Shasta Red Fir-Mountain Hemlock Forest*	54086	0.086%
39	*Whitebark-Lodgepole Pine Montane Forest*	1323	0.002%
40	*Ponderosa Pine Dominant Mixed Conifer Forest*	427295	0.679%
41	*Northeast Ore. Mixed Conifer Forest*	3144370	4.994%
42	*Jeffery Pine Forest and Woodland*	53781	0.085%
43	*Serpentine Conifer Woodland*	51874	0.082%
44	*Lodgepole Pine Forest and Woodland*	256444	0.407%
45	*Subalpine Fir-Lodgepole Pine Montane Conifer*	714286	1.134%
46	*Coastal Lodgepole Forest*	41869	0.066%
49	*Douglas-Fir-W. Hemlock-W. Red Cedar Forest*	6618660	10.512%
50	*Douglas-Fir-Port Orford Cedar Forest*	166450	0.264%
51	*Douglas-Fir-Mixed Deciduous Forest*	10894	0.017%
52	*Douglas-Fir-White Fir/Tanoak-Madrone Mixed Forest*	1126290	1.789%
53	*Douglas-Fir/White Oak Forest*	196692	0.312%
54	*Ponderosa Pine Forest and Woodland*	4680430	7.434%
56	*Douglas-Fir Dominant-Mixed Conifer Forest*	2553290	4.055%
57	*Ponderosa Pine/White Oak Forest and Woodland*	163112	0.259%
58	*Ponderosa Pine-W. Juniper Woodland*	201553	0.320%
59	*Ponderosa-Lodgepole Pine on Pumice*	1502790	2.387%
61	*Western Juniper Woodland*	3784130	6.010%
63	*Red Alder Forest*	124929	0.198%
64	*Red Alder-Big Leaf Maple Forest*	4268	0.007%
66	*Aspen Groves*	22287	0.035%
67	*Mixed Conifer/Mixed Deciduous Forest*	1412120	2.243%
68	*Cottonwood Riparian Gallery*	2574	0.004%
72	*Siskiyou Mtns Mixed Deciduous Forest*	200396	0.318%
75	*Oregon White Oak Forest*	115579	0.184%
77	*South Coast Mixed Deciduous Forest*	2894	0.005%
110	*Subalpine Parkland*	76262	0.121%

Table 2.1. continued.

SHRUBLAND AND GRASSLAND TYPES			
Map Code #	*CLASS NAME*	*Area of Land Cover (acres)*	*% of State*
85	*Siskiyou Mtns Serpentine Shrubland*	32404	0.051%
87	*Hawthorn-Willow Shrubland*	8132	0.013%
89	*Manzanita Dominant Shrubland*	15440	0.025%
90	*Mountain Mahogany Shrubland*	1378	0.002%
91	*Sagebrush Steppe*	5244610	8.330%
93	*Low-Dwarf Sagebrush*	435480	0.692%
95	*Salt Desert Scrub Shrubland*	571920	0.908%
96	*Big Sagebrush Shrubland*	12325200	19.576%
97	*Bitterbrush-Big Sagebrush Shrubland*	152276	0.242%
103	*Northeast Ore. Canyon Grassland*	404702	0.643%
105	*Subalpine Grassland*	107232	0.170%
106	*Forest-Grassland Mosaic*	382767	0.608%
112	*Modified Grassland*	963640	1.531%
113	*Coastal Strand*	1941	0.003%
121	*Grass-shrub-sapling or Regenerating young forest*	1846210	2.932%
NON-NATIVE OR MINIMAL VEGETATIVE COVER			
122	*Alkali Playa*	128075	0.203%
124	*Urban*	601668	0.956%
125	*Agriculture*	6455430	10.253%
126	*Exposed Tidal Flat*	23039	0.037%
127	*Lava Flow*	157010	0.249%
128	*Coastal Dunes*	48728	0.077%
129	*Alpine Fell-Snowfields*	154748	0.246%
130	*Open Water*	1709630	2.715%
RIPARIAN AND HERBACEOUS WETLAND TYPES			
114	*Wet Meadow*	2911	0.005%
135	*Palustrine Forest*	26901	0.043%
136	*Palustrine Shrubland*	7640	0.012%
137	*Estuarine Emergent*	965	0.002%
138	*Palustrine Emergent*	19950	0.032%
200	*NWI Palustrine Forest*	921	0.001%
201	*NWI Palustrine Shrubland*	1005180	1.597%
202	*NWI Estuarine Emergent*	40822	0.065%
203	*NWI Palustrine Emergent*	50431	0.080%

Methods

Landsat TM Imagery

Twenty-three Landsat TM scenes formed the basis for interpretation of the OR-GAP version 2 landcover. All imagery had less than 10% cloud cover and was acquired from May to October between 1991 and 1993. Cloudy and smoke-obscured regions within the imagery were interpreted using adjacent imagery, where possible, or using aerial photography as the information source. Imagery was registered to the Universal Transverse Mercator (UTM) map coordinate system, zones 10 and 11.

Table 2.2 Landsat TM Imagery and dates used for mapping project

Path/Row	Month/year	Path/Row	Month/year	Path/Row	Month/year
P42/R28	June / 1991	P44/R28	May / 1993	P46/R28	Aug / 1991
P42/R29	July / 1992	P44/R29	June / 1992	P46/R29	June / 1992
P42/R30	July / 1992	P44/R30	Oct / 1991	P46/R30	July / 1992
P42/R31	June / 1993	P44/R31	June / 1991	P46/R31	July / 1992
P43/R28	Sept / 1993	P45/R28	Oct / 1993	P47/R28	Sept / 1991
P43/R29	July / 1991	P45/R29	June / 1992	P47/R29	July / 1991
P43/R30	Aug / 1993	P45/R30	July / 1992		
P43/R31	Aug / 1991	P45/R31	Aug / 1991		

Map Development

Each of the 23 Landsat TM scenes that were used in the classification of Oregon's vegetation underwent a two phase, multi-step process. The major steps involved with the two phases are briefly described below.

Phase I—Image Preparation, Radiometric Preview, and Image Analysis

1) *Partitioning imagery into ecoregional similarity*. Previous mapping efforts by the Northwest Habitat Institute (NHI) staff have demonstrated that whenever classification takes place over a large land area, (such as a TM scene), the problem of signature extension severely compromises classification effort. Ecoregional partitioning was used to reduce spectral complexity displayed in a full TM scene, and to group vegetation types into more "probable" associations.
2) *Construct derivative bands*. A normalized difference vegetation index (NDVI) and the first three principal component bands of a Tasseled Cap Transformation algorithm was incorporated with TM bands 1-5 and 7 to form a 10 band image. This image was the basis of all subsequent spectral analysis.
3) *Conversion of TM imagery to TIFF format files*. A three-band (bands 3, 4 and 5) image was subset from the 10-band image and converted to a TIFF, which was downloaded to a laptop computer for field reconnaissance purposes.
4) *Conversion of vector format ancillary data*. Coverages which assisted the analyst during field verification, especially the road and stream networks, were converted to a DXF format and brought into the lap top computer to display over the TIFF images.

Phase II—Image Classification, Field Verification, and Accuracy Assessment

1) *Unsupervised classification of the scene ecoregion*. Initial classification procedure started with a sufficiently large number of spectral clusters (generally between 100-150), to form mutually exclusive spectral signatures. These signatures were then run through a maximum likelihood classifier to produce the initial spectral cluster map.
2) *Preliminary assignment of spectral class to vegetation class*. Linking spectral clusters to vegetation information classes was first done through an on-screen examination of the clusters overlaid on the image. In many cases the information class was spectrally distinct enough that cluster labeling was very straightforward. However, there were always a number of spectral clusters that were indeterminable at this stage, as well as classes that did not readily lend themselves to an identification (like palustrine forest). Which is the reason an iterative process was used to determine spectral/information class relationships.
3) *Field verification of spectral-vegetative condition*. This process involved recording vegetation identity at known points within the image. This entailed linking our global positioning system (GPS) unit to the TIFF version of the TM scene through Field Notes software and recording field training sites. A database was developed for each ecoregion using the Field Notes software that includes XY coordinates, the vegetation/land cover class, and environmental variables that were determined to be useful for future processing iterations. The database was brought into ARC/INFO as a point location file and displayed over the various thematic classifications. Other ancillary data, (the National Wetland Inventory (NWI) and stream and road network data) were utilized extensively with the TIFF data to assist in cover type identification.
4) *Refinement-reclassification of spectral class to vegetative condition*. This step began the process of winnowing the scene into identifiable and unidentifiable, or "problem" spectral classes. Once the analyst was confident of the relationship between spectral cluster and land cover class that class was masked out of succeeding classification iterations. Once the problem spectral classes were identified, separate classifications were performed where each class partitioned into many spectral classes and, if possible, those classes were related to probable land cover types and masked out. Further refinement of spectral cluster/land cover type was accomplished through the use of ancillary data as "logical operators". For example, deep shadows in mountainous terrain typically can be confused with water signatures -- and by using a digital elevation model the analyst was able to overlay that spectral class on all slopes less than 1 % and quickly ascertain those areas which are too steep to pond water.
5) *Field verification of "problem" spectral-vegetation classes*. If the analyst was not confidently able to relate a spectral cluster to land cover class, another field visit was often necessary to uncover the spectral cluster identity.
6) *Editing the refined coverage*. As a last step in the classification phase the analyst used on screen editing of those areas, which were too obscure to classify by conventional image processing techniques. Typically, these were the cloud, cloud shadow, or smoke obscured areas. Aerial photo interpretation of recent aerial photography was the interpretation basis for the classification within these obscured regions.
7) *Accuracy assessment* Accuracy assessment techniques and procedures are discussed in Appendix 2.2, although an accuracy assessment has not been done for either of the OR-GAP existing land coverages.

Mapping Standards

Special Feature Mapping

Several collateral databases (National Wetlands Inventory, riparian vegetation; and the Oregon State Service Center urban growth boundary) were incorporated into the vegetation database to assist with distributional mapping of riparian wetland and urban cover types.

Minimum Mapping Unit

The minimum mapping unit used was 100 hectares.

Results

Landsat TM Imagery Mapping

The statewide current land cover map (Figure 2.1) displays distributional information on the 65 landscape level vegetation types. Despite the large number of landscape level vegetation types the 10 most commonly occurring types constitute 76.7 per cent of the total vegetation (Table 2.3). Big sagebrush and its variant sagebrush steppe account for nearly a third of the total vegetation coverage, and this figure is probably conservative since a fair amount of the western juniper, and the northeastern Oregon canyon grassland and shrubland types could have been put into big sagebrush or sagebrush steppe. On the other hand, a number of the types have less than one per cent of the proportional land area. Some of these types are rare by virtue of their unique relationship to localized environments (e.g. Siskiyou Mountains Serpentine shrublands). Other types, particularly the riparian gallery forests and riparian types, are more widespread than indicated in Table 2.1, but generally are smaller than map resolution.

When you aggregate the cover types by vegetative form (i.e. forest, shrub, etc.), forest and woodland occupy 48% of total land area. Of the entire state, only 14.6% is classified as either non-vegetated, water or human created (urban or agriculture) types. The remainder, 85.4%, is classified as having predominantly native vegetation (although areas dominated by exotic species were not mapped). This proportion of vegetated to other surface type is very similar to California's (79.8%) (Davis *et al.* 1998).

Accuracy Assessment

Introduction

GAP land cover maps are primarily compiled to answer the fundamental question in gap analysis: what is the current distribution and management status of the nation's major natural land cover types and wildlife habitats? Besides giving a measure of overall reliability of the land cover map for gap analysis, the assessment also identifies which general classes or which regions of the map do not meet the accuracy objectives for the Gap Analysis Program. Thus an accuracy assessment can identify where additional effort will be required when the map is updated.

The purpose of accuracy assessment is to allow a potential user to determine the map's "fitness for use" for their application. It is impossible for the original cartographer to anticipate all future applications of a land cover map, so the assessment should provide enough information for the user to evaluate fitness for their unique purpose. This can be described as the degree to which the data quality characteristics collectively suit an intended application. The information reported include details on the database's spatial, thematic, and temporal characteristics and their accuracy.

Assessment data are valuable for purposes beyond their immediate application to estimating accuracy of a land cover map. The reference data is therefore made available to other agencies and organizations for use in their own land cover characterization and map accuracy assessments (see Data Availability for access information). The data set will also serve as an important training data source for later updates.

Even though we have reached an endpoint in the mapping process where products are made available to others, the gap analysis process should be considered dynamic. We envision that maps will be refined and updated on a regular schedule. The assessment data will be used to refine GAP maps identifying where the land cover map is inaccurate and where more effort is required to bring the maps up to accuracy standards. In addition, the field sampling may identify new classes that were not identified at all during the initial mapping process.

Airborne Videography

ODFW had airborne videography recorded between August 25 and September 3, 1993 in an attempt to improve the land cover, and to assist in the accuracy assessment. Unfortunately, ODFW was unable to use this video successfully to validate the Version 2 cover (Barrett, 1998). A more detailed discussion of the ODFW use of video for OR-GAP is included in Appendix 2.2.

Assessment of the Oregon GAP Map Accuracy

No statewide accuracy assessment was completed. OR-GAP hopes to complete an accuracy assessment sometime in the near future. These results will be posted under “Oregon Updates” on the National Gap Home Page (http://www.gap.uidaho.edu/gap/).

Limitations and Discussion

There are no constraints to the use of these data. However, these data were produced with intended application at the state, or ecoregional level with an accuracy in detail and precision based on USGS 1:100,000 maps. These data were created to provide a coarse filter approach to vegetation/wildlife habitat relationships where not every occurrence of animal habitat is mapped;

rather, only large, generalized distributions are mapped. Therefore, this data set is most valid when used in analysis of 1:100,000 applications or greater.

The method we used to map current vegetative conditions is not suited to analysis of canyon-land vegetation types or other vegetation that is environmentally restricted to localized environments. Some of the cover types mapped (i.e. big sagebrush shrubland), created huge polygons that spanned a number of environmental conditions. Due to this large intra-polygon variability, there can be quite a range in the appearance of the type. Physiognomic attributes such as stand structure and floristic information like sub-canopy species could not be mapped within the project constraints.

Area calculations of the various cover types need to be interpreted with some caveats. The coarse scale (1:100,000) and large minimum mapping unit (MMU) (100 ha) of the vegetation and habitat maps provide reasonable representations of the actual acreage, but not as accurate as fine-scale maps because fine-scale maps depict boundaries with greater precision, which in turn affects area calculations.

CHAPTER 3: HISTORIC VEGETATION MAPPING

Introduction

In 1997, as part of the Oregon Biodiversity Project (*Our Living Landscape* 1998), a historic vegetation cover was developed for the state of Oregon. The goal was to allow OBP to look at historic vegetation patterns and the changes which have occurred over time. A comparison of the historic and existing vegetation maps allow for analysis of the vegetation types which have declined the most. More significantly for the gap analysis concept, it also allows for an analysis of how well the historic extent of the various vegetation types and species distributions are represented in the statewide network of conservation lands.

The development of the 1997 version (Version 1) of the historic vegetation cover, and the subsequent update (Version 2) used in this analysis, are described below. Both covers represent a compilation of data from three primary sources, and as a result, the accuracy varies. However, the overall patterns and results appear to be at least as accurate as the information from the existing vegetation map. Figure 3.1 is a fold-out Historic Land Cover map.

Land Cover Classification

In order to facilitate a comparison with the existing vegetation coverages, the National Vegetation Classification System (NVCS) (FGDC, 1997) was used in the development of the historic vegetation map. When data was limited, some types were aggregated, but in general, alliances were used. Table 3.1 outlines the vegetation types from the Version 2.

Methods, Mapping Standards and Map Development

The Oregon Natural Heritage Program has almost completed the development of a 1:24,000, historic vegetation coverage for the Willamette Valley ecoregion of Oregon. This region, which includes most of the population, agriculture and development in Oregon, has been a major focus of vegetation alteration and restoration. The development of detailed, historic vegetation coverages at the USGS Quad scale was done to assist in assessing wetland losses, and to help in developing restoration plans. In addition to the Willamette Valley coverage, the U.S. Forest Service Experiment Station has digitized a detailed forest vegetation coverage developed by H.J. Andrews based on detailed forest inventories from the 1920's and 1930's. This coverage mapped most forest habitats at a very fine level (approximately a 1:100,000 scale) and contained most of the forest types which corresponded very well to the NVCS alliances. The Bureau of Land Management had also digitized a detailed forest vegetation map from 1901, although this coverage only had stand structure mapped, rather than the dominant canopy vegetation type. For the non-forested areas, the Interior Columbia River Basin Assessment had produced a historic vegetation coverage. Since all of these pieces were available, the Oregon Biodiversity Project and ORNHP decided to produce a statewide coverage as an aggregation of these coverages.

Table 3.1 Historic vegetation types and proportional area of land cover for Oregon.

Vegetation Type	Total Area (hectares)	Vegetation Type	Total Area (hectares)
Forests, Woodlands and Savannas		*Barren and Non-Vegetated Types*	
Coast Redwood	5,636	Alpine	*54,188*
Douglas-fir	4,921,046	Inland Dunes	30,378
Grand Fir	475,527	Lava Field	26,482
Jeffrey Pine	80,716	Open Water	209,396
Lodgepole Pine	619,967	Playa	53,499
Mixed Conifer	330,886	*Wetland and Riparian Types*	
Oak-Madrone Woodland	158,754	Marshes and Riparian Types	204,391
Oregon White Oak Savanna	772,569	Quaking Aspen	20,092
Pacific Silver Fir-Mountain	320,599	Riparian	349,347
Ponderosa Pine	3,796,376	Wet Meadows	104,492
Port Orford Cedar	19,700		
Shasta Red Fir-White Fir	235,017		
Shore Pine	11,004		
Sitka Spruce-Western Hemlock	275,018		
Subalpine Fir	340,984		
Western Juniper	703,862		
Western Red Cedar	1,476		
Whitebark Pine	4,157		
Shrublands and Grasslands			
Antelope Bitterbrush	45,188		
Big Sagebrush	3,292,725		
Canyon Shrubland	148,260		
Low Sagebrush	1,359,407		
Mixed Sagebrush	1,432,452		
Mountain Big Sagebrush	626,378		
Salt-desert Shrub	332,283		
Alkali Grassland	808,543		
Perennial Bunchgrass	2,903,020		

The ORNHP data in the Version 2 coverage is mainly based on General Land Office (GLO) surveyor records which have been copied onto microfilm and are available through the Oregon State Office of the Bureau of Land Management. For the entire Willamette Valley ecoregion, these GLO surveyor's notes were transcribed and mapped onto 1:24,000 mylar overlays, showing the locations and species of all trees and shrubs along survey lines. These overlays and the USGS topographic maps were used to digitize a historic vegetation coverage. A total of 84 types were mapped, although for the statewide coverage, these were aggregated into 5 major types. The minimum mapping unit was 4 hectares. The Columbia Basin ecoregion in Oregon was mapped directly onto 1:100,000 USGS topographic maps, based on the GLO surveyor's notes. Since this area has limited trees, the vegetation information in the notes was less detailed. The Columbia

Basin work was completed using a grant from the U.S. Environmental Protection Agency's Regional Geographic Initiative program. The minimum mapping unit for this coverage was also 4 hectares, although it is closer to a 100-hectare MMU coverage.

The forest vegetation (outside of the Willamette Valley) in Oregon was developed entirely from the coverage developed by H.J. Andrews from 1936 and digitized by the U.S. Forest Experiment Station. The coverage was developed for Oregon and Washington, and the data was provided to ORNHP and OBP by a USFS Forest Science researcher, Janet Ohmann. A total of 19 types were included in the H.J. Andrews cover. The Oregon portion of the map included 11 natural vegetation types which were split into 19 forested natural vegetation types as follows:

1) Balsam Fir-Mtn. Hemlock upper slope types ± a) Silver fir-Mountain Hemlock, b) White fir-Shasta fir, and c) Grand fir
2) Cedar-Redwood ± d)Western red cedar, e) Port-Orford cedar, and f) Coast redwood
3) Lodgepole Pine ± g) Lodgepole pine and h) Shorepine
4) Pine mixture ± i) Jeffrey pine and j) Mixed Conifer
5) Hardwoods - Alder, Ash, Maple ± k) Aspen and l) Riparian Hardwoods
6) Hardwoods - Oak, Madrone ± m) Oak-Madrone woodland
7) Subalpine and certain non-commercial ± n) Subalpine fir and o) Whitebark pine
8) Spruce-Hemlock ± p) Sitka spruce-Western hemlock
9) Douglas-fir ± q) Douglas-fir
10) Western Juniper ± r) Western Juniper
11) Pure Ponderosa pine ± s) Ponderosa pine

A combination of geography, geology (for Jeffrey pine forests), elevation and aspect was used to distinguish these types. For all of the conifer types, the coverage distinguished stands with large trees or old growth from smaller trees or second growth. These were all combined in the historic coverage. The Andrews coverage included three classes of disturbed forested habitats: Deforested burns, recent cutover, and non-restocked cutover. These classes made up a fairly small portion of the overall forested landscape in Oregon, and these were individually reclassed into an adjacent type using expert review. This coverage has no established minimum mapping unit or scale. Based on the detail, it appears to be finer than the 1:100,000 scale Version 2 Gap Land Use cover. The smallest polygon mapped in Oregon in this coverage was 1.5 hectares, and there are 2,437 polygons in Oregon which are smaller than 40 hectares.

For Version 2, all the non-forested lands outside the Columbia Basin ecoregion in Eastern Oregon were attributed using a model developed at ORNHP. The natural vegetation classes in the 1:250,000 Gap Vegetation Map (Version 1) were used as the basis for the non-forested historic classes. A combination of factors including soils, geology, and elevation were used to classify non-native types (agriculture, urban, exotic species). For Version 2, some related vegetation alliances (e.g. low sagebrush, black sagebrush and rigid sagebrush) were combined. Additionally, historic data was available for certain major eastern Oregon valleys, particularly the Grande Ronde (LaGrande) and Klamath Basin (Klamath Falls). These were digitized at ORNHP at 1:100,000 from hard copy maps. Future GLO data acquisition will greatly increase the map accuracy for the other large eastern Oregon valleys, particularly the Silvies-Silver Creek Basin (Burns), the Malheur-Snake Valley (Ontario), the Wallowa Valley (Enterprise) and the Powder River Valley (Baker City).

Special Feature Mapping

Only in the Willamette Valley, the Columbia Basin and the forested habitats were riparian habitats adequately mapped, since they were mapped directly from the GLO information. To deal with the lack of riparian information, all perennial streams in the 1:100,000 Streamnet (an interagency, four state database developed by the Bonneville Power Administration, the Northwest Power Planning Council, Oregon, Washington, Idaho and Montana, and managed by the Pacific States Marine Fisheries Commission) coverage were buffered at 80 meters, intersected with the upland coverage and defined as potential Riparian for the wildlife species distributions. In future versions, riparian vegetation maps or buffers will be included for all the non-forested habitats.

Results

A primary objective of developing the historic coverage was to allow an analysis of declines of the different habitat types. For analysis purposes, OR-GAP crosswalked the historic vegetation classification and the existing vegetation classifications to the wildlife habitats because the vegetation types in the existing vegetation map did not correspond very well to alliance types. Table 3.2 shows the historic and current distributions of the habitat types used in the gap analysis, the changes in area since settlement both by area in hectares and by percentage. Details of habitat changes by ecoregion for each of the habitat types are included as Appendix 3.1.

The results shown in Table 3.2 must be examined with the knowledge that the two coverages were developed quite differently, and may not represent vegetation change well at some scales. For example, natural vegetation types mapped in one coverage but not the other (such as chaparral or alkaline grasslands) could not be compared. Alpine habitats show a 28% increase -- which almost certainly is a function of differences in how the types were mapped. Changes of less than 20% in either direction probably do not represent substantial or significant change, given the potential for error in both the existing and historic coverage. For example, a 9% increase in overall sagebrush habitat in Oregon may be close to the actual change, but the accuracy of the historic map certainly is not sufficient for this to be meaningful. However, the results do provide important insights into the widespread habitats which have changed significantly over the last 150 years.

The major habitat which shows the greatest decreases are the perennial bunchgrasses. The conversion of much of Oregon’s Columbia Basin, Willamette Valley and eastern Oregon valley prairies to farmland is responsible for this very dramatic loss of habitat. Bunchgrass losses occurred in most of Oregon’s ecoregions and have resulted in significant wildlife losses. Unfortunately, the remaining bunchgrass habitats are among the mostly poorly represented in Oregon’s network of protected areas, as will be seen in Chapter 5.

Salt desert shrub is the other widespread habitat which has shown significant declines. The 36% (110,000 hectare) decline is probably an underestimation, since the losses shown for playas most likely are really salt desert shrub declines. This type is very poorly studied, since it generally provides low forage (and therefore economic) value. While individual stands tend to be species poor, the communities are quite diverse and variable, and represent a critical part of Oregon’s diversity. A number of rare and endangered species occur in salt desert shrub habitat. Losses of salt desert shrub appear to be a result of the conversion of habitat to irrigated farmland - and protection of this habitat type is low.

Table 3.2. Changes in habitats since European Settlement.

Habitat Type	Current (ha)	Historical (ha)	Change (ha)	% Change
Alpine	136279	59804	76475	128%
Perennial Bunchgrass	389920	2797022	-2407102	-86%
Sagebrush (Mtn, Big, Mixed and Low)	7320349	6726639	593710	9%
Playa	49014	69495	-20481	-29%
Salt-desert Shrub	199703	310488	-110785	-36%
Canyon Shrubland	164087	146580	17508	12%
Coastal Dunes	38382	32644	5737	18%
Inland Dunes	72002	79972	-7969	-10%
Wet Meadows	1177	106425	-105248	-99%
Marshes	45330	199445	-154115	-77%
Quaking Aspen	9041	15551	-6510	-42%
Riparian	415813	324382	91431	28%
Wetlands and Riparian	471361	645802	-174442	-27%
Western Juniper	1610870	689633	921237	134%
Ponderosa Pine-While Oak	3049766	4583113	-1533346	-33%
Douglas-fir Mixed Conifer	1429803	694493	735310	106%
Early Shrub-Tree	742435	10563	731872	6929%
Mixed Conifer/Deciduous	626537	14100	612437	4344%
Siskiyou Mixed Conifer	522636	323957	-198679	61%
Western Douglas-fir Mixed Conifer	3764028	5683743	-1919715	-34%
Low Elevation Conifer Forests	7085440	6726856	358584	5%
Montane-Lodgepole Pine	391568	865288	-473720	-55%
Mountain Hemlock	779396	314452	464944	148%
Montane Conifer Forests	1170965	1179740	-8776	-1%
All Conifer Forests	7085440	6726856	76475	5%

The comparison of the individual wetland, marsh and riparian types probably are not meaningful, since they were mapped so differently in the two coverages. The changes in total wetland and riparian areas, shown by the sum of the four wetland habitat types, show losses of about 175,000 hectares of wetlands or 27%, which is fairly close to estimates made by Oregon's Division of State Lands. The increases in riparian habitat are an artifact of mapping, since riparian was only mapped in two small ecoregions (the Willamette Valley and the Columbia Basin) in the historic coverage. Version 3 of the historic coverage will include riparian and wetlands from all the other ecoregions. Similarly, the very large losses in wet meadow and marsh habitats are from differences in mapping and from the fact that many marshes and wet meadows are too small to map. However, what is shown by the comparison is the dramatic decrease in the very large marshes and wet meadows. In eastern Oregon, large river basins were home to some of the largest marshes and wetlands in North America. The Klamath Basin, Warner Basin, Malheur/Silvies Basin and many others each had very large marsh-wetland complexes. These complexes have been mapped on the historic coverage as marsh and wetland, but are mostly agriculture on the existing vegetation coverage – resulting in the large losses shown. The next version of the historical land cover map will do a better job showing historic riparian habitats, and using this cover will better reflect the real riparian losses.

The only habitat to show a substantial increase in distribution is Western Juniper. Juniper has increased 57%, representing approximately 920,000 new hectares of juniper in Oregon. This reflects major changes in habitat distribution resulting from fire suppression and livestock grazing. Juniper expansion has been a major concern for grassland and shrub steppe land managers. Recent studies have shown that juniper distribution has likely been cyclical in Oregon, although the recent rapid increases are probably not a natural process (Miller and Wigand 1994). While western juniper is indeed expanding into many sagebrush and grassland habitats in Oregon, old-growth western juniper is declining rapidly from development in central Oregon. Efforts to increase livestock forage and reduce juniper expansion has led to the removal of old-growth juniper in areas where it has dominated for thousands of years. Restoring fire and developing management strategies should be a major focus for eastern Oregon land mangers in order to broaden the natural range of variability for Western Juniper and all grassland and shrub steppe habitats.

The two most widespread habitat types in Oregon, Sagebrush Steppe and Conifer Forests, show little overall change. The primary reason is that there has not been large scale conversions of these types to agriculture, urban or other types. The OR-GAP 1998 vegetation update does not show the very dramatic qualitative changes which have occurred in these habitat types. For the sagebrush steppe communities, the introduction of cheatgrass (*Bromus tectorum*) and other exotic species and the planting of crested wheatgrass (*Agropyron cristatum*) have dramatically changed the ecological function of hundreds of thousands of hectares of sagebrush steppe in Oregon. While these altered habitats cannot be mapped using TM imagery, finer scale mapping efforts have been done in southeastern Oregon using Ortho-Photo quads by the Burns District of the BLM. These detailed maps show major declines in habitats dominated by sagebrush/native bunchgrasses due to large areas dominated by sagebrush/cheatgrass (*Bromus tectorum*) or sagebrush/crested wheatgrass (*Agropyron cristatum*). These native sagebrush habitat losses are found in all of the eastern Oregon ecoregions in which they occur (OBP 1998).

Similarly, there have not been significant changes in the overall acreage dominated by coniferous forests. However there have been significant changes in how these forests look, how they function ecologically, and the type of wildlife they support. The increases and decreases in the different conifer habitat types between the historic and existing coverages do not appear to be particularly meaningful. Using other coverages of existing vegetation which show conifer forest stand age and structure, the U.S. Forest Service (FEMAT 1993) has analyzed how dramatically forests have changed in Oregon.

Accuracy Assessment

No accuracy assessment was done for either Version 1 or Version 2 of the historic vegetation cover. Given the lack of baseline data, an accuracy assessment was not practical. It is possible to use the

GLO survey data to test the accuracy of the H.J. Andrews coverage, and it should also be possible to test the accuracy of the modeled non-forested eastern Oregon types. These are both objectives for future work.

Limitations and Discussion

Unlike many other states, much of Oregon's landscape is intact and dominated by native vegetation. As mentioned above, fire suppression, exotic species introductions, grazing and logging have altered many of the native vegetation types. These processes or changes in the landscape are not represented in either of the coverages, and therefore not in the analysis. However, the changes in vegetation patterns, processes and structure which have occurred over the last 150 years are dramatic, local, and critical to the protection of Oregon's wildlife and diversity.

The historic and existing vegetation coverages were completed using very different techniques – so only very dramatic changes can be assumed to be meaningful. While the accuracy is difficult to assess for the existing coverage and impossible for the historic coverage, both appear to represent accurate overall estimates of the aggregated habitat abundances and distributions. An examination of more detailed (higher resolution) vegetation coverages can provide substantially greater information on changes in local habitat distributions. For example, ORNHP has completed a comparison of 1:24,000 existing and historic vegetation coverages for the Willamette Valley ecoregion. This comparison shows not only how much area each of the historic vegetation community types has lost, but also accurately shows the patterns of changes. Many natural habitats have been replaced by agriculture, but fire suppression and changes in the fire regime have also led to conifer forests and mixed oak-conifer forests replacing many of the upland prairies and oak savannas reported in 1851. It is quite likely that fire suppression has also significantly altered the distribution of ponderosa pine forests and mixed conifer forests in Eastern Oregon.

The greatest value the historic vegetation information provides to GAP is an assessment of how widespread habitats and species were before the major changes that have occurred since European settlement. This is valuable because it allows conservation planners to attempt to include species and habitats in the network of conservation lands based on how widespread they were, and how much genetic diversity they might contain or be representing. Since the vegetation information in GAP represents the coarse filter, vegetation types which were very widespread likely represent a greater range of variability than local types. How well the current distribution of habitat types is represented in the network of conservation areas only provides a partial measure of how well the coarse filter is protected. How well the original (natural or historic) distribution of these types is represented in the network is a better measure of the success of biodiversity protection efforts.

CHAPTER 4: PREDICTED ANIMAL DISTRIBUTIONS AND SPECIES RICHNESS

Introduction

All species range maps are predictions about the occurrence of those species within a particular area (Csuti 1994). Traditionally, the predicted distribution of most species begins with collections made at individual point locations. Most species range maps are small-scale (e.g. >1:10,000,000), derived primarily from point data, and created to construct field guides. The purpose of the GAP vertebrate species maps is to provide more precise information about the current predicted distribution of individual native species within their general ranges. With this information, better estimates can be made about the actual amounts of habitat area and the nature of its configuration.

GAP maps are produced at a nominal scale of 1:100,000 and are intended for applications at the landscape or "gamma" scale (homogeneous areas generally covering 1,000 to 1,000,000 hectares and made up of more than one kind of natural community). Applications of these data to site- or stand-level analyses (site—a microhabitat, generally 10 to 100 square meters; stand—a single habitat type, generally 0.1 to 1,000 ha; Whittaker 1977, see also Stoms and Estes 1993) are likely to be compromised by the finer-grained patterns of environmental heterogeneity that occurs at those patch sizes.

Gap analysis uses the predicted distributions of native vertebrate species to evaluate their conservation status relative to existing land management (Scott *et al.* 1993). However, the maps of vertebrate species distributions may be used to answer a wide variety of management, planning, and research questions relating to individual species or groups of species. In addition to the maps, great utility may be found in the consolidated specimen collection records and literature that have been assembled into databases used to produce the maps.

Previous to this effort, no maps were available, digital or otherwise, showing the likely present-day distribution of species by habitat type across their ranges. Because of this, ordinary species (i.e., those not threatened with extinction or not managed as game animals) are generally not given sufficient consideration in land-use decisions in the context of large geographic regions or in relation to their actual habitats. Their decline, because of incremental habitat loss can, and does, result in one threatened or endangered species "surprise" after another. Frequently, the records that do exist for an ordinary species are truncated by state boundaries. Simply creating a consistent spatial framework for storing, retrieving, manipulating, analyzing, and updating the totality of our knowledge about the status of each vertebrate species is one of the most necessary and basic elements for preventing further erosion of biological resources.

Mapping Standards

OR-GAP developed maps using two different methods. The first (Version 1) species distribution maps for amphibians, reptiles, breeding birds and mammals were developed for the *Atlas of Oregon Wildlife* (Csuti *et al.* 1997a). These maps were created using hexagonalized range maps based on a database created for the U.S. Environmental Protection Agency's (EPA) Environmental Monitoring and Assessment Program (EMAP), overlaid with the OR-GAP Version 1 land cover map (Kagan and Caicco 1992). The Version 1 land cover map had 133 major vegetation types that were grouped into 30 wildlife habitat types. We created a Wildlife by Habitat Relationships matrix to link the hexagon distributions to the habitat polygons.

The second version of the distribution maps were prepared using the revised hexagon data set from ORNHP, a revised version of the Wildlife by Habitat Relationships matrix, and the Version 2 OR-GAP land cover vegetation map from ODFW, consisting of 65 vegetation types which we grouped into 31 wildlife habitat types.

Methods

The modeling approach used to predict vertebrate distributions included five steps. First, we determined which species would be included in our analyses. Second, the distributional limits of each species were defined by recording the species' presence or absence within the EPA's hexagon grid system for Oregon (White *et al.* 1992). Third, we developed a Wildlife-Habitat Relationships (WHR) matrix which defined the affinities of terrestrial vertebrate species to land cover types. Fourth, the hexagon and WHR databases were used in a GIS-modeling process which assigned species to habitat polygons based on their known or expected occurrence within hexagons and their association to habitat features. Finally, hardcopy maps of predicted species distributions were reviewed by acknowledged experts. Unlike other state GAP efforts, Oregon had access to existing hexagon distribution maps created for the Biodiversity Research Consortium. These hexagon maps were used for the *Atlas of Oregon Wildlife* (Csuti *et al.* 1997a) and the resulting species distribution maps served as the first version GAP maps. For this GAP final report, all hexagon distributions were reviewed, and a new vegetative cover map was used, which necessitated a new Wildlife-Habitat Relationships matrix.

We included in our analysis all 441 terrestrial vertebrates that breed in Oregon, as described in the *Atlas of Oregon Wildlife* (Csuti *et al.* 1997a), as well as 10 additional species. We did not include birds which only winter in the state, birds found in Oregon only during migration, or accidentals. We created maps for full species only, combining all subspecies in the state into one map. We chose to include non-native species in our analysis. There were no problems identifying which mammals, amphibians, or reptiles to include in the analysis. However, there were occasional differences of opinion regarding when to exclude certain bird species. When we began this project there was no recent statewide publication on Oregon birds, so we relied on the opinion of experts when deciding whether or not to include certain bird species. The taxonomy and nomenclature used to describe species was adopted from The Nature Conservancy and selected as a standard by GAP (Wilson and Reeder 1993, AOU 1998, Collins 1990).

Version 1 Maps

Range maps were created for each species documenting expected occurrence in each of 441 equal area hexagons. Each hexagon covers approximately 647 square kilometers. Each hexagon record received an occurrence status code (Table 4.1) reflecting the likelihood of finding that particular species in the given hexagon. An example of a hexagon map for the snowy plover is shown as Figure 4.1. The primary sources of information used to document species occurrence in hexagons

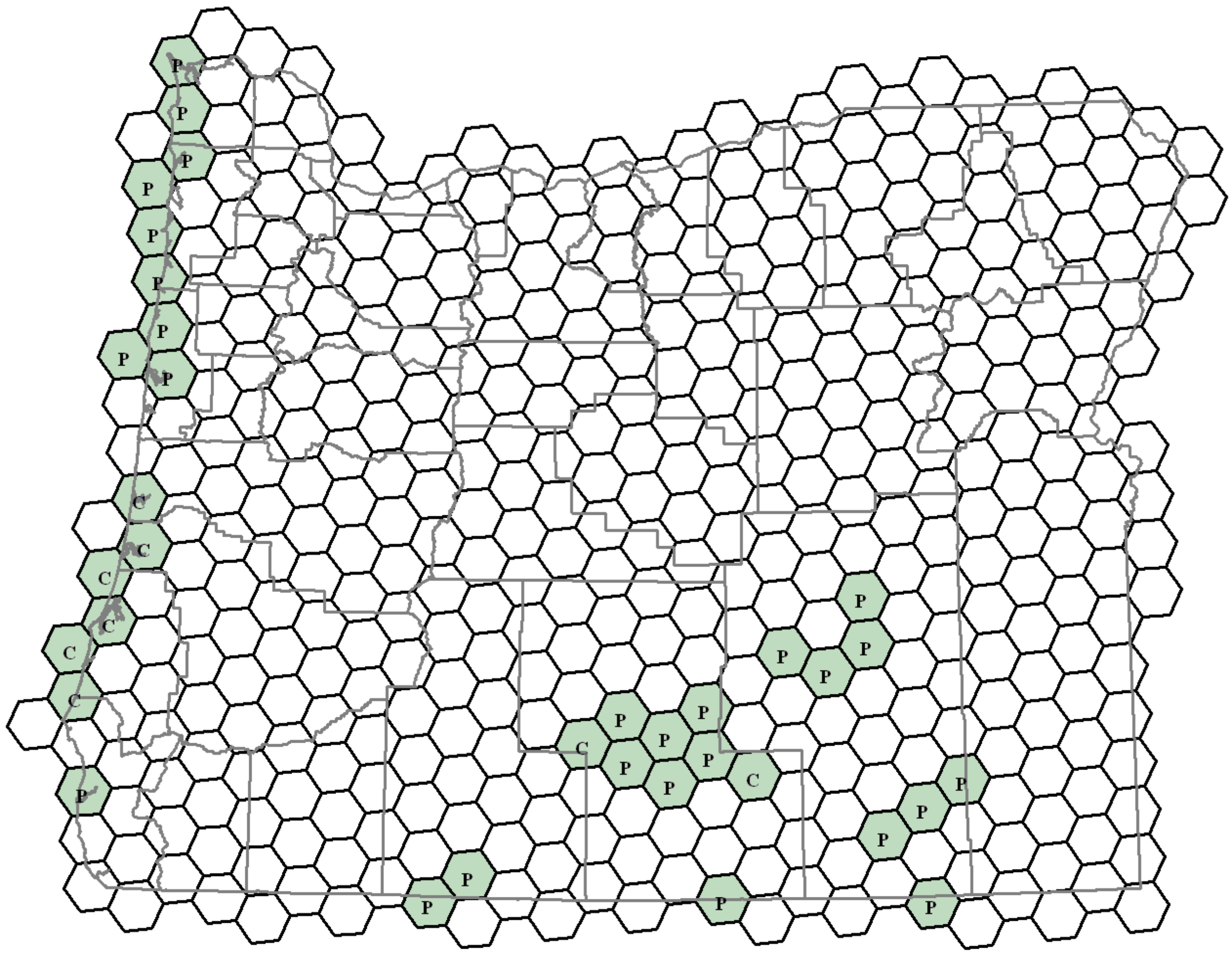

Figure 4.1. Hexagon Distribution Map of the Snowy Plover in Oregon. P = probable (80-95% confidence), C = confirmed (>95% confidence). There are no possible (PO) hexagons for the Snowy Plover in Oregon.

were published range maps, species locality records, and expert opinion. We started by using published range maps (Table 4.2) and improved them with species locality records. Species locality records were obtained from existing vertebrate databases (Table 4.3). Occurrence status was assigned to species locality records based on the date of the record. Species locality records collected in 1983 and later were coded as Confirmed (C). Records collected between 1982 and 1973 were considered Probable (P). Records dated prior to 1972 were coded as Possible (PO). These dates were the source of much disagreement among Heritage Program staff and outside reviewers. They were settled on through group compromise. Many species locality records were too general to be used (e.g. county records). To be included in the data set, a species locality record had to contain a PLSS (public land survey system) description or some other location description specific enough to allow us to assign the record to a hexagon.

Table 4.1 Categories used to qualify species occurrence in hexagons.

CONFIRMED (C)	The species is confidently assumed (> 95% certain) or known to occur in the hexagon.
PREDICTED (P)	The species is predicted to occur in the hexagon based on the "fact-pattern" (i.e. presence of suitable habitat or conditions and historical record and/or presence in adjacent hexagons[s]); at least 80% certain that the species occurs in the hexagon.
POSSIBLE (PO)	The species possibly or potentially occurs in the hexagon; its estimated likelihood of occurrence in the hexagon is thought to be between 80% and 10% (or less for extremely rare species where suitable habitat or conditions may be present).

Table 4.2 Published range maps used to create initial hexagon distributions.

Hall, E.R. 1981. The mammals of North America. 2nd ed. 2 vols. John Wiley and Sons, New York, NY. 1,181 pp.

Jones, J.O. 1990. Where the birds are. A guide to all 50 states and Canada. William .Morrow & Co., New York. 400 pp.

Leonard, W.P. et al. 1993. Amphibians of Washington and Oregon. Seattle Audubon Soc. 168 pp.

Loy, W.G. et al. 1976. Atlas of Oregon. University of Oregon Books. 215 pp.

Marshall, David B. et al. 1996. Species at Risk: Sensitive, Threatened, and Endangered Vertebrates of Oregon. Second Edition. Oregon Dept. Fish and Wildlife, Portland, OR.

Nussbaum, R. A., and E. D. Brodie, Jr. and R. M. Storm. 1983. Amphibians and Reptiles of the Pacific Northwest. University Press of Idaho. 332 pp.

Storm, R.M. and W.P. Leonard, eds. 1995. Reptiles of Washington and Oregon. Seattle Audubon Society, Seattle, WA. 176 pp.

Verts, B. J. and L. N. Carraway. 1984. Keys to the Mammals of OR. Oregon State University Press, Corvallis, OR. 178 pp.

Table 4.3 Existing vertebrate databases used to improve hexagon distributions

Carnegie Museum of Natural History, Mammals Collection. Pittsburgh, PA.

Carnegie Museum of Natural History, Herpetology Department. Pittsburgh, PA.

Agassiz Museum of Comparative Zoology, Department of Herpetology. Harvard University.

Agassiz Museum of Comparative Zoology, Department of Mammalogy. Harvard University.

University of Michigan, Museum of Zoology, Herpetology Department. Ann Arbor, Michigan.

Oregon Natural Heritage Program Element Occurrence database.

Oregon State University Museum of Comparative Zoology. Corvallis, Oregon. Amphibian and reptile collections.

Oregon State University Museum of Comparative Zoology, Mammals Collection. Corvallis, OR.

Smithsonian Institute, National Museum of Natural History. Mammal Collections.

Museum of Vertebrate Zoology, University of California at Berkeley. Herpetology Collection.

Museum of Vertebrate Zoology, University of California at Berkeley. Mammals Collection

Washington State University Charles F. Conner Museum. Pullman, Washington.

The resulting draft hexagon maps were then sent out for review to 16 experts (Table 4.4). Expert reviewers were asked to add, delete, verify or modify existing records. Once the hexagon distribution maps were completed and reviewed by experts, we assigned species to habitats in a wildlife-by-habitat relationship matrix (WHR). For the OR-GAP Version 1 hexagon maps, the WHR matrix contained the 30 habitat types described by O'Neil *et al.* (1995) (Appendix 4.3). The OR-GAP Version 1 land cover map had 133 primary vegetation types (Kagan and Caicco 1992). These were grouped into the 30 wildlife habitats (O'Neil *et al.* 1995). We intersected the reviewed hexagon distribution maps and the land cover map using the WHR matrix, to develop the Version 1 vertebrate distribution maps. These maps were reviewed by experts in the biology of different groups (Table 4.4) and edits were made as recommended. The resulting vertebrate distribution maps were used for the *Atlas of Oregon Wildlife* (Csuti *et al.* 1997a).

Table 4.4 Experts reviewing hexagon distributions

Expert	**Maps reviewed**
Brad Bales, ODFW	Birds
Kat Beal, USACE	Birds
Joseph Beatty, OSU	Amphibians and Reptiles
Andrew Blaustein, OSU	Amphibians and Reptiles
Frank Conley, Ornithologist	Birds
Alan Contreras, Ornithologist, Oregon Birds	Winter Birds
Blair Csuti, Oregon Zoo, formerly University of Idaho	All groups
Jeff Gilligan, Oregon Birds editor	Birds
Ross Keister, USFS	Amphibians and Reptiles
C.D. Littlefield, USFWS	Birds
Harry Nehls, Ornithologist	Birds
S. Kim Nelson, OSU	Birds
Joe Pesek, ODFW	Birds
Ken Popper, ORNHP	Birds
Mark Stern, ORNHP	All Groups
Merritt Stegmeier, USACE	Birds
Al St. John, Private consultant, reptile expert	Amphibians and Reptiles
Douglas R. Stone, EA Engineering	Amphibians
Robert Storm, OSU	Amphibians and Reptiles
Cynthia Tait, BLM	Amphibians

Version 2 Vertebrate Maps

To develop the OR-GAP Version 2 maps, we began by editing the Version 1 hexagon distribution maps and incorporating recommended changes from the users of the *Atlas of Oregon Wildlife* (Csuti *et al.* 1997a). These resulted in corrections to the ORNHP vertebrate species hexagon database. All newly revised maps were reviewed by Heritage Program staff, while Blair Csuti reviewed the new reptile, amphibian and mammal maps.

The Version 2 OR-GAP land cover map was produced by Oregon Department of Fish and Wildlife (Kiilsgaard 1999) and is described in detail in Chapter 2. It contains 65 vegetation cover types we combined into 31 wildlife habitat types (Figure 4.2). The WHR used to develop the *Atlas of Oregon Wildlife* (Csuti *et al.* 1997a) was modified to reflect the new habitat types (Appendix 4.3 shows the crosswalk between the Version 1 and Version 2 WHR and Land Coverages).

Major changes included dropping two types, Idaho Fescue and Alkali Grasslands, because they were not mapped in the Version 2 coverage. Three types were added to better represent wildlife habitats. One type was added by splitting Douglas-fir Forests, to differentiate Westside Douglas-fir from Eastside Douglas-fir Mixed Conifer Forests. A second new type was created by separating Agriculture from Urban, which had been lumped in the Version 1 Wildlife by Habitat Relationships matrix. Finally, a Rocky Shore category was added to represent islands and rocky shorelines along the coast, using a geologic layer to separate rocky coastal areas from coastal beaches and dunes. We combined the revised hexagon maps and the new GAP vegetative cover map using the modified Wildlife by Habitat Relationships matrix to create the final distribution maps. Table 4.5 shows the habitat types used in Version 2, with the area covered in Oregon by each type. The statewide wildlife habitat map (Figure 4.3) displays distributional information for the 31 habitats used in this analysis.

Creating updated habitat designations to representing wildlife has been the focus of a recent project in the Pacific Northwest. This project included an analysis of all the 286 NVCS alliances for Oregon and Washington, and a lumping of alliances into alliance groups which appear to be suitable for mapping wildlife habitats. This lumping is similar to the development of alliance mosaics or plant community groups, resulting in the creation of species-habitat vegetation types. These types were primarily identified based on vegetative characteristics. Criteria for the aggregation of alliances (Johnson and O'Neil 1997) were based on:

- Floristic similarity of the vegetation between types
- Physiognomic and environmental similarity of alliances
- Mosaic-like alliances in a similar environment were lumped together if they were not regional in extent and occurred in close proximity to each other.
- Alliances that were largely the result of human modification were lumped based on physiognomy, and to a lesser degree, major environmental zones.

In this new study, using the aggregation criteria list above, the 286 NVCS alliances were aggregated to 87 landscape level alliance groups (Chappell *et al.* 1997). OR-GAP hopes to use these 87 landscape level alliance groups in future, finer scale wildlife modeling efforts.

O'Neil and Johnson further condensed these 87 types into 27 upland terrestrial wildlife habitat types using a cluster analysis procedure (O'Neil *et al.* 1995) first produced for the Version 1 Oregon wildlife habitat types. These 27 types have been tied to the Version 2 Land Cover Map. These new types, their relationship to native vertebrates, and a complete discussion regarding species composition and environmental characteristics defined by this project will be available in the near future (Johnson *et al.* 1999). Since it was not available, this newly defined version of the habitats was not used in this analysis.

Table 4.5. Rank of habitat type by proportional land area for OR-GAP land cover Version 2.

Rank	**Number**	**Habitat**	**# of Polygons**	**Area (ha)**
1	4	Big Sagebrush	4570	4,971,165
2	30	Western Douglas-fir Mixed Conifer	9843	3,764,028
3	22	Ponderosa Pine-While Oak	8632	3,049,766
4	2	Agriculture	5876	2,610,343
5	17	Mountain Big Sagebrush	4050	2,112,817
6	31	Western Juniper	3571	1,610,870
7	8	Douglas-fir Mixed Conifer	4556	1,429,803
8	18	Mountain Hemlock	1999	779,396
9	9	Early Shrub-Tree	5002	742,435
10	14	Mixed Conifer/Deciduous	5535	626,537
11	28	Siskiyou Mixed Conifer	1740	522,636
12	24	Riparian	2710	415,813
13	16	Montane-Lodgepole Pine	1438	391,568
14	20	Perennial Bunchgrass	489	389,920
15	19	Open Water	1830	297,182
16	29	Urban	943	245,475
17	26	Salt-desert Shrub	274	199,703
18	12	Low Sagebrush	446	174,593
19	5	Canyon Shrubland	367	164,087
20	3	Alpine	843	136,279
21	6	Chaparral	765	99,660
22	10	Inland Dunes	295	72,002
23	11	Lava Field	67	63,617
24	15	Mixed Sagebrush	84	61,774
25	21	Playa	79	49,014
26	13	Marshes	366	45,330
27	7	Coastal Dunes	264	38,382
28	23	Quaking Aspen	36	9,041
29	25	Rocky Coast	285	5,529
30	32	Wet Meadows	4	1,177
31	27	Saltmarsh	8	803
Total				25080745

Riparian Habitats

Because riparian habitats were under-represented in both versions of OR-GAP land cover maps, we wanted to add riparian habitats to our analysis. A riparian vegetation cover is not available for Oregon, although OR-GAP is working to create one. For this analysis, riparian habitats were approximated by using the 1:100,000 stream cover buffered to a total of 80 meters (40 meters on each side of the center line of the stream).

Riparian obligate species (Table 4.6) were mapped in polygons created by intersecting hexagon distributions, vegetative cover, the WHR, and the buffered streams layer. Thus, species like the water shrew are shown in a much smaller distribution based on their affinity for wet areas in forested habitats, rather than the entire forested habitat polygon (Figure 4.2).

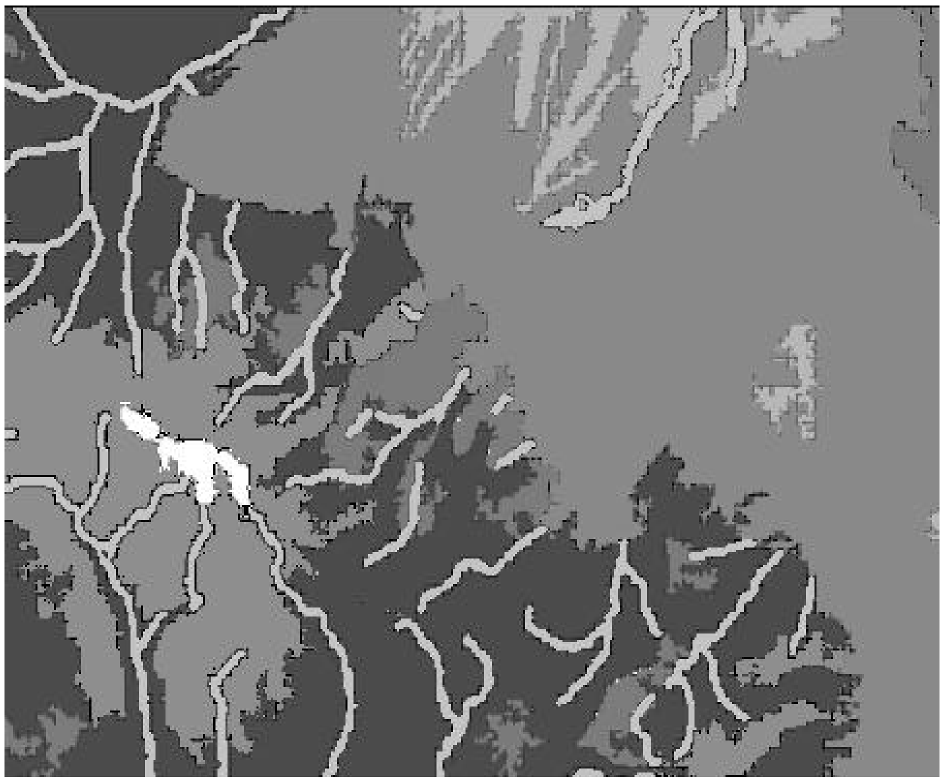

Figure 4.2. Riparian distribution for the water shrew, showing upland vs riparian habitat. The outlined light gray areas show upland types within an 80 m buffer of an aquatic feature that have been designated as potential riparian habitat.

ORNHP staff created the list of riparian obligate species, relying on staff expertise and information in the Heritage databases. Species for this list were chosen if they occurred in riparian habitats in any part of their range. This was to assure that species were mapped in hexagons in which they were known to occur. In some other studies, such as one done for the Muddy Creek Watershed in Oregon (Freemark *et al.* 1996), lists of riparian obligates were much smaller. For Muddy Creek, only 24 species, most of which were entirely aquatic, were included. However, in this study, shrub and forest riparian vegetation was fairly well mapped, and birds and mammals which are not aquatic, but concentrate in these forests could be mapped in them. For OR-GAP, the riparian and shrub riparian forests do not appear, probably because of the large minimum mapping unit of the vegetation coverages. Therefore, the list was fairly inclusive. However, it is quite possible that this list was a bit too expansive.

Table 4.6. Riparian species mapped in potential riparian habitats outlined using an 80 meter buffer of the 1:100,000 stream cover intersected with the upland vegetation cover.

Common Name	Scientific Name
Birds	
Pied-billed Grebe	*Podilymbus podiceps*
Great Blue Heron	*Ardea herodias*
Green Heron	*Butorides virescens*
Black-crowned Night-heron	*Nycticorax nycticorax*
Wood Duck	*Aix sponsa*
Mallard	*Anas platyrhynchos*
Northern Pintail	*Anas acuta*
Blue-winged Teal	*Anas discors*
Cinnamon Teal	*Anas cyanoptera*
Northern Shoveler	*Anas clypeata*
Gadwall	*Anas strepera*
American Wigeon	*Anas americana*
Ring-necked Duck	*Aythya collaris*
Harlequin Duck	*Histrionicus histrionicus*
Hooded Merganser	*Lophodytes cucullatus*
Common Merganser	*Mergus merganser*
Osprey	*Pandion haliaetus*
Bald Eagle	*Haliaeetus leucocephalus*
American Coot	*Fulica americana*
Spotted Sandpiper	*Actitis macularia*
Calliope Hummingbird	*Stellula calliope*
Belted Kingfisher	*Ceryle alycon*
Willow Flycatcher	*Empidonax traillii*
Black Phoebe	*Sayornis nigricans*
Tree Swallow	*Tachycineta bicolor*
Marsh Wren	*Cistothorus palustris*
American Dipper	*Cinclus mexicanus*
Veery	*Catharus fuscescens*
Gray Catbird	*Dumetella carolinensis*
Red-eyed Vireo	*Vireo olivaceus*
Yellow Warbler	*Dendroica petechia*
American Redstart	*Setophaga ruticilla*
Northern Waterthrush	*Seiurus noveboracensis*
Macgillivray`s Warbler	*Oporonis tolmiei*
Common Yellowthroat	*Geothlypis trichas*
Wilson`s Warbler	*Wilsonia pusilla*
Yellow-breasted Chat	*Icteria virens*
Black-headed Grosbeak	*Pheucticus melanocepalus*
Lincoln`s Sparrow	*Melospiza lincolnii*
Red-winged Blackbird	*Agelius phoeniceus*

Common Name	Scientific Name
Amphibians	
Black Salamander	*Aneides flavipunctatus*
Dunn`s Salamander	*Plethodon dunni*
Cope`s Giant Salamander	*Dicamptodon copei*
Southern Seep Salamander	*Rhyacotriton variegatus*
Cascade Seep Salamander	*Rhyacotriton cascadae*
Columbia Seep Salamander	*Rhyacotriton kezeri*
Tailed Frog	*Ascaphus truei*
Woodhouse`s Toad	*Bufo woodhousii*
Red-legged Frog	*Rana aurora*
Foothill Yellow-legged Frog	*Rana boylii*
Cascades Frog	*Rana cascadae*
Bullfrog	*Rana catesbeiana*
Northern Leopard Frog	*Rana pipiens*
Oregon Spotted Frog	*Rana pretiosa*
Columbia Spotted Frog	*Rana luteiventris*
Mammals	
Water Shrew	*Sorex palustris*
Little Brown Myotis	*Myotis lucifigus*
Yuma Bat	*Myotis yumaensis*
Nuttall`s Cottontail	*Sylvilagus nuttallii*
American Beaver	*Castor canadensis*
White-footed Vole	*Phenacomys albipes*
Long-tailed Vole	*Microtus longicaudus*
Water Vole	*Microtus richardsoni*
Muskrat	*Ondatra zibethicus*
Western Jumping Mouse	*Zapus princeps*
Pacific Jumping Mouse	*Zapus triornatus*
Nutria	*Myocastor coypus*
Mink	*Mustela vison*
Northern River Otter	*Lutra canadensis*
Reptiles	
Painted Turtle	*Chrysemys picta*
Western Pond Turtle	*Clemmys marmorata*
California Mtn Kingsnake	*Lampropeltis zonata*
Pacific Aquatic Garter Snake	*Thamnophis couchii*

Historic Distribution Maps

With the availability of an historical vegetation map, OR-GAP was able to create historical vertebrate species distribution maps. The historical vegetation map consisted of 38 cover types combined into 28 of the 31 habitat types used in our Version 2 species coverages (Figure 4.4). Two of the three missing cover types (Urban and Agriculture) were not found in the historic landscape. The only habitat not mapped in the historic coverage was chaparral. Therefore, losses could not be assessed for this type. ORNHP will distinguish chapparal in the next updates of the historic vegetation cover.

The current WHR was modified to reflect the different types and changes in habitat use from present times. A new set of vertebrate hexagon maps were created to reflect estimated historic distributions. Distributions were estimated for extirpated species and introduced species were deleted (Bailey 1936, Csuti pers. com., Gabrielson and Jewett 1940, Nussbaum *et al.* 1983, Verts and Carraway 1984, Verts and Carraway 1998). For riparian obligates we used a buffered stream layer created the same way as for the current species distributions.

Existing and Historic Map Creation by Group

<u>Mammals</u>: Existing ranges were approximated from range maps in Hall and Kelson (1959) and Verts and Carraway (1984). Hexagon maps were refined with ORNHP data and museum collection data (Table 4.3). Mammal hexagon distributions were reviewed by Blair Csuti. These distributions were intersected with the first GAP vegetation cover map and the WHR, resulting in the Version 1 maps. After the maps were published in the *Atlas of Oregon Wildlife* (Csuti *et al.* 1997a), additional comments were received. These, and new publications that had been unavailable for the first version maps (Maser 1998, Verts and Carraway 1998) were used to update the hexagon distribution maps at ORNHP. When the final GAP vegetation cover was available, the WHR was modified to reflect the vegetation types in the new vegetation cover and the Version 2 GAP distribution maps were generated. Historic hexagon distributions were developed largely from Bailey (1936), with some input from Verts and Carraway (1998). These historic hexagon distributions were combined with the historic vegetation map to create historic mammal distributions.

<u>Birds</u>: Existing breeding bird draft hexagon distribution maps were created from information in the *Atlas of Oregon* (Loy *et al.* 1976)**.** The original maps used for this book were available, and were more helpful than the very small maps actually printed in the atlas. Information from the ORNHP databases, museum collections, and USFWS National Wildlife Refuge species lists were also used. The hexagon maps were then reviewed by Harry Nehls, whose changes were so extensive that it would have been more time-efficient to simply have asked Harry to create the hexagon distributions from scratch. Heritage Program staff provided additional review. After the initial hexagon maps were created, the bird distribution maps proceeded with the same methods described for mammals. Historic bird distributions were estimated from Gabrielson and Jewett (1940).

<u>Reptiles</u>: Draft hexagon current distribution maps were created from the dot maps in Nussbaum *et al.* (1983) and improved with ORNHP and museum collection records. These reptile hexagon maps were reviewed by Blair Csuti, Ross Keister, Joseph Beatty, Andrew Blaustein, and Robert

Storm. There was no source for historic reptile distributions, so most of the information used was from Nussbaum *et al.* (1983) and museum records.

Amphibians: Draft current amphibian hexagon distribution maps were created from the dot maps in Nussbaum *et al.* (1983) and improved with ORNHP and museum collection records. Amphibian hexagon maps were reviewed by Blair Csuti, Ross Keister, Joseph Beatty, Andrew Blaustein, and Robert Storm. As with reptiles, a source for historic amphibian distributions was not available, so information in Nussbaum *et al.* (1983) and museum records were used.

Existing and Historic Maps for Other Groups of Species

Trees and Butterflies: ORNHP created hexagon distribution maps for all tree species, butterflies and floaters (freshwater aquatic clams in the family *Unionidae*) using the methods outlined above. Habitat distribution covers were not created for these, due to complications regarding habitat relationships. However, butterfly maps will be completed by OR-GAP in the near future.

Fish: ORNHP created hexagon distribution maps for all fish species which reproduce in the wild in Oregon. We utilized information from Lee *et al.* (1980), selected ODFW district fish biologists, and a data base from Carl Bond and Doug Markle of Oregon State University (OSU). Al Smith and Hal Weeks, both with ODFW, provided information on warm water fish and sensitive species, respectively. The US Fish and Wildlife Service, Bureau of Reclamation, and the Klamath Tribes contributed information regarding suckers and other sensitive fish in the Klamath Basin. Hexagon distributions were reviewed by Hiram Lee, Doug Markle, and Carl Bond at OSU. Fish hexagon distribution received a second, very thorough review by members of the Oregon Chapter of American Fisheries Society. An analysis of this fish distribution information was recently completed at OSU and published (Rathert *et al.* 1999). Habitat distribution maps were outside the scope of this project but will be available from ORNHP in the near future, hopefully as part of a statewide aquatic gap analysis.

Results

Distributions of 450 terrestrial vertebrate species were predicted including 263 birds, 127 mammals, 29 reptiles, and 31 amphibians. A listing of WHRs and complete statewide distribution maps for each of these 450 species are included in an atlas and CD which includes this report, published by National GAP. OR-GAP is also developing an internet application to make these maps available. Figure 4.5 shows an example of the mapped current and historic distribution of one species, the pronghorn antelope.

Mammals: Maps of predicted current distribution for 116 native and 7 introduced mammalian species were developed. One hundred twenty maps of predicted historic distribution for native species were also developed. Four extirpated species were included in the historic distributions: bison, gray wolf, grizzly bear and Wyoming ground squirrel.

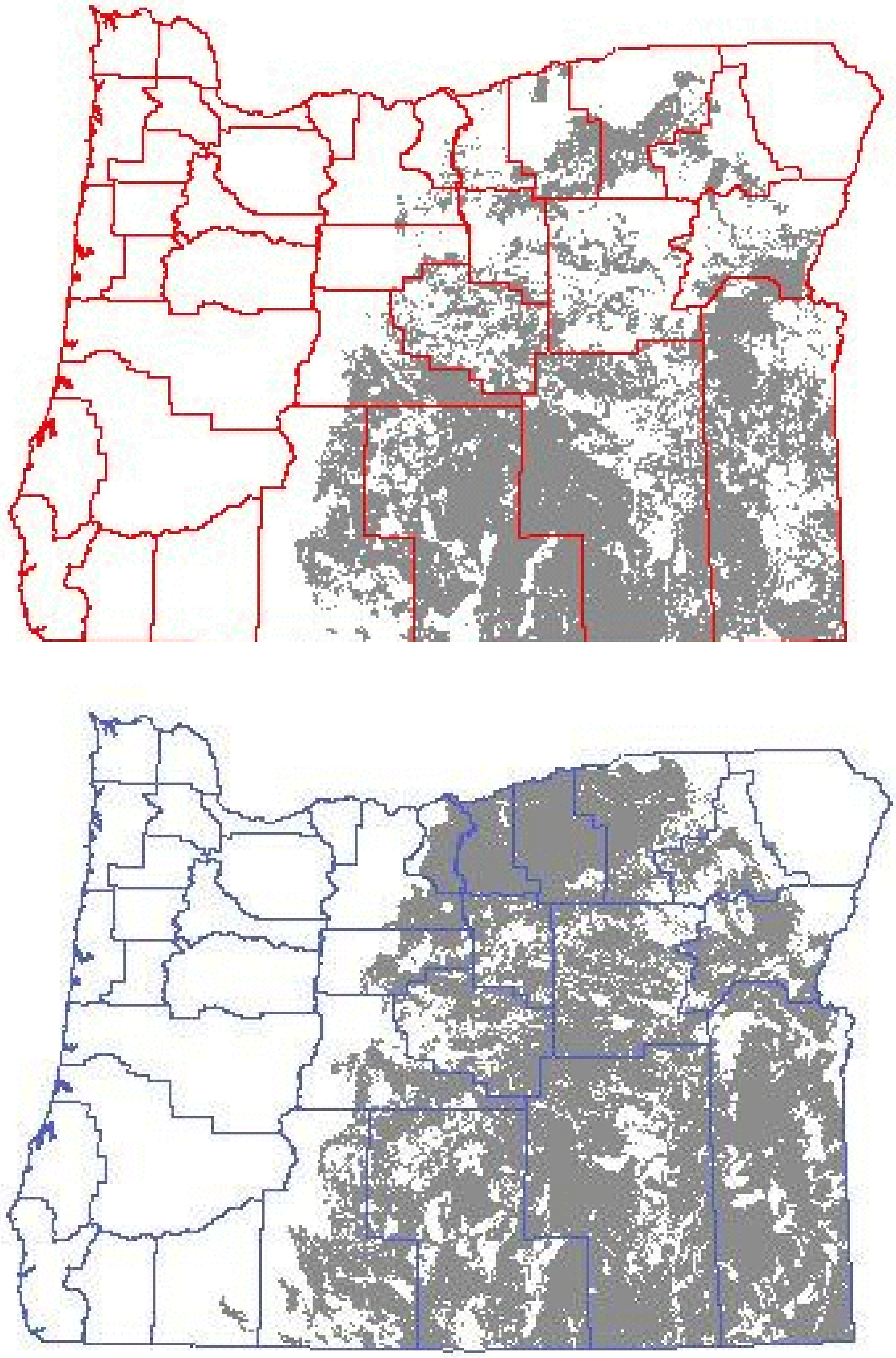

Figure 4.5. Current (top) and Historic (bottom) distributions of the pronghorn antelope in Oregon. The top (existing) map includes 7,685,865 ha, while the bottom has 10,618,212 ha (a 38% loss).

Current and historic distributions for species that are restricted to rocky sub-habitats are not as accurate as we would have liked. Talus slopes and other rocky areas are usually too small to have been included in the land cover (and therefore habitat) maps used. Thus, distributions for species like the canyon mouse, pika and yellow-bellied marmot are either grossly over or under represented actual area of occurrence. It was decided to represent these species as present in the larger habitat types that contain rocky subhabitats.

The distribution maps for the common porcupine overestimate the range in the sagebrush areas of Eastern Oregon. In these areas the porcupine is restricted to riparian habitats. Because this species is not restricted to riparian areas in forested habitats, it could not be accurately included with the other riparian obligates, and there was no other way to restrict this species in sagebrush habitats.

Bats also are particularly difficult to model, since they require caves and rocky micro-habitats which have been impossible to map. Since so many of Oregon's bats are sensitive species, OR-GAP and ORNHP has very good distribution information for many bats. The more widespread species, such as the spotted bat, have been somewhat problematic, and show a much greater decline than probably really occurred.

Birds: There were 256 native and 7 introduced avian species' maps of predicted current distribution and 253 maps of predicted historic distribution for native species developed. There are two extirpated bird species, the California condor and the merlin, that were not modeled for historic distribution because their habitat areas were too small to be mapped. Three native species that were modeled for current distribution were not modeled for historic distribution because, from available data cattle egret, solitary sandpiper and the black-chinned sparrow appear to be relatively new additions to the state's fauna.

As with the mammals, there were a few species, such as the peregrine falcon, white-throated swift, rock wren, and many coastal birds, for which predicted distributions were difficult to model accurately. The distribution for these species is not correlated to any particular vegetative type but to small micro-habitat features. Rather than underestimate distributions, they were modeled as present in the larger habitat types that contain the habitat features required by these species. For coastal birds requiring rocky habitats, a geologic layer was used to separate rocky coastal areas from coastal beaches and dunes.

Reptiles: Maps of predicted current distribution for 28 native and one introduced reptile were developed. Twenty eight maps of predicted historic distribution for native species were also developed. No Oregon reptiles are known to have been extirpated statewide since historic times.

Amphibians: Maps of predicted current distribution for 29 native and two introduced amphibians were developed. Twenty nine maps of predicted historic distribution for native species were developed. No Oregon amphibians have been extirpated statewide since historic times.

Accuracy Assessment

Assessing the accuracy of the predicted vertebrate distributions is subject to many of the same problems as assessing land cover maps, as well as a host of more serious challenges related to both the behavioral aspects of species and the logistics of detecting them. These are described further in the Background section of the GAP Handbook on the national GAP home page. It is, however, necessary to provide some measure of confidence in the results of the gap analysis for each species (comparison to stewardship and management status), and to allow users to judge the suitability of the distribution maps for their own uses. We therefore feel it is important to provide users with a statement about the accuracy of GAP predicted vertebrate distributions within the limitations of available resources and practicalities of such an endeavor. We acknowledge that distribution maps are never finished products but are continually updated as new information is gathered. However, assessing the accuracy of their current iteration provides useful information about their reliability to potential users. We especially encourage wildlife biologists and amateur naturalists to treat the predicted distributions as testable hypotheses and engage the process of validation and iterative modeling. Our goal was to produce maps that predict distribution of terrestrial vertebrates and from that, total species richness and species content with an accuracy of 80% or higher. Failure to achieve this accuracy indicates the need to refine the data sets and models used for predicting distribution. The methods for validating and assessing the accuracy of the vertebrate distribution maps are presented below along with the results.

<u>Accuracy Assessment Methods</u>

Because Oregon began this project with an existing hexagon data set which utilized all available data, there was very little data suitable for use in an accuracy assessment that was not already incorporated into the distribution maps. Checklists from nine National Wildlife Refuges and one National Antelope Refuge were compared to our distribution maps for these specific areas (Table 4.7).

Table 4.7. Areas with species lists and available groups used in the accuracy assessment.

Refuge Name	*Amphibians*	*Reptiles*	*Birds*	*Mammals*
Ankeny NWR			Ž	
Baskett Slough NWR			Ž	
Cold Springs NWR			Ž	
Finley NWR	Ž	Ž	Ž	Ž
Hart Mtn NAR	Ž	Ž	Ž	Ž
Klamath Marsh NWR	Ž	Ž	Ž	Ž
Malheur NWR	Ž	Ž	Ž	Ž
Umatilla NWR			Ž	
Upper Klamath NWR	Ž	Ž	Ž	Ž

Accuracy Assessment Results

The results of the accuracy assessment are summarized in the tables below. Table 4.8 lists the sites sampled, with the errors of commission and omission. Table 4.9, A-D show the results for birds, mammals, reptiles and amphibians. Overall, errors of omission for all species had a median of 19.4% (range 10.6-57.7%), and when examined across separate classes, was highest for birds (Table 4.9.A), suggesting that our habitat coverage was not satisfactory for predicting the presence of bird species. The highest omission errors occurred for birds on three USFWS National Wildlife Refuges (Table 4.9.A), and all species omitted in these refuges were present in adjacent habitat.

These refuges are primarily used as wintering/feeding grounds for migratory game birds. The species checklists obtained from the refuges were for all species observed on the refuge during the breeding season. Omitted species may feed on refuge lands, but nest outside the refuge in more suitable habitat. When these refuges were left out of the analysis the median omission rate dropped to 16.8% (range 10.6-19.9%), suggesting that the intended use of the refuge/protected area must be taken into account when using supplied list for evaluation purposes.

Table 4.8. Accuracy assessment for overall species distributions. Overall accuracies are 71.8% Confirmed, 21.4% Commission and 24.7% Omission. * - Birds only; ** - no amphibians/reptiles; *** - no mammals.

Test Site	Confirmed	% Confirmed	Commission	% Commission	Omission	% Omission	Total
Ankeny NWR*	63	42.3%	47	31.5%	65	43.6%	149
Baskett Slough NWR*	98	64.1%	88	57.5%	55	35.9%	153
Cold Spring NWR*	60	65.9%	95	104.4%	31	34.1%	91
Finley NWR	185	81.5%	31	13.7%	42	18.5%	227
Hart Mtn NWR	204	77.9%	41	15.6%	42	16.0%	262
Klamath NWR (basin)	237	89.4%	63	23.8%	28	10.6%	265
Malheur NWR***	158	81.0%	95	48.7%	37	19.0%	195
Umatilla NWR**	123	71.9%	28	16.4%	34	19.9%	171
Total/Median	1128	74.9%	488	27.6%	334	19.4%	1513

Overall errors of commission were evaluated for all sites, whether or not they had all four vertebrate classes present. There was a median of 27.6% (range 13.7 - 104.4%) of commission errors. When the classes were examined separately, these errors were highest for reptiles and amphibians (Table 4.9.A-B). The greatest number, not percentage, of commission errors were in mammals (median 24), and were due to incomplete lists from analysis sites. The commission rates for sites with list for all four taxa was 15.6% (range 13.7 - 23.8%), and was highest for amphibians (Table 4.9D).

Table 4.9. (A-D) Comparison of OR-GAP predictive species maps with site species lists for the four vertebrate classes modeled. The median value is the median of the percentages from each site.

4.9.A. Birds

Test Site	Confirmed	% Confirmed	Commission	% Commission	Omission	% Omission	Total
Ankeny NWR*	63	42.3%	2	1.3%	86	57.7%	149
Baskett Slough NWR*	98	64.1%	14	9.2%	55	35.9%	153
Cold Spring NWR*	60	65.9%	39	42.9%	31	34.1%	91
Finley NWR	115	73.7%	14	9.0%	41	26.3%	156
Hart Mtn NWR	145	80.6%	19	10.6%	31	17.2%	180
Klamath NWR (basin)	150	89.8%	47	28.1%	17	10.2%	167
Malheur NWR***	146	81.6%	20	11.2%	33	18.4%	179
Umatilla NWR**	82	70.7%	28	24.1%	34	29.3%	116
Total/Median	859	72.2%	183	10.9%	328	27.8%	1191

4.9.B. Mammals

Test Site	Confirmed	% Confirmed	Commission	% Commission	Omission	% Omission	Total
Ankeny NWR*			28	100%			
Baskett Slough NWR*			54	100%			
Cold Spring NWR*			42	100%			
Finley NWR	48	98.0%	14	28.6%	1	2.0%	49
Hart Mtn NWR	42	64.6%	20	30.8%	10	15.4%	65
Klamath NWR (basin)	68	88.3%	9	11.7%	9	11.7%	77
Malheur NWR***			67	100.0%			
Umatilla NWR**	41	74.5%	5	9.1%	14	25.5%	55
Total/Median	199	81.4%	239	65.4%	34	13.6%	55

4.9.C. Reptiles

Test Site	Confirmed	% Confirmed	Commission	% Commission	Omission	% Omission	Total
Ankeny NWR*			12	100%			
Baskett Slough NWR*			13	100%			
Cold Spring NWR*			9	100%			
Finley NWR	12	100.0%	3	25.0%			12
Hart Mtn NWR	14	93.3%	1	6.7%	1	6.7%	15
Klamath NWR (basin)	13	86.7%	3	20.0%	2	13.3%	15
Malheur NWR***	9	90.0%	7	70.0%	1	10.0%	10
Umatilla NWR**			11	100%			
Total/Median	48	91.7%	59	85%	4	10.0%	52

4.9.D. Amphibians

Test Site	Confirmed	% Confirmed	Commission	% Commission	Omission	% Omission	Total
Ankeny NWR*			5	100%			
Baskett Slough NWR*			7	100%			
Cold Spring NWR*			5	100%			
Finley NWR	10	100.0%	0	0.0%	0	0.0%	10
Hart Mtn NWR	3	100.0%	1	33.3%	0	0.0%	3
Klamath NWR (basin)	6	100.0%	4	66.7%	0	0.0%	6
Malheur NWR***	3	50.0%	1	16.7%	3	50.0%	6
Umatilla NWR**			6	100%			
Total/Median	22	100%	29	66.7%	3	0%	25

Limitations and Discussion

The lack of complete species lists for analysis sites makes accurate assessment of errors difficult to evaluate. The data used for the accuracy assessment were heavily skewed towards birds and limitation in mapping critical habitat, such as wetlands, may skew the analysis. However, improving both the land cover maps and the wildlife habitat relationships model, particularly for birds, should increase the accuracy of the predictions.

Species Richness

Species richness patterns for vertebrates have been the focus of extensive research in Oregon. The Biodiversity Research Consortium (BRC) used OR-GAP Version 1 hexagon data to show species richness patterns for all vertebrates, and to compare the variations between mammals, herps and birds (White *et al.* 1999). This work included a number of prioritization and richness analysis for the Oregon biodiversity data set, as well as comparisons to similar data sets from Pennsylvania. It also included some analysis using a supercomputer to establish an exact set of hexagons in Oregon to include all biodiversity, which they represented by using all vertebrates, trees and shrubs, butterflies and freshwater clams. An analysis of environmental correlates for species richness patterns of freshwater fish from Oregon (Rathert *et al.* 1999) has been recently published. Keister *et al.* (1996) report on similar analysis of biodiversity richness patterns for Idaho using hexagon data.

Figure 4.3 shows the species richness patterns for all the Version 2 coverages; the four maps displaying richness patterns for all species, birds, herps, and mammals. We were also able to develop the first species richness maps of the historic distributions for these vertebrate groups, which are shown as Figure 4.4. The patterns shown are similar to those shown using a similar analysis of hexagon distributions. However, some of the high richness areas which resulted from a hexagon containing a large number of habitats (such as the Steens Mountain/Alvord Desert hexagon) do not appear as important concentrations in these polygon coverages. Bird species richness is the greatest in the Klamath Basin of south-central Oregon, herps in the Siskiyou Mountains of southwestern Oregon, and Mammals in the Klamath Basin, the Siskiyou Mountains, as well as isolated concentrations in the central East Cascades and Coast Range. As a result, overall richness concentrations are clearly the highest in the Klamath Basin and the Siskiyou Mountains.

OR-GAP does not feel that species richness patterns are particularly useful in identifying priority areas in which to try to protect biodiversity. Richness includes no evaluation of how much species ranges have declined or how well they are protected. Many species may not be represented in species rich areas (Csuti *et al.* 1997b). Also, species richness patterns are often driven by concentrations of more common species, or migratory species and may not indicate concentrations of species needing conservation. In spite of this, the three areas of greatest species richness, the Klamath Basin, Siskiyou Mountains, and the Malheur Basin have long been the focus of conservation activities in Oregon and have been identified in other analyses as critical areas for conservation work (OBP 1998). OR-GAP has developed species richness maps for a subset of species which are not well protected or have experienced substantial declines. These are discussed in Chapter 6.

CHAPTER 5: LAND STEWARDSHIP

Introduction

To fulfill the analytical mission of GAP, it is necessary to compare the mapped distribution of elements of biodiversity with their representation in different categories of land ownership and management. As will be explained in the Analysis section, these comparisons do not measure viability, but are a start to assessing the likelihood of future threat to a biotic element through habitat conversion—the primary cause of biodiversity decline. We use the term "stewardship" in place of "ownership" in recognition that legal ownership does not necessarily equate to the entity charged with management of the resource, and that the mix of ownership and managing entities is a complex and rapidly changing condition not suitably mapped by GAP. At the same time, it is necessary to distinguish between stewardship and management status in that a single category of land stewardship such as a national forest may contain several degrees of management for biodiversity.

The purpose of comparing biotic distribution with stewardship is to provide a method by which land stewards can assess their relative amount of responsibility for the management of a species or plant community, and identify other stewards sharing that responsibility. This information can reveal opportunities for cooperative management, which directly supports the primary mission of GAP to provide objective, scientific information to decision makers and managers to make informed decisions regarding biodiversity. It also is likely that a steward that has previously borne the major responsibility for managing a species may, through such analyses, identify a more equitable distribution of that responsibility. We emphasize, however, that GAP only identifies private land as a homogenous category and does not differentiate individual tracts or owners, unless the information was provided voluntarily in recognition of a long-term commitment to biodiversity maintenance.

After comparing distribution with stewardship, it is also necessary to compare biotic occurrence to categories of management status. The purpose of this comparison is to identify the need for change in management status for the distribution of individual elements or areas containing high degrees of diversity. Such changes can be accomplished in many ways that do not affect the stewardship status. While it will eventually be desirable to identify specific management practices for each tract, and their influence on each element, GAP currently uses a scale of 1 to 4 to denote relative degree of maintenance of biodiversity for each tract. A status of "1" denotes the highest, most permanent level of maintenance, and "4" represents the lowest level of biodiversity management, or unknown status. This is a highly subjective area, and we recognize a variety of limitations in our approach, although we maintain certain principles in assigning the status level. Our first principle is that land ownership is not the primary determinant in assigning status. The second principle is that while data are imperfect, and all land is subject to changes in ownership and management, we can use the intent of a land steward as evidenced by legal and institutional factors to assign status. In other words, if a land steward implements a program backed by legal and institutional arrangements that are intended for permanent biodiversity maintenance, it is taken into consideration when assigning status.

The characteristics used to determine status are as follows:

- Permanence of protection from conversion of natural land cover to unnatural (human-induced barren, exotic-dominated, arrested succession).
- Relative amount of the tract managed for natural cover.
- Inclusiveness of the management, i.e. single feature or species versus all biota.
- Type of management and degree that it is mandated through legal and institutional arrangements.

The four status categories can generally be defined as follows (after Scott *et al.* 1993, Edwards *et al.* 1995, Crist *et al.* 1995):

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, and intensity) 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 use or management practices that degrade the quality of existing natural communities.

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 or localized intense type. It also confers protection to federally listed endangered and threatened species throughout the area.

Status 4: Lack of irrevocable easement or mandate to prevent conversion of natural habitat types to anthropogenic habitat types. Allows for intensive use throughout the tract. Also includes those tracts for which the existence of such restrictions or sufficient information to establish a higher status is unknown.

Mapping Standards and Methods

Stewardship Mapping

The land stewardship and management status layer is a key component developed by OR-GAP. Like many of the other covers, this has been an iterative process. The cover used in this analysis is Version 2 (Figure 5.1), which was based on, but developed slightly differently from OR-GAP Version 1. In spite of the fact that Oregon is more than 50% publicly owned, there has never been a comprehensive land ownership coverage available for the state.

The OR-GAP Version 1 coverage was developed by Blair Csuti and the Oregon Natural Heritage Program. The 1:100,000 Bureau of Land Management (BLM) land ownership coverage served as the base cover. Boundaries of The Nature Conservancy (TNC) preserves, Research Natural Areas (RNAs), Wilderness Areas, National Wildlife Refuges, National Parks and Monuments, and BLM Areas of Critical Environmental Concern (ACECs) were transcribed from the original documents at the ORNHP managed area files onto BLM 1:100,000 paper base maps. The base data for these varied from 1:24,000 to 1:100,000. They were labeled consistently, sent to Idaho Department of Water Resources and hand digitized under contract with National GAP. The Oregon Department of Fish and Wildlife independently digitized their Wildlife Management Areas to add to the coverage.

Version 2 was developed by OR-GAP using the 1:100,000 land ownership coverage provided by the Oregon State Service Center for GIS (SSCGIS) as the base coverage. The 1993 version of this cover used for OR-GAP was developed by the Bureau of Land Management. Protected areas were obtained from the BLM, the U.S. Forest Service (USFS) and all other agencies, at the finest scale possible. Most USFS protected areas were obtained in digital format at 1:24,000 (although most lacked metadata). Most BLM data were incorporated at 1:100,000. Fine scale (1:24,000) data for Fish and Wildlife Refuges were obtained from the U.S. Fish and Wildlife Service, while similar scale information on National Parks was provided by the National Park Service.

For the 1998 Oregon Natural Heritage Plan (ORNHP 1998), ORNHP developed a 1:24,000 cover and cross reference for all formerly proposed natural areas in the state, including all RNAs**,** ACECs, state Natural Heritage Conservation Areas (NHCAs), and TNC preserves. This coverage is continually updated and published each calendar year (with OR-GAP version 2 including the 1999 update).

Additional data layers were obtained from BLM and Forest Service interagency offices. These included some obtained from the Columbia River Basin Assessment Project in Walla Walla, which provided digital coverage showing all the BLM Wilderness Study Areas (WSAs) and eastern Oregon Wild and Scenic Rivers. Others were from their Regional Ecosystem Office in Portland, particularly the Late Successional Reserves (LSRs) established by Forest Ecosystem Management Assessment Team (FEMAT 1993).

Management Status Categorization

The Version 1 Management categorization was developed by Blair Csuti using standard GAP methodology. Version 1 did not include either the LSRs or the WSAs, so was more typical of GAP categorizations. RNAs, ACECs, TNC Preserves, NHCAs, Wilderness Areas, and the undeveloped portions of National Parks were assigned Category 1. Wildlife Refuges, State Wildlife Management Areas, State Parks, and local parks were assigned Category 2. Other public lands were assigned Category 3, and private lands were assigned Category 4.

The Defenders of Wildlife, OR-GAP, ORNHP and the Oregon Field Office of TNC were also involved in the update of the Version 1 Management cover for the Oregon Biodiversity Project (OBP 1998). For the OBP, each of the protected areas in the Version 1 cover was assigned a category of 1-10, with 10 representing the best protection, and 1 the least. A detailed description of the process of designating these 1-10 categories, and their definitions are contained in the final report, *Oregon's Living Landscape* (OBP 1998). For their analysis, OBP used categories 8-10 to represent the network of conservation lands. The primary difference from Version 1 was that each protected area was individually assessed.

Viability and defensibility of sites were important considerations in management rankings. As a result, nature reserves managed by The Nature Conservancy ranged from 7-10, as did Research Natural Areas and Wilderness Areas. Small nature reserves designed to protect a local population of an endangered plant species might be rated lower than a larger reserve managed for all biodiversity. State Parks also varied widely, some providing important biodiversity protection and ranked as an 8 or 9, while others largely developed for recreation, ranked as a 5 or 6. Using size and quality of the areas make the designations somewhat different from the 1-4 gap designations. The OBP designations match the gap designations for public lands pretty closely. Lands designated as 9 or 10 generally correspond to Gap 1 sites, 7 and 8 usually correspond to Gap 2 sites, and 4-6 mostly match Gap 3 sites. OBP characterized LSRs as 9, so they were part of the protected area network. BLM WSAs were 5 or 6, similar to general BLM lands, and were not counted in OBP's network of protected areas.

In OR-GAP version 2, each site in the network of conservation lands was also individually ranked, using the 1-4 standard GAP ranking system. Figure 5.2 shows the map of Oregon with the OR-GAP classifications displayed. The OBP categorization and information, along with any other data we had, were used to update the sites' classification. Sites were designated by ORNHP staff, and reviewed by the public lands coordinator of The Nature Conservancy. The primary difference between the OR-GAP Version 2 cover was the inclusion of the BLM WSAs and the USFS and BLM LSRs. These two categories of public stewardship designations impact large areas of forest lands in western Oregon, and rangelands in eastern Oregon. Their designations clearly impact biodiversity, but are more difficult to categorize, especially using a 1-4 scale. OR-GAP finally chose to include these areas as Category 2, although they do seem intermediate between general public lands and protected areas. In both the rangelands of eastern Oregon, and the forests of the Cascades and Coast Range, these designations more than triple the overall size of Oregon's network of protected areas. Table 5.1 below shows the major groups of land in Oregon, and the GAP status they were assigned. Appendix 5.1 has the complete list of managed areas in Oregon, with their GAP and OBP categorization.

Table 5.1. Management status assigned to land stewardship categories in Oregon.

Status 1	Status 2	Status 3	Status 4
USFS Wilderness Area	BLM Wilderness Study Area (WSA)	BLM matrix lands	Private Lands
NPS National Parks	Late Successional Old Growth Reserves (LSRs)	USFS matrix lands	
NPS National Monuments		State Forestry lands	
Nature Conservancy Preserves	BLM ACEC (Areas of Critical Environmental Concern)	DSL lands	
Research Natural Areas		USFS National Grasslands	
State Natural Heritage Conservation Areas	USFS Special Interest Areas	USFS National Recreation Areas	
	USFWS Wildlife Refuges		
	State Parks		

Results

Public lands account for over 56% of Oregon, of which 52% is federally owned or managed, and 3% managed by the State of Oregon. Table 5.2 provides a summary of the ownership patterns, and how they vary by GAP Status in Oregon. While including only 52% of the land base in Oregon, federal lands account for 94.9% of the Status 1 and 2 lands. Private lands (1%), state lands (1.5%), and water (2.4%) account for the rest of the protected areas. Undoubtedly, federal lands have been the source of most protection in Oregon and will likely continue to be critical.

Table 5.2 Ownership and Gap Status in Oregon (hectares).

Owner	Status 1	Status 2	Status 3	Status 4	Total	Percent
City	0	2,227	0	0	2,227	0.01%
County	0	0	1,233	0	1,233	0.00%
Exempt	317	638	29,956	217,093	248,004	0.98%
Federal	1,206,293	2,912,591	8,857,243	7	12,976,135	51.49%
Private	44,366	249	11,218	10,882,251	10,938,084	43.40%
State	2,215	65,233	185,464	396,949	649,862	2.58%
Water	43,836	58,818	235,408	48,655	386,716	1.53%
Total	1,297,027	3,039,756	9,320,522	11,544,955	25,202,260	
Percent	5.1%	12.1%	37.0%	45.8%		

It is equally important to evaluate land ownership and stewardship on an ecoregional basis, so that land stewards can see to what degree their lands generally contribute to biodiversity maintenance. Public lands are distributed throughout the state, although two ecoregions, the Willamette Valley and the Columbia Basin, are unique due to their very high proportion of private lands. Table 5.3 shows the ownership distribution by ecoregion, which identifies the varied pattern of ownership by ecoregion. These differences create major variations in conservation strategies for the different ecoregions. For example, the Basin and Range ecoregion is over 75% federally owned, with over 70% managed by the Bureau of Land Management, mostly in two districts (Lakeview and Burns). Similarly, the West Cascades ecoregion is about 73% federally owned, with 63% managed by the U.S. Forest Service as part of four national forests (Mount Hood, Willamette, Umpqua and Rogue River). Conservation or stewardship land patterns in these ecoregions are a result of decisions made by these agencies. On the other hand, in the Willamette Valley and the Columbia Basin ecoregions, the majority of the lands (94% and 90% respectively) are in private ownership. In these ecoregions, there is only limited potential for protected areas on public lands, and therefore conservation strategies must involve private landowner cooperation and participation.

Appendix 5.2 is an analysis of the habitat types in Oregon, including a comparison of the current and historic distribution of each of the types. A detailed discussion of this comparison is included in Chapter 6 (page 52) related to species losses. Appendix 5.2 includes information on changes in the distribution and abundance of each habitat type, as well as how much of each type is currently represented in the network of protected areas.

Table 5.3. Ownership by ecoregion and percentages in Oregon

Owner	Basin & Range hectares	Basin & Range percentage	Blue Mountains hectares	Blue Mountains percentage	Coast Range hectares	Coast Range percentage
Bureau of Land Management	2642914	70.30%	350295	8.14%	325225	13.25%
Bureau of Reclamation	0	0.00%	0	0.00%	0	0.00%
Bonneville Power Administration	0	0.00%	0	0.00%	0	0.00%
Army Corps of Engineers	0	0.00%	17	0.00%	24	0.00%
Department of Defense	0	0.00%	17	0.00%	1517	0.06%
National Park Service	0	0.00%	0	0.00%	41	0.00%
US Forest Service	14005	0.37%	2292551	53.26%	355000	14.46%
US Fish and Wildlife Service	172388	4.59%	0	0.00%	90	0.00%
Federal lands	2829307	75.26%	2642881	61.40%	681897	27.77%
State lands	105238	2.80%	24493	0.57%	258136	10.51%
Tribal lands	7714	0.21%	5748	0.13%	1531	0.06%
County lands	0	0.00%	0	0.00%	860	0.04%
City lands	0	0.00%	0	0.00%	1819	0.07%
Private	734957	19.55%	1624429	37.74%	1499212	61.07%
Water	82347	2.19%	7124	0.17%	11651	0.47%
Total	3759563	100.00%	4304674	100.00%	2455105	100.00%

Owner	Columbia Basin hectares	Columbia Basin percentage	East Cascades hectares	East Cascades percentage	Klamath Mountains hectares	Klamath Mountains percentage
Bureau of Land Management	90989	5.29%	123581	4.65%	366493	23.44%
Bureau of Reclamation	0	0.00%	31	0.00%	0	0.00%
Bonneville Power Administration	0	0.00%	0	0.00%	0	0.00%
Army Corps of Engineers	491	0.03%	0	0.00%	1367	0.09%
Department of Defense	24119	1.40%	0	0.00%	0	0.00%
National Park Service	0	0.00%	1474	0.06%	185	0.01%
US Forest Service	22	0.00%	1315635	49.48%	427214	27.32%
US Fish and Wildlife Service	3567	0.21%	13252	0.50%	0	0.00%
Federal lands	119187	6.92%	1453974	54.68%	795258	50.85%
State lands	46482	2.70%	19796	0.74%	11462	0.73%
Tribal lands	3391	0.20%	95056	3.57%	0	0.00%
County lands	4	0.00%	342	0.01%	0	0.00%
City lands	0	0.00%	0	0.00%	0	0.00%
Private	1549881	90.03%	1035254	38.93%	754233	48.23%
Water	2528	0.15%	54764	2.06%	2886	0.18%
Total	1721473	100.00%	2659186	100.00%	1563839	100.00%

Table 5.3 (continued). Ownership by ecoregion and percentages in Oregon.

	Lava Plains		Owyhee Uplands		Pacific Ocean	
Owner	hectares	percentage	hectares	percentage	hectares	percentage
Bureau of Land Management	564545	29.13%	1709419	70.84%	2	0.04%
Bureau of Reclamation	0	0.00%	10980	0.46%	0	0.00%
Bonneville Power Administration	0	0.00%	0	0.00%	0	0.00%
Army Corps of Engineers	0	0.00%	0	0.00%	0	0.00%
Department of Defense	0	0.00%	0	0.00%	80	1.48%
National Park Service	4237	0.22%	0	0.00%	0	0.00%
US Forest Service	85944	4.43%	0	0.00%	135	2.50%
US Fish and Wildlife Service	107	0.01%	0	0.00%	40	0.73%
Federal lands	654833	33.79%	1720399	71.30%	257	4.75%
State lands	32760	1.69%	129502	5.37%	676	12.49%
Tribal lands	49794	2.57%	0	0.00%	0	0.00%
County lands	0	0.00%	0	0.00%	0	0.00%
City lands	0	0.00%	0	0.00%	0	0.00%
Private	1195042	61.66%	548221	22.72%	2361	43.63%
Water	5627	0.29%	14780	0.61%	2117	39.13%
Total	1938055	100.00%	2412902	100.00%	5411	100.00%

	West Cascades		Willamette Valley		Total Statewide	
Owner	hectares	percentage	hectares	percentage	hectares	percentage
Bureau of Land Management	205931	7.12%	35605	2.59%	6415000	25.57%
Bureau of Reclamation	0	0.00%	0	0.00%	11011	0.04%
Bonneville Power Administration	0	0.00%	165	0.01%	165	0.00%
Army Corps of Engineers	7597	0.26%	6850	0.50%	16345	0.07%
Department of Defense	0	0.00%	0	0.00%	25734	0.10%
National Park Service	66032	2.28%	0	0.00%	71969	0.29%
US Forest Service	1837739	63.58%	196	0.01%	6328442	25.23%
US Fish and Wildlife Service	138	0.00%	4435	0.32%	194016	0.77%
Federal lands	2117437	73.26%	47251	3.44%	13062682	52.07%
State lands	8374	0.29%	18689	1.36%	655607	2.61%
Tribal lands	53729	1.86%	0	0.00%	216964	0.86%
County lands	409	0.01%	1000	0.07%	2615	0.01%
City lands	21	0.00%	408	0.03%	2249	0.01%
Private	691042	23.91%	1296639	94.35%	10931270	43.58%
Water	19355	0.67%	10277	0.75%	213455	0.85%
Total	2890368	100.00%	1374264	100.00%	25084841	100.00%

Discussion

Land ownership and protection patterns are critical to this analysis - and to protection of biodiversity in Oregon. The state has a long history of endangered species controversy, and the Endangered Species Act continues to be the major force driving conservation activities of public agencies. Recent listings of anadromous fish by the National Marine Fisheries Service, and listings of the lynx and bull trout by the US Fish and Wildlife Service have resulted in endangered species impacts occurring throughout the state.

Figure 5.3 contains two maps showing endangered and sensitive species locations in Oregon. The top map has the distribution of state and federally listed threatened and endangered species in Oregon, from ORNHP's element occurrence database. Fish occurrences are shown as lines, while plant and animal occurrences are shown as points. The distribution of these points has driven the distribution of protected areas in western Oregon. However, they do not do a good job of representing overall species patterns, or other species of concern. In western Oregon, the concentration of endangered species match the pattern of the LSRs, since spotted owls were driving the creation of these areas.

However, while the network of protected areas matches the distribution of concentrations of listed endangered species, it does not adequately represent the distribution of other species of concern. The bottom map in Figure 5.3 shows the locations of all the rare, threatened and endangered species currently tracked by ORNHP. A number of these species, such as the sage grouse and the Washington ground squirrel may soon be proposed for federal listing in Oregon. Neither of the maps in Figure 5.3 adequately represents the distribution of listed or sensitive fish in Oregon, since that information has not yet been centralized. However, a comparison of the two coverages shows how poorly the distribution of both currently listed endangered species and the current network of protected areas match the distribution of rare species in Oregon. It also shows that the Endangered Species Act, in spite of being the most effective tool of conservation in the United States, is not a reliable way to protect diversity.

Oregon is fortunate to have a large number of LSRs and BLM WSAs, many of which are very large. Unfortunately, they tend to bias the overall protected area network. LSRs in Oregon account for 2,104,501 hectares, although some LSRs include established Wilderness, RNAs or other protected sites. If these are excluded, non-wilderness LSRs include 1,499,697 hectares of general BLM and USFS matrix lands. The BLM WSAs add another 1,149,924 hectares. The overall network of protected areas in Oregon (GAP 1 and 2 lands), including these LSRs and WSAs, adds up to 4,336,782 hectares. This means that together, WSAs (26.5%), and non-wilderness LSRs (34.6% of the total protected area network) account for over 60% of GAP 1 and 2 lands. While the LSRs and BLM WSAs do not provide permanent protection, they certainly are more protected than GAP Category 3, general public lands, and must be placed in Category 2. This is a good case for considering some new system of GAP stewardship categorization, which includes at least one more category. In Chapter 7, we examine the impact that LSRs and BLM WSAs have on how well habitats and vertebrate species groups are protected in Oregon.

In spite of this huge network of protected areas in Oregon, including LSRs, USFS wlderness areas, BLM WSAs, and a major private and public network of preserves and natural areas, only 17.2% of Oregon is managed for wildlife or biodiversity. As can be seen in the final chapter, this large protected area network does not do a very good job of including either the current or historic distribution of Oregon's habitats and wildlife.

Limitations

This map and coverage is a compilation of ownership maps provided by a variety of sources who are individually responsible for their accuracy. It was created for the purpose of conducting the analyses described in this report and may not be suitable for locating boundaries on the ground. It is certainly not suitable for determining precise area measurements of individual tracts, given the scale of 1:100,000 for the baseline data. Some of the data for protected areas in the Oregon cover was mapped at 1:24,000, and can provide good estimates of the locations of these sites, although all the boundaries are limited by the coarseness of the scale. The baseline data had some significant problems, particularly in southwestern Oregon, where there is a patchwork mosaic of public and private ownerships. These patchwork or checkerboard lands, were digitized separately for the ownership cover and the stewardship coverage, and the linework did not match. OR-GAP spent considerable time rectifying these errors, but some slivers and mis-matched polygons still remain.

While OR-GAP and ORNHP will continually update the Stewardship and Management Cover, for this report and analysis, a single edition had to be used. The Version 2 cover (1999 edition) was completed in March of 1999. A number of land ownership and designation changes have occurred since that time. An updated coverage will be produced each year and will be available at both the National GAP and OR-GAP FTP sites. However, it is important to keep in mind that the analysis contained in this report are based on the Version 2 stewardship cover. The OR-GAP ownership designations currently reflect surface feature only, and do not consider either mineral or water rights, which can be critical to wildlife maintenance. In addition, many of the smaller designated areas have varied land uses in a single designated area. For example, a number of US Fish and Wildlife Refuges have areas which are farmed to increase waterfowl production. While these areas do not generally provide the same protection for all biodiversity, they were not segregated out in this coverage. Similarly, the US Forest Service and BLM have different management prescriptions for some of the Late Successional Reserves which were not shown in the categorizations.

Oregon is now involved in a statewide effort to restore watersheds and salmon stocks throughout the state. In an effort to improve water quality, recover listed and declining salmon, and to restore Oregon's rivers, Governor Kitzhaber developed a Watersheds and Salmon Restoration Plan. This involves the creation of watershed councils throughout the state, and all state agency actions must support the plan, which now includes significant funding to both restore and acquire lands and water to benefit fish and wildlife habitat. Many of the ongoing or proposed restoration efforts are occurring on private lands or on the un-designated public lands. While these sites and projects may provide important protection for fish and wildlife, they are not available in a digital form and could not be included in this stewardship coverage.

However, in spite of all these limitations, the stewardship cover and designations are the only statewide representation of protected lands in Oregon and do an excellent job of representing areas currently set aside for biodiversity protection.

CHAPTER 6: ANALYSIS BASED ON STEWARDSHIP AND MANAGEMENT STATUS

Introduction

As described in the general introduction to this report (see pg. 1), the primary objective of GAP is to provide information on the distribution and status of several elements of biological diversity. This is accomplished by first producing: maps of land cover (see pg. 16), predicted distributions for selected animal species (see pg. 46), and land stewardship and management status (see pg. 63). Intersecting the land stewardship and management map with the distribution of the elements results in tables that summarize the area and percent of total mapped distribution of each element in different land stewardship and management categories. The data are provided in a format that allows users to carry out inquires about the representation of each element in different land stewardship and management categories as appropriate to their own management objectives. This forms the basis of GAP's mission to provide land owners and managers with the information necessary to conduct informed policy development, planning, and management for biodiversity maintenance.

Although GAP "seeks to identify habitat types and species not adequately represented in the current network of biodiversity management areas" (GAP Handbook, Preface, Version 1, pg. I), it is unrealistic to create a standard definition of "adequate representation" for either land cover types or individual species (Noss *et al.* 1995). A practical solution to this problem is to report both percentages and absolute area of each element type in biodiversity management areas (as described above) and allow the user to determine which types are adequately represented in natural areas. Opinions will differ among users, but this is an issue of policy, not scientific analysis. We have however provided a breakdown along three levels of representation (10%, 20%, and 50%) that have been recommended in the literature (Noss and Cooperider 1994; Noss 1991; Odum and Odum 1972; Specht, Roe, and Boughlon 1974; Ride 1975; Miller 1994).

The network of Conservation Data Centers (CDCs) and Natural Heritage Programs (NHPs) established cooperatively by The Nature Conservancy and various state agencies maintains detailed databases on the locations of rare elements of biodiversity. GAP uses these data to develop predicted distributions of potentially suitable habitat for these elements (see pg. 16), which may be valuable for identifying research needs and preliminary considerations for restoration or reintroduction. Conservation of such elements, however, is best accomplished through the fine-filter approach of the above organizations. It is not the role of GAP to duplicate or disseminate Heritage Program or CDC Element Occurrence Records. Users interested in more specific information about the location, status, and ecology of populations of such species are directed to their state Heritage Program or CDC.

Currently, land cover types and terrestrial vertebrates are the primary focus of GAP's mapping efforts although other components of biodiversity, such as aquatic organisms or selected groups of invertebrates, may be incorporated into GAP distributional data sets. Where appropriate, GAP data may also be analyzed to identify the location of a set of areas in which most or all land cover types or species are predicted to be represented. The use of "complementarity" analysis, that is, an approach that additively identifies a selection of locations that may represent biodiversity rather than "hot spots of species richness" may prove most effective for guiding biodiversity maintenance efforts. Several quantitative techniques have been developed recently that facilitate this process (see Pressey *et al.* 1993, Williams *et al.* 1996, Csuti *et al.* 1997b, for details). These areas become candidates for field validation and may be incorporated into a system of areas managed for the long-term maintenance of biological diversity.

Land Cover Analysis

The table found in Appendix 4.1 provides the area in hectares of each types' mapped distribution by management status, and Appendix 4.2 in land stewardship designations. For example Oregon white oak forest type has 311 ha in US Fish and Wildlife Service (USFWS) lands that are ranked Status 2, which represents 0.66% of it's total distribution. Distribution of protected areas (GAP 1 & 2 lands) occur throughout a majority of the state with a mix of 165 BLM ACEC/RNA's, 76 BLM WSA, 35 USFS Wilderness Areas, 3 NPS units, 18 USFWS Wildlife Refuges, 158 USFS RNAs and PRNAs, and other minor special management areas in various administration units.

Three ecoregions in Oregon have limited protection (Appendix 3.1, Figure 5.2), the Willamette Valley (WV), the Columbia Basin (CB) and the East Cascades (EC). Ownership in both the WV and the CB is primarily private (94% and 90% respectively), with protected lands are managed by State Parks, USFWS, the Department of Defense (DOD) and The Nature Conservancy (TNC). Ownership pattern in the EC is primarily USFS (49%) and private (39%) with protected areas managed primarily by BLM (ACEC/RNA) and TNC.

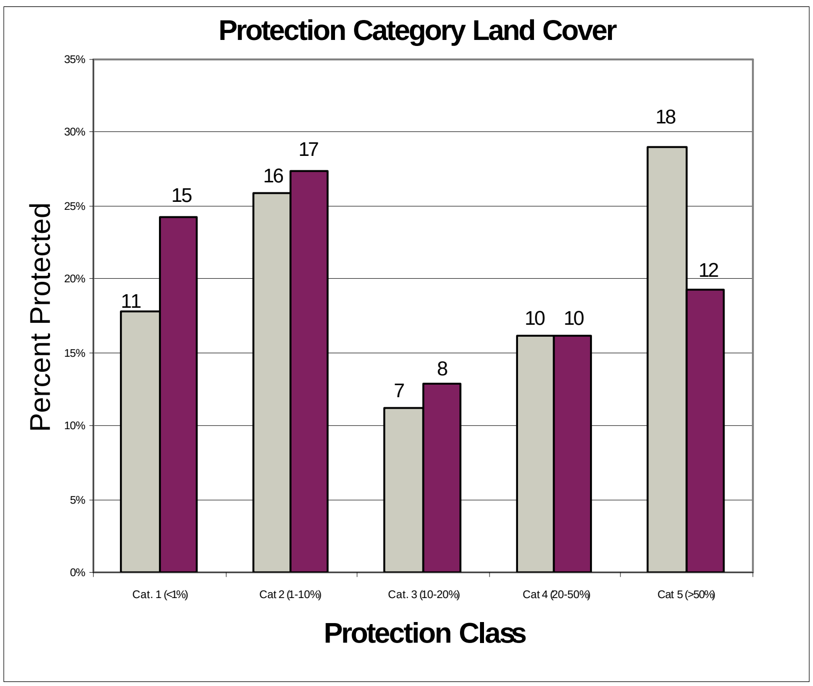

Figure 6.1. Distribution of land cover classes in protection categories from 1-5. Light gray lines include all protected areas, while dark, solid lines exclude LSRs.

OR-GAP has identified five categories (or protection classes) of land cover types, based on their overall conservation concern. These range from Category 1 which has less than 1% of habitats included in the network of conservation lands to Category 5 with over 50% of their distribution are in the network on conservation lands. Figure 6.1 shows the distribution of cover types in these categories.

Nine non-anthropogenic land cover types have < 1% of their total area protected in status 1 and 2 lands, and include five types of conservation concern (Appendix 6.7). None of the nine land cover types are widespread (> 100,000 ha) in Oregon. There are five types in Category 1 that have high wildlife value and substantial threats due to habitat loss and habitat conversion: hawthorn-willow shrubland, palustrine wetlands, wet meadows, modified grassland (which mostly represent native

Idaho fescue bunchgrass habitats), and Oregon white oak forest. Historically, Oregon white oak covered over ten times the area in the Willamette Valley that it now covers and remnants are limited to patches in private ownership. Immediate threats include expansion of urban growth boundaries in the Willamette Valley and conversion to agriculture. Both coastal strand and hawthorn-willow shrubland land cover types are conservation targets identified by state organizations and currently have limited protection in Oregon.

When LSR lands are removed from status 2 designation an additional three land cover types are included in Category 1. Both palustrine forest and south coast mixed conifer forests have limited distribution (< 12,000 ha) in Oregon, offer high wildlife habitat value, and are a high priority for conservation. Ponderosa-lodgepole pine on pumice has moderate distribution (> 500,000 ha) and probably has a lower priority for conservation effort.

Fifteen naturally occurring land cover types are in Category 2, with 1-10% of their total distribution in protected areas. These occur primarily in the East Cascades and Blue Mountains ecoregions. Four ponderosa pine types comprise over 2.5 million ha with the majority described as ponderosa pine forest and woodland (1.9 million ha). All ponderosa pine types in Oregon require a moderate conservation effort. The structure of ponderosa types have changed dramatically since the 1800s due to alterations in natural fire regimes, timber harvest, and cattle grazing (OBP 1998). Ponderosa types are predominantly managed by the USFS and because ponderosa occurs at lower elevations, little is protected by wilderness designation. Sagebrush steppe is widely distributed in Oregon (2,113,257 ha), and while not currently a conservation priority, the potential federal listing of the sage grouse may focus future efforts in this land cover type.

Four additional land cover types are included in protection Category 2 when LSR lands are excluded (Figure 6.1). Both Douglas-fir dominant-Mixed Conifer Forests (1,032,916 ha) and Douglas-fir-Western Hemlock-Western Red Cedar Forest (2,678,388 ha) have 86% of their current protected extent in LSR lands, and are considered critical habitat for the northern spotted owl and marbled murrelet (coastal areas only). The Siskiyou Mountains Mixed Deciduous Forest has 70% of its current protected extent in LSR lands and is important habitat for two endemic salamander species (see Amphibians and Reptiles results).

Seventeen land cover types have more than 10% and less than 50% of their total extent in Status 1 and 2 protection (Categories 3 and 4). All but five (excluding open water) have > 100,000 ha in total distribution and are considered adequately protected. Open Water was not satisfactorily described for this analysis and will be covered in more detail by future efforts including Aquatic Gap Analysis (P. Crist, personal communication) and TNC's ecoregional planning efforts. Exposed tidal flats may also be better represented in a conservation planning effort focusing exclusively on aquatic systems. Coastal Lodgepole Forests are under-mapped in Oregon (225 ha, 30% protected) and protection for the type is likely higher because the largest contiguous stands occur in federally protected dune areas. As in previous land status categories, the exclusion of LSR lands has an effect on the protection of the included land cover types. Without LSRs, six land cover types moved from the > 50% category to the 10-50% categories (Categories 3 and 4) and five dropped from one of the 10-50% categories to the 1-10% protection category.

Eighteen land cover types have most (> 50%) of their total distribution protect in status 1 and 2 lands. Fourteen of these occur primarily on USFS lands at higher elevations and include all the sub-alpine forest and grassland types. Only the whitebark-lodgepole pine montane forest has 100% of its distribution protected. Four types are considered conservation targets in Oregon and have < 70,000 ha of total distribution. Coastal dunes (16,644 ha, 57% protected) are likely underestimated for protection since state laws prohibit development of any dune area (although these are very threatened by exotic species). The Douglas-fir-Port Orford Cedar Forest (67,434 ha, 81% protected) is also a coastal type. However, its extent is not covered by state laws but protected primarily by USFS wilderness areas and LSRs. The final land cover type of conservation concern is the mountain mahogany shrubland (512 ha, 80% protected) which is mapped exclusively in the Steens Mountains of southeast Oregon. Six land cover types drop from the > 50% protected category when LSR lands are excluded from protected status (Figure 6.1). All but one of the downgraded land covers are forest types and includes Douglas-fir-Port Orford Cedar Forests. Appendix 3.1 shows the area in hectares and percentages of all mapped cover types in the different gap management categories. Appendix 6.7 shows the distribution of land cover types by ecoregion, with both ownership and protected area designation displayed for each type.

Vertebrate Species Analysis

Birds

Five (<2%) of the 263 birds modeled in Oregon had <1% of their predicted distribution in habitats occurring in status 1 and 2 lands. Of these five species only the grasshopper sparrow is tracked by ORNHP and is considered a state vulnerable species by the Oregon Department of Fish and Wildlife (ODFW). The black-chinned sparrow is on the northern edge of its range in Oregon, its breeding occurrence in the state is uncertain, and possibly should not have been included. Habitat for three of the four species is primarily bunchgrass and riparian habitat which have been highly impacted by habitat loss and fragmentation. The inclusion of LSR lands as status 2, described in the stewardship chapter, had a substantial effect on protection status of bird species (Figure 6.2) . When LSR lands are left as status 3, as done in Washington GAP, two species (solitary sandpiper and least flycatcher) are included as unprotected. Both of these birds have limited, somewhat peripheral distributions in Oregon and as such are not high conservation priorities.

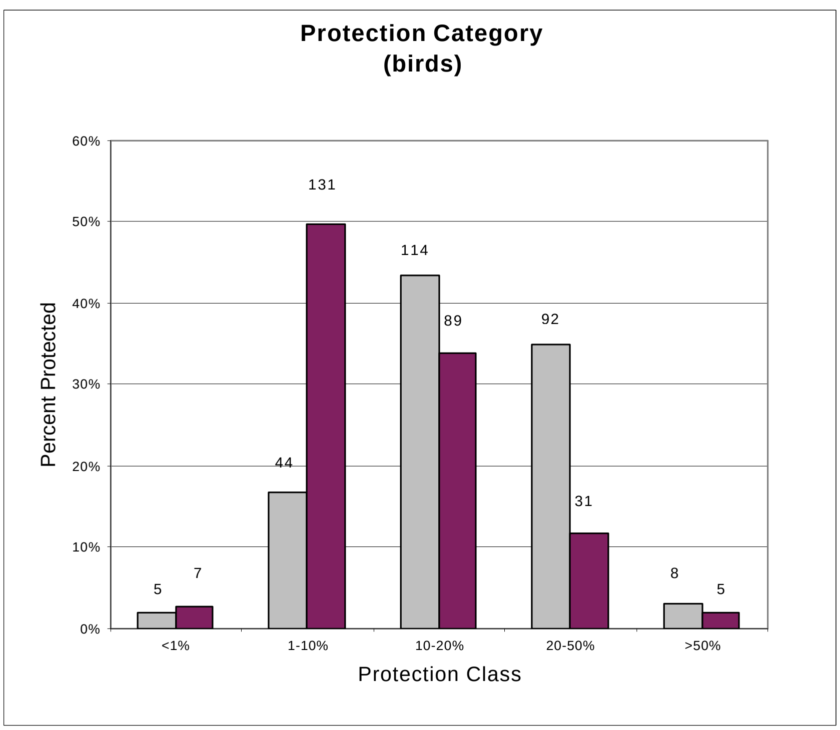

Figure 6.2. Distribution of 263 bird species in five categories based on protection class. Light gray lines include LSRs and dark, solid lines exclude the LSRs as protected areas.

Forty-four (17%) bird species have 1-10% of their predicted distribution protected (Figure 6.2). Approximately one-third of these species are associated with, or have habitat occurrence in, areas protected by the BLM Wilderness Study Areas (BLM WSA), or are strongly affected by LSR lands (Figure 6.2). Species habitat use for this group is not limited to one type of habitat, but twenty-seven (10%) of these bird species had historic use of much of the Oregon coast and are now limited to breeding populations on coastal islands. Six (2%) bird species are considered globally or state rare (Appendix 6.2), and are tracked by state agencies as conservation targets. A majority of the species occurring in this category are broad ranging species and likely have adequate protection, but ten species (Appendix 6.1) have <100,000 ha of total habitat in the state, nine of which are considered breeding residents and may not be adequately protected. The inclusion of LSR lands as a status 2 management category may artificially decrease the number of species which might fall within this category (Figure 6.2). Without LSR's, the number of species listed is tripled to 131 species, including 10 (4%) of the bird species tracked as conservation targets in the state.

One-hundred fourteen (43%) bird species have 10-20% and ninety-two (35%) birds have 20-50% of their predicted habitat in protected areas (Figure 6.2). As observed with the other management status categories, the designation of LSR lands has a major affect on the distribution of protection status bird species. Both the federally threatened marbled murrelet (20% protected) and spotted owl (29% protected) have 77% and 74%, respectively, of their predicted protected distribution in LSR lands, and drop to the 1-10% protection category when LSR lands are not included. Additionally, the northern waterthrush, yellow rail, and harlequin duck lose 18-24% of their protected habitat and are included in the 1-10% category. Two bird species, the black swift (48% of protected range in LSR) and Cassin's auklet (1% of protected range in LSR) drop from the 20-50% category to the 10-20% category.

Included in the eight (3%) bird species protected in more than 50% of their distribution only the black rosy-finch has 100% of its distribution protected in status 1 or 2 lands. This protection is due exclusively to the network of BLM WSA lands across the alpine habitat of the Steens Mountains of southeastern Oregon. The trumpeter swan displays a similar trend with 81% of its distribution protected by US Fish and Wildlife Service (USFWS) refuges. The remaining six species (Figure 6.2) fall within areas set aside as US Forest Service Wilderness Areas (USFS WA), or a combination of BLM WSA, USFWS Refuge or other coastal protected areas.

<u>Birds - Historic</u>

One-fifth (57 species) of all (the 253 modeled) birds in Oregon have faced substantial habitat loss and/or low habitat protection when compared to their historic habitat distribution. Twenty species have more than 20% of their current distribution in protected areas and would generally be identified as adequately protected, if habitat loss is not a consideration. For example, upland sandpiper has 31.65% (6,365 ha) of its current distribution protected. However it lost over 160,000 ha and current protection represents only 1% of its historic range. Thirty species occur in wetland/shoreline habitats and many are now limited to offshore islands all of which are protected in reserves by USFWS. Species with the greatest habitat loss and smallest ratio of currently protected habitat include nine sensitive species (Appendix 6.2).

Conversely, 58 (23%) bird species have gained in either total habitat, or increased protection (Appendix 6.2). Seven of these species gains are from non-native upland game bird introductions. One species (cattle egret) had no historic distribution, but is considered a naturally occurring emigrant (Gilligan *et al.* 1994). The majority of species which have increased range or high protection status occur in agriculture/urban and open water (reservoir) habitats. While species such as the orange-crowned warbler, chipping sparrow, mountain bluebird and Lazuli bunting are not associated with agriculture or urban areas, they are considered early successional species and have increased their range in managed forests.

Mammals

None of the 116 modeled native mammals have less than 1% of their habitat protected with LSRs and WSAs included. Mammals exhibit a trend similar to birds when LSRs are removed from protected status, with two mammal species included in the <1% protection category: the California vole and Townsend's vole. Both vole species lose over 50% of their protected range (59% and 68% respectively) with the loss of LSR lands. There are no mammal species tracked by state agencies in this category. Nineteen (48%) mammal species have 1-10% of their predicted distribution in protected areas (Figure 6.3).

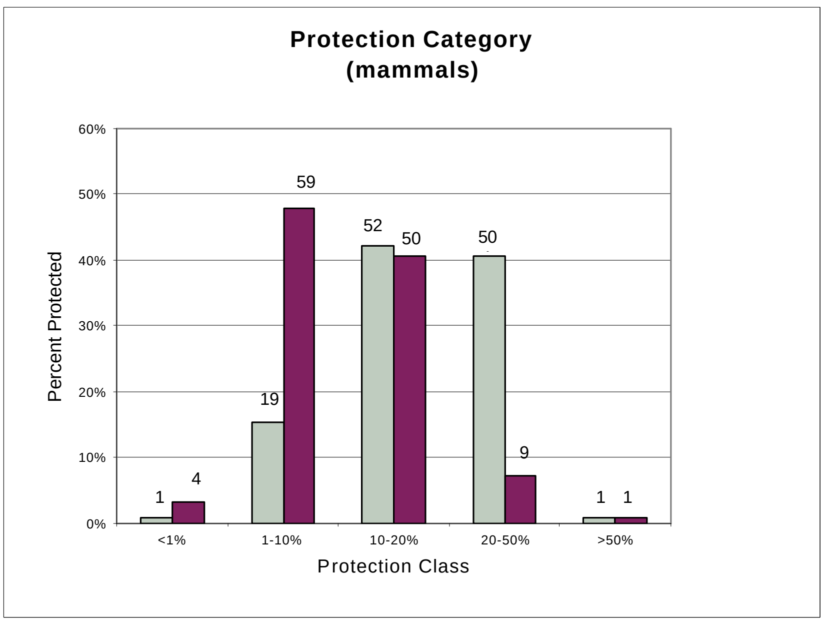

Figure 6.3. Distribution of 123 mammal species in five categories based on protection class. Light gray lines include LSRs, while the solid, dark lines exclude the LSRs as protected areas.

Three species, the Brazilian free-tailed bat, Columbian white-tailed deer (a federally listed subspecies from western Oregon) and the Washington ground squirrel, are tracked by Oregon as conservation targets. The Washington ground squirrel is limited to the Umatilla Basin and has specific conservation concern for Oregon since much of its remaining distribution is limited to state lands which are leased to a private company and threatened by habitat conversion. The Columbian white-tailed deer is a federally listed endangered subspecies of the more widespread species. It is limited to the Puget Trough ecosystem, including the Willamette Valley and is threatened primarily by habitat conversion. When LSR lands are excluded, no species of state concern are removed from this category, but 40 (30%) additional species are included in this protection category. All additional species, excluding the white-footed vole, have > 100,000 ha of total state distribution. As observed in the birds distribution, the inclusion of LSRs in protected areas weighs towards species which predominately occur in forested habitats (Appendix 6.3).

Fifty-two (42%) mammal species have 10-20% and 51 (41%) mammals have 20-50% of their predicted distribution in protected areas (Appendix 6.3). Six of these species are considered conservation targets within the state, but all have > 800,000 ha of total distribution in Oregon. The predicted distributions for the pygmy rabbit and the spotted bat may be misleading since both species may be more limited by micro-habitat selection than macro-habitat as modeled by GAP. The exclusion of LSRs has the greatest effect on total species in the 20-50% category with a total loss of 42 species. The kit fox (50.61%) is the only mammal which has >50% of it's predicted distribution in protected areas. The high level of protection assigned to the kit fox is due to the assignment of BLM WSA lands as status 2 protection. The kit fox would decrease substantially (2% protected) if BLM WSA lands were dropped from status 2 protection to status 3 protection.

Mammals - Historic

Thirty-one (24%) mammal species have experienced substantial habitat loss or low protection (< 0, Index 2), when compared to historic distributions (Appendix 6.4). Four are extant in Oregon and are covered by the endangered species act for reintroduction. Fourteen (11%) have more than 20% of their existing distribution in protected areas and should be re-evaluated for their protection status in Oregon. When historic distribution is taken into account, median habitat loss for mammals was 65%. Eight mammal species had more than 70% decreases in habitat, although unlike birds, mammals with historic loss were found in all ecoregions and habitats. Seven of these mammal species are considered conservation targets in Oregon, including the Washington ground squirrel. Ninteen native mammal species have gained habitat or protection status.

Amphibians and Reptiles

Figure 6.4 shows the distribution of reptile and amphibians in five protection categories. No amphibians or reptiles had < 1% of their predicted distribution in status 1 and 2 lands. When LSRs were excluded from status 2, only the common kingsnake, with 85% (4,012 ha) of its protected habitat in LSR lands, had < 1% of its habitat protected. Three of the nine species with 1-10% of their predicted distribution are considered species of conservation concern in Oregon. Both the common kingsnake and the painted turtle are threatened by habitat loss in Willamette Valley and the Klamath Mountains ecosystems. When LSR lands are excluded from the analysis the total number of species in the 1-10% protection category increased by over 370% with an additional 25 species.

The analysis shows that the Northwest Forest Mangement Plan (Femat 1993) and associated LSRs does an especially good job in protecting amphibians, as shown in Figure 6.4 (below). Looking at the 19 amphibians taxa with less than 10% of their habitat protected, a median of 18% of their predicted distributions occur in LSRs. The 14 reptiles in the same group have a median of 6% of their predicted distribution in the same management category. The discrepancy observed between the two groups is due primarily to forest lands in the Klamath ecoregion where newt and salamander diversity is second only to the Great Smoky Mountains.

Eight amphibians and 16 reptiles have between 10-20% of their predicted distribution in protected areas, and include four amphibians of state conservation concern (Table 6.4). The Siskiyou Mountain salamander (31,615 ha protected), a state conservation target, is endemic to the Klamath

Mountains and occurs primarily on BLM, USFS and private land with 81% of its protected lands in LSR designation.

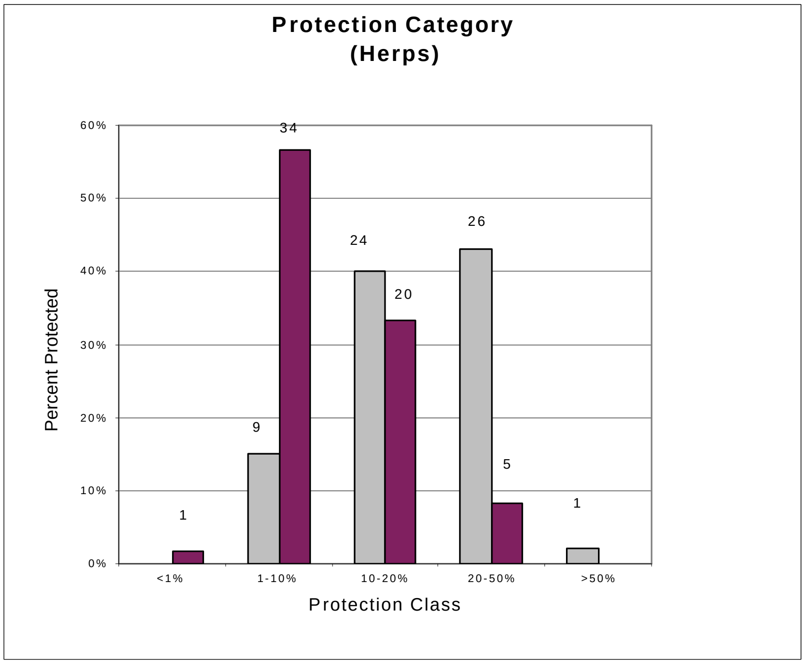

Figure 6.4. Distribution of 60 amphibian and reptile species in five categories based on protection class. Light gray lines include LSRs, solid dark lines exclude the LSRs.

Eighteen amphibians and 7 reptiles have between 20-50% of their predicted distribution in protected areas, and include four salamanders of state conservation concern (Appendix 6.5). The ensatina has a subspecies (*E. e. picta*) endemic to the Klamath Mountains (1,857,972 ha protected) found primarily on BLM, USFS and private lands with 74% of its protected habitat in LSRs. The species distribution for the 20-50% category of protection has the greatest reduction of species richness when LSR lands are excluded from status 2 protection, with a loss of all amphibians and a decrease of three reptiles. Only the Larch Mountain salamander has > 50% of its predicted distribution in protected areas with 57,894 ha (51%) in status 1 and 2 lands. Protection for this species occurs primarily in USFS Wilderness Areas and LSR lands. When LSR are removed from protected status the Larch Mountain salamander drops to 17% protected with 66% on LSR lands (Appendix 6.5).

<u>Amphibians and Reptiles - Historic</u>

Similar to birds and mammals, 22% (13) of amphibians/reptiles have experienced substantial habitat losses and are poorly protected (Appendix 6.6). No amphibians or reptiles with this level of loss are proposed for federal or state listing in Oregon, and historical losses may not be as critical an issue as in other groups. Three of these taxa have < 60,000 ha of total current distribution and historically none had > 100, 000 ha. Most herps have high mico-habitat requirements and are likely better evaluated using a finer scale analysis. Fourteen (22%) species have substantial habitat gains, or high protection, and include three introduced species.

Summary of Vertebrates in Protected Areas

Vertebrate species protection in Oregon follows the same trend observed in land cover with species ranges comprising a higher percentage of their range in protected areas. A summary of all species in Category 1 is found in Table 6.1, Category 5 in Table 6.2, and Category 2 in Table 6.3 below.

Table 6.1. Native species with less than 1% of their distribution in status 1 or 2. Taxa are listed by relative degree of protection, with those at the beginning being least protected.

Amphibians/Reptiles	Mammals	Birds	
Tiger salamander	Camas pocket gopher	Black-chinned sparrow	- Common snipe
Common kingsnake	Gray-tailed vole	Least flycatcher	- Sandhill crane
Columbia seep salamander	California vole	Bobolink	- Bullock’s oriole
Northern leopard frog	White-tailed deer	Grasshopper sparrow	- Blue-gray gnatcatcher
Painted turtle	Townsend`s vole	White-tailed kite	- Ash-throated flycatcher
Northwestern garter snake	Western harvest mouse	Pinyon jay	- Rhinoceros auklet
Western pond turtle	Brazilian free-tailed bat	Wilson`s phalarope	- House finch
Southern alligator lizard	California kangaroo rat	Tricolored blackbird	- Lesser goldfinch
	California ground squirrel	Sora	- Northern harrier
	Columbian ground squirrel	Virginia rail	- Black-chinned hummingbird
	Washington ground squirrel	Eastern kingbird	- American goldfinch
	Montane vole	Upland sandpiper	- Allen`s hummingbird
	Northern pocket gopher	Red-necked grebe	- White-crowned sparrow
	Brush rabbit	Short-eared owl	- Red-eyed vireo
		Pygmy nuthatch	- Anna`s hummingbird
		Killdeer	- Purple finch
		Solitary sandpiper	- Chipping sparrow
		Franklin`s gull	- Mountain quail
		Savannah sparrow	- American kestrel
		Canada goose	- Black oystercatcher
		Yellow-billed cuckoo	- California quail
			- Red-naped sapsucker

Table 6.2. Native species with more than 50% of predicted distribution in status 1 or 2. Taxa are listed by relative degree of protection, with those at the top being least protected.

Amphibians/reptiles	Mammals	Birds
Larch Mountain Salamander	Kit fox	Three-toed woodpecker
		Spruce grouse
		Snowy plover
		Black swift
		Gray-crowned rosy-finch
		American pipit
		Black rosy-finch

Table 6.3. Category 2 vertebrate species (taxa with between 1% and 10% of their distribution in status 1 or 2 lands.) Taxa are listed by relative degree of protection, with those at the beginning being least protected.

Amphibians/Reptiles	Mammals	Birds	
Sharptail snake	Coyote	Brandt`s cormorant	- Spotted towhee
Woodhouse`s toad	American badger	Pelagic cormorant	- Ring-billed gull
Racer	Botta`s pocket gopher	Pigeon guillemot	- Wilson`s warbler
Great basin spadefoot	Belding`s ground squirrel	Lark sparrow	- Bank swallow
Short-horned lizard	Great Basin pocket mouse	Common murre	- Lincoln`s sparrow
Siskiyou mountains	Western pipistrelle	Leach`s storm-petrel	- Bewick`s wren
Long-toed salamander	Black-tailed jackrabbit	Tufted puffin	- Veery
Gopher snake	Least chipmunk	Glaucous-winged gull	- White-headed woodpecker
Western rattlesnake	Western small-footed bat	American avocet	- Lewis` woodpecker
Striped whipsnake	Yellow-pine chipmunk	Mourning dove	- Sage thrasher
Western skink	Western spotted skunk	Barn owl	- Orange-crowned warbler
Oregon spotted frog	Common raccoon	Brewer`s sparrow	- Hutton`s vireo
Western fence lizard	Sagebrush vole	Vesper sparrow	- California gull
Western terrestrial garter snake	Nuttall`s cottontail	Red-tailed hawk	- White-breasted nuthatch
Rubber boa	Pronghorn	Red-shouldered hawk	- Western screech-owl
Pacific treefrog	Striped skunk	Common poorwill	- Brown-headed cowbird
Common garter snake	Pinon mouse	California towhee	- Northern flicker
Western toad	Townsend`s ground squirrel	Western meadowlark	- American robin
Side-blotched lizard	White-tailed jackrabbit	Gray flycatcher	- Willow flycatcher
Night snake	Pallid bat	Oak titmouse	- Common nighthawk
Sagebrush lizard	Canyon mouse	Horned lark	- Great horned owl
Ringneck snake	Yellow-bellied marmot	Loggerhead shrike	- Macgillivray`s warbler
Columbia spotted frog	Southern red-backed vole	Rock wren	- Black-headed grosbeak
	Dusky shrew	White-throated swift	- Turkey vulture
	California myotis	Western kingbird	- Flammulated owl
	Bushy-tailed woodrat	Western gull	- Western bluebird
	Fringed bat	House wren	- Common raven
	Western jumping mouse	Ferruginous hawk	- Green-tailed towhee
	Townsend`s pocket gopher	Black-capped chickadee	- Violet-green swallow
	Mule deer	Long-eared owl	- Nashville warbler
	Dusky-footed woodrat	Bushtit	- Gray catbird
	Long-tailed weasel	Say`s phoebe	- Long-billed curlew
	Deer mouse	Swainson`s hawk	- Ruffed grouse
	Big brown bat	Black-billed magpie	- Bald eagle
	Red squirrel	American crow	- Cassin`s finch
	Long-legged bat	Song sparrow	- Sage sparrow
	Long-eared bat	Nrn rough-winged sparrow	- Vaux`s swift
	Vagrant shrew	American redstart	- Mountain chickadee
	Townsend`s mole	Cliff swallow	- Williamson`s sapsucker
	Bobcat	Lazuli bunting	- Sage grouse
	Coast mole	Solitary vireo	- Black-throated gray warbler
	Merriam`s shrew	Brewer`s blackbird	- Dark-eyed junco
	Preble`s shrew	Downy woodpecker	- American dipper
	Ord`s kangaroo rat	American bittern	- Steller`s jay
	Northern grasshopper mouse	Barn swallow	- Green heron
	Common porcupine	Wood duck	- Brown creeper
	Long-tailed vole	Canyon wren	- Hairy woodpecker
	Broad-footed mole	Yellow-breasted chat	- Swainson`s thrush
	Golden-mantled ground squirrel	Burrowing owl	- Dusky flycatcher
	Pygmy rabbit	Purple martin	- Mountain bluebird
	Red fox	Golden eagle	- Red-breasted nuthatch
		Prairie falcon	- Winter wren
		Fork-tailed storm-petrel	- Calliope hummingbird
		Yellow-headed blackbird	- Hooded merganser
		Fox sparrow	- Rufous hummingbird
			- Black-throated sparrow

Priority Species for Conservation

Species loss is not just related to habitat loss. If this were the case, management decisions could focus on species which had the greatest habitat losses. To describe the change in vertebrate distributions caused by anthropocentric changes in Oregon over the last century, both the loss of habitat and how well the current and historic range of the species is protected need to be evaluated. To determine which species were most affected by habitat loss/gain, and if protection status was low or high, three indices which value species-area change and protection differently were examined. The first index, Formula 1, is shown as Figure 6.5. It incorporates the difference in protection of current distribution and historic distribution as a factor of habitat lost or habitat gained. Because the index is weighted by the change in habitat area, the species identified by the index tend to be those that lost, or gained the most habitat. Species with high loss in habitat and a low ratio of current protected habitat, have a negative value.

$$\text{Index 1} = \left(\frac{1 - \left[\frac{c-p}{c} \right]}{1 - \left[\frac{h-p}{h} \right]} \right) \left(\frac{c-h}{c} \right)$$

Figure 6.5. Formula 1, where hectares of historic habitat = h, hectares of current habitat = c, and hectares currently protected = p

A second index (Formula 2) was suggested by Frank Davis of UC Santa Barbara, somewhat similar to Index 1 but with a greater focus on vulnerability of the remaining, unprotected habitat. His index was modified slightly, changing it from positive to negative to match the other indices (Figure 6.6).

$$\text{Index 2} = \left(\frac{h-c}{h} - \frac{p}{c} \right) * -100$$

Figure 6.6. Formula 2, an index of change where h=historic habitat, c=current habitat, and p=currently protected lands.

Denis White of the Environmental Protection Agency lab in Corvallis recommended the third additive index which allows for weighting of how well areas are protected and how much habitats have been lost. Denis noted that additive indices often work better than multiplicative ones. Values for this index range from 0 to 2. This is Formula 3, shown in Figure 6.7 to the left.

$$\text{Index 3} = \left(\frac{p}{c} \right) + \left(\frac{c}{c+h} \right)$$

Figure 6.7. Formula 3, an index of change where h=historic habitat, c=current habitat, and p = currently protected

All three formulas have been applied to the entire set of species and habitats developed for this project. As mentioned above, these range from negative to positive, with the species most in need of attention having larger negative values, and those most secure having large positive values. Results are similar for the three indices, but not identical. Table 6.4, below shows the 20 bird species most in need of protection based on the three formulas, in priority order. Certain species, e.g. the yellow rail, the least flycatcher and the yellow-billed cuckoo show up as priorities using all the indices, although the differences between them are intriguing. Appendices 6.2, 6.4 and 6.6 show the results of this analysis for all species, including hectares of habitat in the historic and existing coverage, the percent change, area currently protected, the percentage of the historic and current distribution this represents, the percent change in habitat from historic to current, and the three indices.

Table 6.4. Top 20 priority bird species based on the three habitat loss/protected area formulas.

Formula 1	Formula 2	Formula 3
Yellow Rail	Least Flycatcher	Least Flycatcher
Yellow-billed Cuckoo	Yellow-billed Cuckoo	Yellow-billed Cuckoo
Peregrine Falcon	Grasshopper Sparrow	Grasshopper Sparrow
Fork-tailed Storm-petrel	Fork-tailed Storm-petrel	Franklin`s Gull
Cassin`s Auklet	Franklin`s Gull	Fork-tailed Storm-petrel
Grasshopper Sparrow	Upland Sandpiper	Upland Sandpiper
Bonaparte`s Gull	Yellow Rail	Wilson`s Phalarope
Lewis` Woodpecker	Rhinoceros Auklet	Rhinoceros Auklet
Marbled Murrelet	Red-eyed Vireo	Red-eyed Vireo
California Towhee	Wilson`s Phalarope	California Towhee
Black-necked Stilt	California Towhee	Red-necked Grebe
Red-eyed Vireo	Cassin`s Auklet	Yellow Rail
Franklin`s Gull	Lewis` Woodpecker	Lewis` Woodpecker
Rhinoceros Auklet	Peregrine Falcon	Mockingbird
Green-winged Teal	Marbled Murrelet	Cassin`s Auklet
Hutton`s Vireo	Hutton`s Vireo	Hutton`s Vireo
Snowy Plover	Yellow-headed Blackbird	Common Murre
Upland Sandpiper	Red-necked Grebe	Leach`s Storm-petrel
Pacific Slope Flycatcher	Tufted Puffin	Tufted Puffin

Similar results were obtained for mammals, reptiles and amphibians. The top 20 reptile and amphibians are shown below in Table 6.5, and mammals in Table 6.6, both in priority order.

Table 6.5. Top 20 priority reptile and amphibian species based on the three habitat loss/protected area formulas in priority order.

Formula 1	Formula 2	Formula 3
Common Kingsnake	Common Kingsnake	Common Kingsnake
Columbia Seep Salamander	Columbia Seep Salamander	Columbia Seep Salamander
Southern Seep Salamander	Western Pond Turtle	Western Pond Turtle
Red-legged Frog	Southern Seep Salamander	Northern Leopard Frog
Western Pond Turtle	Red-legged Frog	Painted Turtle
Dunn`s Salamander	Dunn`s Salamander	Striped Whipsnake
Pacific Cst Aquatic Garter Snake	Foothill Yellow-legged Frog	Red-legged Frog
Foothill Yellow-legged Frog	Pacific Cst Aquatic Garter Snake	Dunn`s Salamander
Cascade Seep Salamander	Striped Whipsnake	Southern Seep Salamander
Pacific Giant Salamander	Cascade Seep Salamander	Great Basin Spadefoot
California Mountain Kingsnake	Northern Leopard Frog	Short-horned Lizard
Oregon Slender Salamander	Side-blotched Lizard	Western Skink
Ground Snake	Night Snake	Oregon Spotted Frog
Striped Whipsnake	Painted Turtle	Side-blotched Lizard
Larch Mountain Salamander	Cope`s Giant Salamander	Racer
Cope`s Giant Salamander	Western Redback Salamander	Night Snake
Night Snake	Columbia Spotted Frog	Long-toed Salamander
Side-blotched Lizard	Western Skink	Foothill Yellow-legged Frog
Western Redback Salamander	Oregon Spotted Frog	Columbia Spotted Frog
Mojave Black-collared Lizard	Short-horned Lizard	Cope`s Giant Salamander

A potential use of these indices is to use them to define some group of species which are those most in need of protection. Using the gap data and the indices, OR-GAP produced a species richness map showing concentrations of these priority species. The question to be tested by this was

Table 6.6. Top 20 priority mammal species based on the three habitat loss/protected area formulas in priority order.

Formula 1	Formula 2	Formula 3
Spotted Bat	White-tailed Deer	White-tailed Deer
White-tailed Deer	Washington Ground Squirrel	Washington Ground Squirrel
Washington Ground Squirrel	Spotted Bat	Spotted Bat
Canada Lynx	White-tailed Jack Rabbit	White-tailed Jack Rabbit
White-footed Vole	Townsend`s Big-eared Bat	California Kangaroo Rat
White-tailed Jack Rabbit	White-footed Vole	Townsend`s Big-eared Bat
Mountain Lion	California Kangaroo Rat	Brazilian Free-tailed Bat
Townsend`s Big-eared Bat	Canada Lynx	White-footed Vole
Kit Fox	Mountain Lion	California Vole
California Kangaroo Rat	Brazilian Free-tailed Bat	Canada Lynx
Pacific Jumping Mouse	Pacific Jumping Mouse	Western Harvest Mouse
Fisher	Fisher	Mountain Lion
American Marten	California Vole	Columbian Ground Squirrel
Wolverine	Pronghorn	Pronghorn
Brazilian Free-tailed Bat	Pinon Mouse	Western Small-footed Bat
Little Pocket Mouse	American Marten	Belding`s Ground Squirrel
Pronghorn	Western Small-footed Bat	Pinon Mouse
Ringtail	Wolverine	Northern Pocket Gopher
Snowshoe Hare	Kit Fox	Great Basin Pocket Mouse
Pinon Mouse	Belding`s Ground Squirrel	Western Pipistrelle

whether a species richness map generated using a prioritized subset of Oregon species would be significantly different than the species richness map which used all species. Figure 6.8 compares the total richness of all species (top) and the total richness of the subset of species needing protection (bottom). We believe the priority species richness would be much more useful in identifying areas which might provide the biggest return on conservation investments.

For this richness sub-sample map (Figure 6.8, bottom), we used Index 2, with a cutoff value of 40. This value was selected somewhat arbitrarily, but represented the majority of the species which either were not well represented in the network of conservation areas, or had declined significantly. Overall, a total of 333 of the 455 species (73%) were identified, of which most are birds (56%). However the percentage of the total birds selected (70%) is lower than the percentage of either herps (75%) or mammals (79%), suggesting that birds are generally better protected in Oregon than are the other groups. The color ramps used in the two maps (total species richness map and the sub-sample or priority species richness map) represent the quantile distribution of total data points. Each of the ten color classes in each map contains exactly 10% of the total number of polygons (we were unable to do this using total area instead of number of polygons, but it may be possible). These can also be viewed with an equal value distribution (each color class has the same number of richness values), but we felt the two maps were more comparable using the quantile distributions.

The major centers of species richness (areas with very high species diversity shown in yellow) are the same in both the all species and the priority species richness maps: the Klamath Basin in south-central Oregon, the Malheur Basin in east-central Oregon, and the Siskiyou Mountains in southwestern Oregon. However, areas of high diversity (shown in yellow-green) change dramatically in the sub-sample coverage, with high-richness areas highlighted in the western Columbia River Gorge, the Alvord Basin, and southeastern Wasco County that were not important in the overall species richness map.

CHAPTER 7: CONCLUSIONS AND MANAGEMENT IMPLICATIONS

OR-GAP has been a cooperative effort with numerous partners working over a 10 year period. It started as an effort to answer the question, "Where are the best places to protect diversity in Oregon?". Over the project's lifetime, it has changed significantly, and is now viewed as an effort to provide both biodiversity information and analysis tools for answering the original question. The Version 1 products helped inspire the Oregon Biodiversity Project and led to the publication of *Oregon's Living Landscape* (OBP 1998).

In general, OR-GAP is hesitant to state that the results of the analysis included in this report provide comprehensive information on either diversity patterns in Oregon, or sites where best biodiversity most needs to be protected. As with many projects comprised of numerous cooperators, much of the work has been pieced together. Some of the products and accomplishments are significant, while others still need improvement.

The development of the stewardship coverage and the species distribution databases has improved the ability for others to do statewide and local assessments. The land cover and species distribution covers appear, in areas, to have high error rates. While an accuracy assessment was not done for either of the two versions of the OR-GAP land coverage, both appear to be uneven, with detailed mapping and classification in some areas, and coarser mapping and classification in others. OR-GAP and ORNHP have started a cooperative effort with the U.S. Forest Service and BLM to accumulate all their ecology plot data. When this data set is compiled, ORNHP and OR-GAP will be able to assess the accuracy of both Version 1 and Version 2 land cover maps, as well as the accuracy of the many other local and regional coverages being developed in Oregon.

The wildlife by habitat relationship models were developed for OR-GAP cooperatively by ODFW and Blair Csuti, based on some preliminary analysis of wildlife needs, and a compilation of wildlife habitat reports from a number of researchers. The need for additional work in this area led ODFW and the Washington Department of Fish and Wildlife to seek and raise funds for a three year effort to develop new models. It also, indirectly, led to the creation of a new non-governmental organization, the Northwest Habitat Institute, in Corvallis, Oregon. Unfortunately, the new wildlife by habitat relationship models were not available in time for this analysis. However, the analysis tools OR-GAP developed to produce the species distribution coverage were designed to incorporate new wildlife-habitat models and new vegetation coverages, whenever they become available. We believe that using higher resolution vegetation coverages with more detailed classifications, and the improved wildlife-habitat models would greatly improve the overall accuracy of the analysis. However, this may not change the basic identification of gaps (M. Scott, personal communication).

OR-GAP has been most valuable as a focus to develop and integrate these important data sets. More accurate species lists and species distribution maps will be developed using the species distribution databases and the managed area coverage with the new wildlife-habitat models and ecoregional or local vegetation maps which are currently being produced throughout the state.

OR-GAP intends to continually update the managed area cover, the species distribution databases, and to provide crosswalks between the new wildlife habitat models and any new vegetation or land cover maps which become available. Oregon is exceptionally fortunate to have a number of forward thinking agencies who are spending significant resources to map land cover and vegetation at a fine scale, and to tie these maps to GPS labeled plot data. The Burns District BLM, the Umatilla, Ochoco, Siuslaw and Willamette National Forests among others have developed exceptional 1:24,000 vegetation coverages which are available to the public. OR-GAP and ORNHP intends to aggregate these for the entire state, and to compare these to the coarser scale maps based on satellite imagery. We feel that these fine scale maps will be more useful for ecoregional and watershed analysis. ORNHP is working with TNC to complete ecoregional plans for all of Oregon's ecoregions, and working with the state of Oregon's Watershed Enhancement Board to assist in the development of watershed assessments. We believe the combination of fine scale vegetation data, improved wildlife habitat matrices, and an updated GAP protected area cover will greatly enhance these biodiversity planning efforts. And, ORNHP and OR-GAP intends to remain a source of biodiversity information for anyone interested in studying or protecting biodiversity in Oregon.

OR-GAP data has been used in a recent analysis to write a *State of the Environment Report*, commissioned by the Governor and the Oregon Progress Board, and developed by a science team headed by Dr. Paul Risser, President of Oregon State University. This project, and other assessment projects in Oregon, has allowed OR-GAP to continue updating most of the data developed. Annual updates of the Stewardship/Ownership coverage will be released, as will updates to the vertebrate species distribution database. The Historic Vegetation coverage will be updated one more time in the year 2000, to include new data from the eastern Oregon valleys and from southwestern Oregon.

One of the clear results of this analysis is the significance of the LSRs and the WSAs to the protection of biodiversity in Oregon. The LSRs, designed to protect the northern spotted owl, do a very good job at protecting other vertebrate species using western Oregon forests. Threats or changes to the management of these LSRs would greatly change how well species are protected in western Oregon, and increase the overall number of gaps. The BLM Wilderness Study areas are also critical to the protection of wildlife and habitats, especially in southeastern Oregon. The permanent protection of at least a significant portion of these lands is a critical strategy to assure we do not have the endangered species problems we have had in western Oregon.

The National Gap Analysis Program is moving in two directions which OR-GAP fully intends to assist. The first is to promote regional, multi-state GAP efforts. OR-GAP has worked with adjacent states in a number of regional assessments, and especially sees the need to regionalize land cover maps and other coverages which have varied significantly between programs. The second is to complete aquatic gap analysis for states and the country. This report and the data are clearly biased towards terrestrial systems and elements. Working to develop a coverage and classification of aquatic habitats in Oregon will be a focus of future activities.

PRODUCT USE AND AVAILABILITY

How To Obtain the Products

It is the goal of the Gap Analysis Program and the USGS Biological Resources Division (BRD) to make the data and associated information as widely available as possible. Use of the data requires specialized software called geographic information systems (GIS) and substantial computing power. Additional information on how to use the data or obtain GIS services is provided below and on the GAP homepage (URL below). While a CD-ROM of the data will be the most convenient way to obtain the data, it may also be downloaded via the Internet from the national GAP home page at:

http://www.gap.uidaho.edu/gap

The home page will also provide, over the long term, the status of our state's project, future updates, data availability, and contacts. Within a few months of this project's completion, CD-ROMs of the final report and data should be available at a nominal cost— the above home page will provide ordering information. To find information on this state GAP project status and data, follow the links to "project information" and then to the particular state of interest.

In Oregon, GIS information has been centralized at the State Service Center for GIS (SSCGIS). While this agency has recently lost all of their state funding, they continue to attempt to post all of the data layers available in the state, and with any associated metadata. All of the GIS datasets created as part of OR-GAP, as well as most of the data created through the Oregon Biodiversity Project are available on the SSCGIS's FTP or Internet sites. If funding prohibits the SSCGIS from continuing to post the data, ORNHP, OR-GAP or ODFW will assure they are posted. Until then, the SSCGIS can be contacted through the internet at:

http://www.sscgis.state.or.us

ORNHP also maintains a homepage for the program and OR-GAP. All information produced as part of the OR-GAP is available through this site as well. This includes an electronic copy of this report (in PDF and word processing formats), lists of the rare, threatened and endangered species of Oregon, a complete list of the habitats for Oregon (based on the current National Vegetation Classification System), and a list of GIS data being developed by OR-GAP and ORNHP. The current address is:

http://www.heritage.tnc.org/nhp/us/or

Three sets of species distribution covers were developed as part of OR-GAP. The first and the second sets are the predicted distributions, and differ only in the vegetation cover which was used to generate them. The first was developed from the first land cover map, which was created using LANDSAT Multi-Spectral Scanner false-color infrared positive prints at a scale of 1:250,000 were visually photo-interpreted to identify boundaries of different vegetation cover types. The second set of distribution covers were developed using the second generation cover, which is described in detail in this report. The last set was developed using a historic vegetation coverage developed by ORNHP (cooperatively with the Defenders of Wildlife, ODFW, the USFS Forest Sciences Lab), with significant funding from EPA, the BLM, and the State of Oregon.

All of the species coverages are available on CD-ROM. There are too many coverages, and they are too large, to be all available on-line as grids or ARCINFO coverages.   OR-GAP has developed an ARCVIEW application which uses ESRI's Internet Map Server (IMS) program to generate on-the-fly maps (shape files) of the historic and current distributions of all vertebrate taxa. As currently developed, this application is currently too slow to be an efficient internet application. OR-GAP is working with the ODFW and the State of Oregon to streamline the existing databases and to obtain new equipment to serve this data on line.

All of the data developed as part of the Oregon Biodiversity Project has been incorporated into the Oregon Biodiversity Partnership. This is a cooperative effort between The Defenders of Wildlife, ORNHP, and TNC to develop statewide partnerships to assist in the implementation of the results of the Oregon Biodiversity Project. The Oregon Biodiversity Partnership has a website which describes the partnership in detail, and provides access to data and data products:

http://www.biodiversitypartners.org

Minimum GIS Required For Data Use

Currently, ARC-INFO or ARCVIEW is needed to use the GIS Coverages. When the ARCVIEW - Internet Map Server application discussed in the previous paragraph is completed, anyone with internet access should be able to generate and download historic or current species distribution maps using a free version of Arc Explorer.

Disclaimer

Following is the official Biological Resources Division (BRD) disclaimer as of 29 January, 1996, followed by additional disclaimers from GAP. Prior to using the data, you should consult the GAP home page (see How to Obtain the Data, above) for the current disclaimer.

Although these data have been processed successfully on a computer system at the BRD, no warranty expressed or implied is made regarding the accuracy or utility of the data on any other system or for general or scientific purposes, nor shall the act of distribution constitute any such warranty. This disclaimer applies both to individual use of the data and aggregate use with other data. It is strongly recommended that these data are directly acquired from a BRD server [see above for approved data providers] and not indirectly through other sources which may have changed the data in some way. It is also strongly recommended that careful attention be paid to the content of the metadata file associated with these data. The Biological Resources Division shall not be held liable for improper or incorrect use of the data described and/or contained herein.

These data were compiled with regard to the following standards. Please be aware of the limitations of the data. These data are meant to be used at a scale of 1:100,000 or smaller (such as 1:250,000 or 1:500,000) for the purpose of assessing the conservation status of vertebrate species and vegetation types over large geographic regions. The data may or may not have been assessed for statistical accuracy. Data evaluation and improvement may be ongoing. The Biological Resources Division makes no claim as to the data's suitability for other purposes. This is writeable data which may have been altered from the original product if not obtained from a designated data distributor identified above.

Metadata

Proper documentation of all information sources used to assemble GAP data layers is central to the scientific defensibility of GAP. The information used to describe GAP data is called metadata. Metadata are information about data. Metadata contain information about the source(s), lineage, content, structure, and availability of a data set. Metadata also describe intentions, limitations, and potential uses, allowing for the informed and appropriate application of the data. Descriptions of metadata function have recently been published by the Federal Geographic Data Committee.

The GAP metadata standards have been closely matched to the FGDC standards to ensure current and future compatibility. As the FGDC standards evolve beyond the current publication, we anticipate corresponding refinements in GAP documentation. The format of the GAP metadata consists of eight major documentation sections (Table 1) containing one or more metadata elements. Each element is named (e.g. Map Projection Name), and the "Type" of entry (text, integer, date, time) and "Domain" of the entry (i.e. $x > 0$) are also defined.

Table 1. Metadata Data Element Categories:

I	Identification Information: What the data set is called, file format description.
II	Data Quality Information: Accuracy, consistency, and data sources.
III	Spatial Data Organization Information: Data structure--raster, vector, point, etc.
IV	Spatial Reference Information: Coordinate units, map projection, spatial resolution.
V	Entity and Attribute Information: Attribute codes and reference citations.
VI	Distribution Information: How to order the data, on-line access, transfer size.
VII	Metadata Reference Information: Date of the metadata, contact for metadata updates.
XIII	Contact Information: General data contact, mail, voice, fax, web, e-mail.

Demands for metadata will increase as electronic networks expand across the national and international scene, and more requests are made for distribution of information. As the number of users and the diversity of disciplines and programs sharing the data expand, the information carried by metadata will become increasingly important. One of the goals in defining today's metadata standards is to anticipate these future needs.

For additional information via Internet: GAP home page address: http://www.gap.uidaho.edu/gap

Cogan, C.B., and T.C. Edwards. 1994. Metadata standards for GAP. Gap Analysis Technical Bulletin 3. Idaho Cooperative Fish and Wildlife Research Unit, University of Idaho, Moscow, Idaho. 28 pp. (A postscript file is available from the GAP web page listed above.)

For a postscript version of the current FGDC Metadata Standards (8 June 1994): waisqvarsa.er.usgs.gov (anonymous ftp, cd to wais/docs, get FGDCmeta6894.ps)

Federal Geographic Data Committee. 1995. Content Standards for Digital Geospatial Metadata workbook (March 24). FGDC. Washington D.C. (Describes the FGDC metadata standards.) http://geochange.er.usgs.gov/pub/tools/metadata/standard/metadata.html

Appropriate and Inappropriate Use of These Data

All information is created with a specific end use or uses in mind. This is especially true for GIS data, which is expensive to produce and must be directed to meet the immediate program needs. For GAP, minimum standards were set (see A Handbook for Gap Analysis, Scott *et al.* 1993) to meet program objectives. These standards include: scale or resolution (1:100,000 or 100 hectare minimum mapping unit), accuracy (80% accurate at 95% confidence), and format (ARC/INFO coverage tiled to the 30' x 60' USGS quadrangle). For complete project standards, refer to Appendix 1.3.

Recognizing, however, that GAP would be the first, and for many years likely the only, source of statewide biological GIS maps, the data were created with the expectation that they would be used for other applications. Therefore, we list below both appropriate and inappropriate uses. This list is in no way exhaustive but should serve as a guide to assess whether a proposed use can or cannot be supported by GAP data. For most uses, it is unlikely that GAP will provide the only data needed, and for uses with a regulatory outcome, field surveys should verify the result. In the end, it will be the responsibility of each data user to determine if GAP data can answer the question being asked, and if they are the best tool to answer that question.

Scale

First we must address the issue of appropriate scale to which these data may be applied. The data were produced with an intended application at the ecoregion level, that is, geographic areas from several hundred thousand to millions of hectares in size. The data provide a coarse-filter approach to analysis, meaning that not every occurrence of every plant community or animal habitat is mapped, only larger, more generalized distributions. The data are also based on the USGS 1:100,000 scale of mapping in both detail and precision. When determining whether to apply GAP data to a particular use, there are two primary questions: do you want to use the data as a map for the particular geographic area, or do you wish to use the data to provide context for a particular area? The distinction can be made with the following example: You could use GAP land cover to determine the approximate amount of oak woodland occurring in a county, or you could map oak woodland with aerial photography to obtain a more accurate estimate. You then could use GAP data to determine the approximate percentage of all oak woodland in the region or state that occurs in the county, and thus gain a sense of how important the county's distribution is to maintaining that plant community.

Appropriate Uses

The above example illustrates two appropriate uses of the data: as a coarse map for a large area such as a county, and to provide context for finer-level maps. Specific case-study examples are provided in Appendix 1.1, but following is a general list of applications:

- Statewide biodiversity planning
- Regional (Councils of Government) planning
- Regional habitat conservation planning
- County comprehensive planning
- Large-area resource management planning
- Coarse-filter evaluation of potential impacts or benefits of major projects or plan initiatives on biodiversity, such as utility or transportation corridors, wilderness proposals, regional open space and recreation proposals, etc.
- Determining relative amounts of management responsibility for specific biological resources among land stewards to facilitate cooperative management and planning.
- Basic research on regional distributions of plants and animals and to help target both specific species and geographic areas for needed research.
- Environmental impact assessment for large projects or military activities.
- Estimation of potential economic impacts from loss of biological resource based activities.
- Education at all levels and for both students and citizens.

Inappropriate Uses

It is far easier to identify appropriate uses than inappropriate ones, however, there is a "fuzzy line" that is eventually crossed when the differences in resolution of the data, size of geographic area being analyzed, and precision of the answer required for the question are no longer compatible. Examples include:

- Use of the data to map small areas (less than thousands of hectares), typically requiring mapping resolution at 1:24,000 scale and using aerial photographs or ground surveys.
- Combining GAP data with other data finer than 1:100,000 scale to produce new hybrid maps or answer queries.
- Generating specific areal measurements from the data finer than the nearest thousand hectares (minimum mapping unit size and accuracy affect this precision).
- Establishing exact boundaries for regulation or acquisition.
- Establishing definite occurrence or non-occurrence of any feature for an exact geographic area (for land cover, the percent accuracy will provide a measure of probability).
- Determining abundance, health, or condition of any feature.
- Establishing a measure of accuracy of any other data by comparison with GAP data.
- Altering the data in any way and redistributing them as a GAP data product.
- Using the data without acquiring and reviewing the metadata and this report.

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GLOSSARY OF TERMS

aerial videography - video images of the land surface taken from an airplane algorithm - a procedure to solve a problem or model a solution (In GAP typically refers to a GIS procedure used to model animal distributions.)

alliance level - a land unit made up of an "alliance" of natural communities that have the same dominant or co-dominant plant species or, in the absence of vegetation, by the dominant land cover typically described according to the Anderson land cover classification (see "Natural Community Alliance" in Grossman *et al.* 1995)

alpha diversity - a single within-habitat measure of species diversity regardless of internal pattern, generally over an area of 0.1 to 1,000 hectares (see Whittaker 1960, 1977)

Anderson Level II - the second hierarchical level in the Anderson land cover classification system (see Anderson *et al.* 1976)

anthropogenic - caused by man

assemblages - a group of ecologically interrelated plant and animal species

band, spectral - a segment of the electromagnetic spectrum defined by a range of wavelengths (e.g. blue, green, red, near infrared, far infrared) that comprise the Landsat TM imagery

beta diversity - the change in species diversity among different natural communities of a landscape; an index of between-habitat diversity (see Whittaker 1960, 1977)

biodiversity - generally, the variety of life and its interrelated processes

biogeographic - relating to the geographical distribution of plants and animals

biological diversity - see biodiversity

cartographic - pertaining to the art or technique of making maps or charts

classify - to assign objects, features, or areas on an image to spectral classes based upon their appearance as opposed to ‘classification’ referring to a scheme for describing the hierarchies of vegetation or animal species for an area

coarse filter - the general conservation activities that conserve the common elements of the landscape matrix, as opposed to the "fine filter" conservation activities that are aimed at special cases such as rare elements (see Jenkins 1985)

community - a group of interacting plants and animals

cover type - a non-technical higher-level floristic and structural description of vegetation cover cross-walking - matching equivalent land cover categories between two or more classification systems

delineate - identifying the boundaries between more or less homogenous areas on remotely sensed images as visible from differences in tone and texture

delta diversity - the change in species diversity between landscapes along major climatic or physiographic gradients (see Whittaker 1977)

digitization - entering spatial data digitally into a Geographic Information System

ecoregion - a large region, usually spanning several million hectares, characterized by having similar biota, climate, and physiography (topography, hydrology, etc.)

ecosystem - a biological community (ranging in scale from a single cave to millions of hectares), its physical environment, and the processes through which matter and energy are transferred among the components

edge-matching - the process of connecting polygons at the boundary between two independently created maps, either between TM scenes or between state GAP data sets

element - a plant community or animal species mapped by GAP. May also be referred to as "element of biodiversity"

error of commission - the occurrence of a species (or other map category) is erroneously predicted in an area where it is in fact absent

error of omission - when a model fails to predict the occurrence of a species that is actually present in an area

exact set coverage - a basic optimization problem to determine the best method for identifying general areas that, when selected sequentially, would have the greatest positive cumulative impact on attaining adequate representation of any or all biotic elements of interest

extinction - disappearance of a species throughout its entire range

extirpation - disappearance of a species from part of its range

fine filter - see "coarse filter"

floristic - pertaining to the plant species that make up the vegetation of a given area

formation level - the level of land cover categorization between Group and Alliance describing the structural attributes of a land unit, for example, "Evergreen Coniferous Woodlands with Rounded Crowns" (see Jennings 1993) gamma diversity - the species diversity of a landscape, generally covering 1,000 to 1,000,000 hectares, made up of more than one kind of natural community (see Whittaker 1977)

gap analysis - a comparison of the distribution of elements of biodiversity with that of areas managed for their long-term viability to identify elements with inadequate representation

geographic information systems - computer hardware and software for storing, retrieving, manipulating, and analyzing spatial data

Global Positioning System (GPS) - an instrument that utilizes satellite signals to pinpoint its location on the earth's surface

greedy heuristic - an algorithm for exact set cover analysis (see Kiester *et al.*, 1996)

ground truthing - verifying maps by checking the actual occurrence of plant and animal species in the field at representative sample locations

habitat - the physical structure, vegetational composition, and physiognomy of an area, the characteristics of which determine its suitability for particular animal or plant species

hectare - a metric unit of area of 10,000 square meters and equal to 2.47 acres

hex/hexagon - typically refers to the EPA EMAP hexagonal grid of 635 square kilometer units

hyperclustering - an efficient, interactive method for accurately analyzing and classifying remotely-sensed data that reduces data size and computational requirements while retaining the integrity of the original data

lotic - flowing, e.g., water in a stream or river

metadata - information about data, e.g., their source, lineage, content, structure, and availability

minimum mapping unit - the smallest area that is depicted on a map

neotropics - the zoo-geographic region stretching southward from the Tropic of Cancer and including southern Mexico, Central and South America, and the West Indies

phenology - the study of periodic biological phenomena, such as flowering, breeding, and migration, especially as related to climate

phenotype - the environmentally and genetically determined observable appearance of an organism, especially as considered with respect to all possible genetically influenced expressions of one specific character

physiognomic - based on physical features physiographic province - a region having a pattern of relief features or land forms that differ significantly from that of adjacent regions

pixel - the smallest spatial unit in a raster data structure

polygon - an area enclosed by lines in a vector-based Geographic Information System data layer or a region of contiguous homogeneous pixels in a raster system

preprocessing - those operations that prepare data for subsequent analysis, usually by attempts to correct or compensate for systematic, radiometric, and geometric errors

pro-active - acting in anticipation of an event as opposed to reacting after the fact

range - the geographic limit of the species

range unit - a spatial, geographic unit to record and display species geographic range

reach - a stream or river segment between inflowing tributaries

registration, spatial - matching different images to each other by finding points on the images that can be matched to known points on the ground

remote sensing - deriving information about the earth's surface from images acquired at a distance, usually relying on measurement of electromagnetic radiation reflected or emitted from the feature of interest

resolution - the ability of a remote sensing system to record and display fine detail in a distinguishable manner, or the smallest feature that can be distinguished or resolved on a map or image, such as a TM pixel

scale, map - the ratio of distance on a map to distance in the real word, expressed as a fraction; the smaller the denominator, the larger the scale, e.g. 1:24,000 is larger than 1:100,000

sensitivity analysis - the consideration of a number of factors involved in the mathematical modeling of an ecosystem and its components. These include feedback and control, and the stability and sensitivity of the system as a whole to changes in some part of the system. Predictions can be made from the analysis.

simulated annealing - an algorithm used for set coverage analysis (see Kiester *et al.* 1996)

species richness - the number of species of a particular interest group found in a given area

spectral cluster - a group of adjacent pixels that are uniform with respect to their brightness values supervised classification - the process of classifying TM pixels of unknown identity by using samples of known identity (i.e., pixels already assigned to informational classes by ground truthing or registration with known land cover) as training data

synoptic - constituting a brief statement or outline of a subject; presenting a summary

tessellation - the division of a map into areas of equal and uniform shape such as the EPA-EMAP hexagon

Thematic Mapper - a sensor on LANDSAT 4 and 5 satellites that records information in seven spectral bands, has a spatial resolution of about 30 m x 30 m, and represents digital values in 256 levels of brightness per band

transect - a transversely cut line along which physical and biological observations are made

trophic structure - the various levels in a food chain, such as producers (plants), primary consumers (herbivores), and secondary consumers (carnivores)

Universal Transverse Mercator - one of several map projections or systems of transformations that enables locations on the spherical earth to be represented systematically on a flat map

Universal Transverse Mercator grid - a geographic reference system used as the basis for worldwide locational coding of information in a GIS or on a map

unsupervised classification - the definition, identification, labeling, and mapping of natural groups, or classes, of spectral values within a scene. These spectral classes are reasonably uniform in brightness in several spectral channels.

vector format - a data structure that uses polygons, arcs (lines), and points as fundamental units for analysis and manipulation in a Geographic Information System

virtual reality - a computer-generated simulation of reality with which users can interact using specialized peripherals such as data gloves and head-mounted computer graphic displays

wildlife habitat relationship model - a method of linking patterns of known habitat use by animal species with maps of existing vegetation, thereby identifying the spatial extent of important habitat features for use in conservation and management.

GLOSSARY OF ACRONYMS

ACSM American Congress on Surveying and Mapping
ADAMAS Aquatic Database Management System
AML ARC/INFO Macro Language
ASPRS American Society for Photogrammetry & Remote Sensing
AVHRR Advanced Very High Resolution Radiometer (satellite system)
BEST Biomonitoring of Environmental Status and Trends
BLM Bureau of Land Management
CAFF Conservation of Arctic Flora and Fauna
C-CAP Coastwatch Change Analysis Program (NOAA)
CDC Conservation Data Center
CEC Council on Environmental Cooperation
CENR Committee on Environment and Natural Resources
CERES California Environmental Resources Evaluation System
CIESIN Consortium for Internat'l Earth Science Information Network
CODA Conservation Options and Decision Analysis (software)
CRMP Coordinated Resource Management Plan
CRUC Cooperative Research Unit Center
DLG-E Digital line graph - enhanced
DOI Department of the Interior
EDC EROS Data Center
ECOMAP National Hierarchical Framework of Ecological Units mapping project of the USFS
EMAP Environmental Monitoring & Assessment Program
EMAP-LC EMAP-Landscape Characterization (USEPA)
EMSL Environmental Monitoring & Systems Laboratory (USEPA)
EMTC Environmental Management Technical Center (NBS)
EOS Earth Observing System
EOSAT Earth Observation Satellite Company (the operator of the Landsat satellite system)
EOSDIS EOS Data & Information System
ERL Environmental Research Laboratory, Corvallis (USEPA)
EROS Earth Resources Observation Systems (USGS)
ESRI Environmental Systems Research Institute
ETM+ Enhanced Thematic Mapper plus
FGDC Federal Geographic Data Committee
FTP file transfer protocol
FY Fiscal Year
GAO General Accounting Office (Congress)
GAP Gap Analysis Program
GCDIS Global Change Data and Information System
GLIS Global Land Information System (USGS)
GLOBE Global Learning and Observations to Benefit the Environment
GPS Global Positioning System
GRASS Geographic Resources Analysis Support System
GRIS Geographic Resource Information Systems

HRMSI High Resolution Multispectral Stereo Imager
IALE International Association of Landscape Ecology
IDRISI A GIS developed by Clark University
LAPS Land Acquisition Priority System
LC/LU Land Cover/Land Use (USGS)
MIPS Map and Image Processing System
MMU Minimum mapping unit
MOU Memorandum of Understanding
MRLC Multi-Resolution Land Characteristics Consortium
MSS Multi-Spectral Scanner
MTPE Mission to Planet Earth
NAFTA North American Free Trade Agreement
NALC North American Landscape Characterization (USEPA, USGS)
NAWQA National Water Quality Assessment (USGS)
NBII National Biological Information Infrastructure
NBS National Biological Service
NCCP Natural Communities Conservation Planning program (in CA)
NDCDB National Digital Cartographic Data Base
NERC National Ecology Research Center (Ft. Collins, CO)
NMD National Mapping Division
NPS National Park Service
NSDI National Spatial Data Infrastructure
NSTC National Science and Technology Council
NWI National Wetlands Inventory (USFWS)
OMB Office of Management and Budget (Administration)
PARC Public Access Resource Center
PI Principal Investigator
RMSE Root mean square error
SAB Science Advisory Board (USEPA)
SCICOLL Scientific Collections Permit Database
SDTS Spatial Data Transfer Standard
SGID State Geographic Information Database
SNEP Sierra Nevada Ecosystem Project
SOFIA Southern Forest Inventory and Analysis
SPOT Système Pour l'Observation de la Terre
TIGER Topologically Integrated Geographic Encoding and Referencing (used for U.S. census)
TM Thematic Mapper
TNC The Nature Conservancy
UNESCO United Nations Educational, Scientific, and Cultural Organization
URISA Urban and Regional Information Systems Association.
URL Universal Resource Locator
USFS US Forest Service
USFWS US Fish & Wildlife Service
UTM Universal Transverse Mercator
WHRM Wildlife/habitat relationship model

Appendix 1.1 - List of Example GAP Applications

Businesses and Non-government Organizations:

The following are some examples of applications of GAP data by the private sector:

- The Wyoming Natural Heritage Program (a private non-government organization) transformed the endangered and sensitive species database into a spatially referenced digital geographic information system using the GAP digital base map and other GAP spatial data.
- Hughes Corp. is experimenting with the Utah and Nevada GAP digital base maps, simulating images to aid the development of new space-based remote sensing devices.
- The Nature Conservancy used the Wyoming GAP data to develop a map of ecoregions of Wyoming.
- Weyerhaeuser Corp. is using the Arkansas GAP data in managing their lands in Arkansas.
- IBM Corp. is funding a project at the University of California, Santa Barbara, that, in part, uses GAP data in the development of visualization software.
- NM-GAP vegetation data is being used for an environmental assessment of a proposed spaceport, a state/private venture.

County and City Planning:

Some other examples of the use of GAP by local governments are:

- CA-GAP biological data were combined with the Southern California Association of Governments (SCAG) land ownership data to show which ownerships and jurisdictions were needed for joint conservation planning and management of a particular natural community or species, maximizing efficiency and minimizing the potential for yet another conservation crisis.
- In California, county and city planners of several jurisdictions, wildlife agencies, developers of the 4S Ranch property, and the state Natural Communities Conservation Planning program used the GAP regional data, as well as more detailed information, to conserve 1,640 acres of habitat within a 2,900-acre planned development.
- County planners in Piute County, Utah used GAP data to optimize the siting of a proposed sawmill for aspen with respect to the distribution of aspen stands.
- Missoula County, Montana, used the GAP land cover map of the area as a base map for its comprehensive long-range plan.
- Snohomish County, Washington, used the GAP land cover map in meeting state requirements for a growth management plan.
- The City of Bainbridge Island, Washington, used GAP data to assist them in development of a watershed planning project.

State Uses:

The following are some examples of uses of GAP data by state agencies.

- The GAP database of species habitats was used by the Tennessee Wildlife Resources Agency (TWRA) to update its book “Species in Need of Management.”
- Images of land cover derived from GAP TM data are used by TWRA for locating particular habitat types. Information on the locations of these habitat types is provided by TWRA to the public for a wide variety of public service functions, from education to cooperative resource management.
- Early GAP data developed by TWRA were used to help identify an important area of the state with high biodiversity that was subsequently purchased by the state for conservation.

- Preliminary findings from GAP were used by TWRA to develop three resource management initiatives.
- The Tennessee GAP project, which is being carried out primarily by TWRA, is the foundation of a multi-agency, long-term biodiversity program for Tennessee.
- GAP data have been used by the Tennessee Forestry Stewardship Program to help develop a district program for nine conservation planning districts, outlining Best Management Practices (BMPs) for biological conservation on private lands.
- GAP data are being used extensively by TWRA in the preparation of project proposals to the North American Waterfowl Conservation Program. These proposals require that biodiversity issues are addressed in specific detail. The use of GAP data on occurrence of land cover types and terrestrial vertebrates has made this possible.
- The Wyoming Department of Fish and Game (WYF&G) used GAP data to assist them in transforming the Wildlife Observation System database into a spatially referenced geographic information system.
- The Utah Division of Wildlife Resources and the Bear River Water Conservancy District used the Utah GAP land cover map in a resource management assessment for mitigating conflicts between a proposed groundwater withdrawal project and the maintenance of an elk calving area in the Uinta Mountains.
- The Utah Division of Wildlife Resources, the Rocky Mountain Elk Foundation, and Sheik Safari International used the Utah GAP land cover map to identify critical elk habitat. The environmental profile of these areas was then used to identify other similar areas for elk habitat enhancement.
- The Utah Division of Wildlife Resources used the Utah GAP land cover map for a rapid ecological assessment of the Echo Henefer Wildlife Management Area.
- The Washington Department of Fish and Wildlife used GAP data to develop a breeding bird atlas and an atlas of mammals of Washington State.
- The Washington Department of Fish and Wildlife uses GAP data to operate an integrated landscape management program.
- The Washington Department of Fish and Wildlife uses GAP data from Eastern Washington to assist with an innovative program that brings the forest products industry, state agency biologists, non-government organizations, and tribal biologists together in the field to jointly determine the appropriate management practices for any particular site of concern (Timber, Fish & Wildlife Program).
- The Idaho Department of Fish and Game used GAP data to evaluate the impact from expanded military training activities on public lands in Southern Idaho.
- The Idaho Department of Fish and Game uses GAP data for regional planning efforts on a regular basis.

<u>Statewide Planning</u>:

Biodiversity planning programs or projects are now under way or have been completed in Arizona, California, Colorado, Maine, Missouri, Nevada, Oregon, and Tennessee. It is likely that similar efforts will develop in other states. In some cases, these efforts grew out of the state GAP project, however, in most cases, the GAP data are being used to meet a previously defined need. In all cases, GAP data are central to their development and operations. The goals of each of these programs or projects are presented briefly below.

Federal Agency Applications:

Some examples of applications of GAP data by federal agencies follow:

- GAP data are being supplied to all military installations in the Great Basin ecoregion for integrated management of the natural resources. These installations constitute a very large amount of land area. Much of it is of high value for native species.
- The Ouachita National Forest used the Arkansas GAP data to help them develop an ecosystem management plan.
- The Wyoming GAP data were used by NASA to calibrate a model that predicts vegetation types based on climate and soil variables.
- The potential contributions to biodiversity conservation of four different options proposed for new wilderness designation in Idaho were quantified by the Idaho Cooperative Fish and Wildlife Research Unit in cooperation with the Park Studies Unit.
- The potential contributions to biodiversity conservation of four different options proposed for new national park designation in Idaho were quantified by the Idaho Cooperative Park Studies Unit.
- The U.S. Forest Service in Booneville, Arkansas, used the Arkansas GAP data land cover maps in a 3-dimensional presentation to provide the public with a visual representation of the region and to enhance the public's involvement with the National Forest planning process.
- The U.S. Fish and Wildlife Service regularly uses the GAP data for Southern California for habitat evaluation and management.
- The U.S. Forest Service, Bureau of Land Management, and National Park Service are using the GAP data for a wide variety of natural resource management operations in Utah. For example, the entire Utah GAP database is directly linked with existing National Park Service databases for use by National Parks.
- The Bureau of Land Management uses the Wyoming GAP data for managing the Buffalo Resource Area.
- The U.S. Forest Service used the Utah GAP data to help assist them in evaluating human-induced impacts to forested lands surrounding ski resorts in central Utah.
- The U.S. Fish and Wildlife Service in Delaware used GAP data to help identify potential habitat for the federally endangered Delmarva fox squirrel. These maps were displayed and served as a catalyst for bringing together people with a stake in the issue.
- The U.S. Fish and Wildlife Service used the Indiana GAP data as part of a biological assessment for the base closure of the Jefferson Proving Grounds and its conversion to a National Wildlife Refuge. This 58,000-acre installation has restricted human access due to unexploded ordinance and contains some of the highest quality natural habitat in Indiana.
- The U.S. Fish and Wildlife Service in Louisiana used GAP data to avoid conflict over the designation of critical habitat of the federally endangered Louisiana black bear.
- The U.S. Natural Resources Conservation Service in New Mexico is using a GAP clustered imagery as a base for their land cover mapping activities.
- The Department of Defense (DoD) is funding the development of an electronic environmental information system for the Mojave ecoregion, which would use GAP data as a foundation or base layer of information. The system will link 29 DoD installations to a common source of environmental information.

Appendix 1.2 - Descriptions of Oregon's Ecoregions

Coast Range

The Coast Range Ecoregion includes the entire Oregon coastline and the northern and central Oregon Coast Range Mountains, and extends north though the state of Washington to southwestern British Columbia on Vancouver Island, and south into California. Elevations in the Oregon Coast Range Ecoregion range from sea level to 4,000 feet, and the marine climate creates the most moderate and wettest habitats in the state. Average annual precipitation of 60 to 180 inches supports spectacular stands of temperate rainforests. Vegetation is characterized by forests of Sitka spruce, western hemlock, Douglas fir and red alder.

The Oregon coast has other unique ecological features. Sand deposits from coastal streams and rivers (primarily the Umpqua and Columbia Rivers) have created major coastal dune systems, the largest located at the Oregon Dunes National Recreation Area. In the north coast, steep headlands and cliffs are separated by stretches of flat coastal plain and large estuaries. The south coast includes the warmest areas, with rugged headlands and very mild winters, supporting local endemic species such as the coast redwood and Port Orford cedar.

Almost 40% of the region is in public ownership, primarily in National Forest and State Forest lands. Population is dispersed in many small towns, most located within a few miles of the ocean. Forest products, tourism and fisheries are the mainstays of the local economy. The Coast Range Ecoregion includes all of Oregon's coastal resources, including all of the intertidal, marine and estuarine habitats. These resources are currently not well represented in Oregon's system of natural areas. The publication of the *Territorial Sea Plan* (Oregon Ocean Policy Advisory Council,1994) has created an excellent opportunity to better protect Oregon's marine and intertidal resources.

Willamette Valley

The Willamette Valley Ecoregion is located between the Coast Range and the Western Cascades in northwestern Oregon and includes Oregon's largest river valley. From Oregon it extends north to include the Vancouver, Washington bottomlands. The valley is characterized by broad, alluvial flats and low basalt hills. Soils include deep alluvial silts from river deposits and dense heavy clays from pluvial deposits in the valley bottom's numerous oxbow lakes and ponds.

The abundant rainfall and fertile soils make the valley Oregon's most important agricultural region. This has been the case since the first settlers began arriving via the Oregon trail. As a result, the Willamette Valley is Oregon's most altered ecoregion.

Originally, the valley was a mosaic of gallery riparian forests and wetlands, open white oak savannas and prairie, with valley margins of oak, ponderosa pine and Douglas fir woodlands. Native Americans maintained the prairies, oak savannas and woodlands by regularly burning most of the valley. With settlement, the prairies have been largely farmed and the open oak savannas and oak-conifer woodlands have been logged or become closed canopy forests.

The Willamette Valley is home to most Oregonians, with more than 70% of the state's population, the majority of its industry, and almost half of its farmland. It is also the fastest growing ecoregion, with the human population expected to double in the next 25 years.

The Willamette Valley's location on the Pacific Flyway makes it an important area for migrating and wintering waterfowl. Geese and shorebirds benefit from flooded agricultural lands, and the Willamette River and its many tributaries support salmon and steelhead runs, mostly of hatchery origin due to the large number of dams in the system. The valley’s few remaining fragments of native prairie support many special plant species and endemic invertebrates, while the remaining wetlands provide habitat to the Oregon chub, the western pond turtle and many other sensitive animal species.

Klamath Mountains

The Klamath Mountains Ecoregion covers most of southwestern Oregon and northwestern California and includes the Siskiyou Mountains, California’s Marble Mountains and Trinity Alps and the interior valleys and foothills between these mountain ranges. Elevations range from 100 to over 7,500 feet. Valley bottoms in the interior generally range between 450 feet elevation in the north around Roseburg to almost 2,000 feet at Ashland near the California border.

The ecoregion has the oldest landscapes in Oregon and is one of the few areas of the state not shaped largely by volcanism. It also is by far the most geologically diverse, having large areas of metamorphic and sedimentary rocks such as serpentine, limestone and gabbro, as well as granites and basalt. Topography ranges from steep, dissected mountains and canyons to gentle foothills and flat valley bottoms. The ecoregion also has major climatic extremes. Far western portions receive more than 100 inches of rain per year, with relatively mild temperatures year-round. The southern interior valleys are much drier, with locations receiving less than 20 inches of rain per year and summer high temperatures averaging more than 90E F.

The combination of exceptional climatic, geologic, and topographic diversity supports the most diverse habitats in Oregon. In addition to diverse habitats, the Klamath Mountain Ecoregion is a floristic crossroads, including elements of the Sierra Nevada Mountains, Sacramento Valley and Coast Range Mountains of California; the Cascade Mountains of Oregon and Washington; and the Great Basin to the east.

Because of its geologic age, stable climate, and many unusual habitats, the ecoregion is a major center of species endemism for vascular plants. Of the 4,000 native plant species or subspecies occurring in Oregon, about half are found in this ecoregion, with about a quarter of these known only here. The region is also known for its diversity of conifers, with 30 different species. (In Oregon, the West Cascades has the second largest number of conifer species, with 18 species).

Prior to European settlement, the landscape was dominated by three major vegetation types: Douglas-fir forests, oak woodlands and ponderosa pine woodlands. Other significant communities include native grasslands and chaparral which dominated the historic valley bottoms, and Port Orford cedar forests, which have been decimated by logging and disease. All of the natural habitats have changed since fire suppression became effective in the early twentieth century. The region has a high frequency of dry, summer lightning storms, leading to natural fire frequency of less than 40 years for most of the region, and closer to 20 years in the valleys and eastern portions of the region. Over fifty years of fire suppression have dramatically altered the ecology of the forests, savannas and shrublands in this region.

The human population of the ecoregion is concentrated in the valleys along the Interstate 5 corridor. Forest products, agriculture and tourism are the foundations of the local economy. The region is currently growing at a rate second only to the Willamette Valley.

West Cascades and Crest

The West Cascades Ecoregion extends from southern British Columbia south almost to the California border. This mountainous, heavily forested ecoregion is bounded on the west by the farms and woodlands of the Puget Trough and the Willamette Valley or the drier forests and valleys of the Klamath Mountains. To the east, it spills over the crest of the Cascade Mountains to the drier ponderosa pine forests of the East Cascades Ecoregion.

The crest of the Cascade Range is dominated by a series of volcanic peaks. Mount Hood is the highest peak in the state at 11,240 feet, but a dozen others top 8,000 feet. The western slopes of the range feature long ridges with steep sides and wide, glaciated valleys. Most of the rivers draining the northern two-thirds of the ecoregion flow into the Willamette Valley and then to the Columbia River system; the southern third drains to the Pacific Ocean through the Umpqua and Rogue River systems. The climate varies with elevation and, to a lesser extent, latitude. Higher elevations receive heavy winter snows. The drier southern half has a fire regime similar to the Klamath Mountains, with frequent lightning-caused fires. In the northern half, the natural fire regime has historically produced less frequent but more severe fires.

The ecoregion is almost entirely forested and the flora and fauna are similar to that of the Coast Range Ecoregion. Douglas-fir-western hemlock forests dominate large areas up to elevations of 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 found in a mosaic with hardwood species such as bigleaf maple and red alder. Silver fir-mountain hemlock forests occur at mid-elevations. Silver fir is common between 2,600 and 4,200 feet. Mountain hemlock is most common between 2,200 and 6,000 feet. In the higher areas, mountain hemlock or occasionally Alaska yellow cedar, subalpine fir, or whitebark pine woodlands open into alpine parklands with patches of forest interspersed with shrub and meadow communities. Alpine areas feature a variety of habitats ranging from dwarf shrubs, grasses and forbs to wetlands and barren expanses of rocks and ice.

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 the northern spotted owl, 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 recreation use supplements the traditional timber-based economy.

East Cascades

The East Cascades Ecoregion is a transition zone that extends from below the crest of the Cascade Range east to where the ponderosa pine zone meets the sagebrush-juniper steppe. The ecoregion also extends north into Washington and south into California. In Oregon, the ecoregion is variable, including extensive lodgepole forests on deep Mazama ash, the montane and foothill Ponderosa pine forests, Klamath Basin lakes and wetlands, and many diverse montane forests.

The eastern slopes of the Cascades are drier than the western slopes, with annual rainfall ranging from 14-26 inches per year. The ecoregion is less steep and cut by fewer streams than the west side of the mountain range. It is also predominantly covered by conifer forests growing on volcanic soils. The northern two-thirds of the East Cascades is drained by the Deschutes River system, which includes a series of large lakes and reservoirs near its headwaters. The southern third is drained by the Klamath River, which flows south and west into California.

The Klamath Basin, which extends into the Modoc Plateau in California, is a broad, relatively flat mid-elevation valley that historically supported a vast expanse of lakes and marshes. Oregon's largest lake, Upper Klamath Lake, is the biggest remnant of this wetland system. Most of the basin's wetlands have been drained and converted to agriculture.

The mountains on the northern and eastern edges of the Klamath Basin lack a generally accepted name, but include a series of peaks and ridges extending from Paulina Peak near Bend southward through the headwaters of the Williamson, Sprague and Chewaucan Rivers to the Warner Mountains east of Lakeview. These mountains are generally forested, but the valleys and flats between them 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 number of shorebirds and waterfowl, the densest wintering concentration of bald eagles in the world, and many other wildlife species.

Also of significance is the broad ecological zone found at the northern end of this region in Oregon, where the Columbia River Gorge created the only Oregon white oak zone in eastern Oregon - and a wealth of diversity. This Columbia Gorge transition zone, the extensive Ponderosa pine forests and woodlands, and the vast wetlands of the Klamath and upper Deschutes basin characterize this region.

The ecoregion's human population is concentrated in the cities of Hood River, Bend and Klamath Falls. Forest products, agriculture, recreation and tourism are the biggest contributors to local economies.

Columbia Basin

The Oregon portion of the Columbia Basin Ecoregion (sometimes referred to as the Umatilla Plateau) extends from the eastern slopes of the Cascades Mountains south and east from the Columbia River to the Blue Mountains. The ecoregion also extends northward throughout most of eastern Washington, including a small portion of west central Idaho. The region includes the

Columbia Basin proper, and the Palouse, which is recognized by many geographers as a separate region.

The Columbia River, with its historic floods and large deposits of loess (wind-borne silt and sand) from the end of the last ice age, has greatly influenced the region. Most of the Oregon portion of the ecoregion is a lava plateau broken by basalt canyons carved out by the Deschutes, John Day, and Umatilla rivers and other streams that flow into the Columbia River. The climate is arid, with cold winters and hot summers. Most of the ecoregion receives less than 15 inches of precipitation per year (some areas as little as eight inches), much of that in the form of snow.

The majority of the ecoregion's natural vegetation is native bunchgrass prairie, often called palouse prairie because of the deep, loess soils and plentiful bunchgrass. The majority of the ecoregion in Washington was originally sagebrush steppe. Sandy deposits along the Columbia River support open dunes, grasslands, bitterbrush and sagebrush steppe, and western juniper. A few species of ground-squirrel and plants (milkvetch species among others) adapted to these habitats. The rivers are generally characterized by intermountain riparian vegetation, with black cottonwood, willows, chokecherry and aspen dominating riverbanks. Less common are riparian habitats dominated by black hawthorn and white alder.

Early travelers along the Oregon trail found vast natural grasslands broken by brushy draws and tree- and rimrock-bordered streams with numerous springs. Because of the deep loess soils, mild climate (due to low elevations) and the presence of adequate water (either from wells or from the Columbia, Snake and Umatilla rivers), much of this region provided model farmland. The human population is concentrated in the northeastern portion of the ecoregion, where Pendleton, Hermiston and other smaller communities serve as commercial centers for the agricultural economy.

The Columbia Basin Ecoregion is second only to the Willamette Valley in the percentage of landscape converted to non-native habitats and human uses. Protected areas and public lands are very limited in this region -- with the only vegetation types that have not declined dramatically found on lands that cannot be farmed: the steep canyon grasslands and scablands.

Blue Mountains

The Blue Mountains Ecoregion occupies nearly all of northeastern Oregon and extends into small portions of southern Washington and western Idaho. It encompasses three major mountain ranges -- the Ochoco, Blue and Wallowa Mountains. Landscapes include deep, rocky-walled canyons, glacially cut gorges, dissected plateaus, broad alluvial river valleys, and numerous mountain lakes, forests and meadows. Due to sharp elevational differences, the climate varies over broad temperature and precipitation ranges. Overall, the ecoregion is characterized by short, dry summers and long, cold winters.

The flora is intermediate between the east Cascades and the western Rocky Mountains of Idaho and Montana. Species composition changes with altitude. Sagebrush and grassland steppes dominate the entire eastern length of the region along with significant areas along the south, and include some of the largest and best quality bunchgrass prairies and canyon grasslands remaining in North America. Ponderosa pine woodlands are characteristic at mid-elevations and mixed coniferous forests dominate at higher altitudes. Barely half the ecoregion is forested, but vast sections at all elevations are treeless due to dry conditions and the harsh climate.

Most of the region is thinly populated, with small towns in the major valleys and rural residents scattered throughout the smaller valleys among the mountains. Timber, ranching, agriculture and tourism provide the foundations for the local economy in most areas.

The diversity in elevation, soils and climate yields diverse habitats and many endemic plant species. The Wallowa Mountains alone have more than ten plants species found nowhere else. Bighorn sheep, elk and large mammal populations are among the largest in the state. The variety in habitats, including low, mid and high elevation grasslands, shrublands and forests results in this ecoregion having more habitat diversity than all but the Klamath Mountains Ecoregion. The region is the headwaters for most of eastern Oregon's rivers, and provides critical riparian and fish habitat for more than half of the state.

High Lava Plains

The High Lava Plains is the only ecoregion contained entirely within Oregon's borders. It is essentially a lava plateau dissected by canyons of the Deschutes, John Day and Crooked Rivers. Elevations in most areas are between 3,500 and 4,500 feet, but range from as low as 1,400 feet in the Deschutes River canyon at Warm Springs to as high as 6,500 feet on higher basalt rims and buttes rising from the plateau.

The climate is arid, with 10-20 inches of precipitation per year. Although some of eastern Oregon's major rivers cross the Lava Plains, most of the water originates in adjoining ecoregions. Before the advent of modern reservoirs and irrigation systems, the plateau had no major lakes and few large wetlands.

Western juniper achieves its greatest dominance and diversity in this area, where it occurs in more than 30 plant communities. Before European settlement, basin big sagebrush, native grasslands and riparian woodlands were widespread in this region. Today, it is more common to find irrigated alfalfa, grains and mint occupying the region's valley bottoms and plains, while juniper has expanded into many former shrub-steppe vegetation types.

The ecoregion can be divided into three general sections: the western high plateaus, the John Day River basin and the upper Crooked River steppe. The western-most section, the plateau lands along the Deschutes and lower Crooked Rivers between Bend and Madras, includes substantial areas that have been converted to irrigated agriculture and urbanization. Rapid population growth and increasing recreational uses have increased development pressures dramatically in the juniper woodlands and sagebrush steppes of this area. Agriculture and recreation are key components of an increasingly diversified economy.

The northeastern arm of the ecoregion extends from the sagebrush steppe and juniper-dominated hills east of the Deschutes plateau to the valleys along the main stem John Day River and the lower reaches of its north and south forks. Most of the bottomlands along the rivers have been converted to agriculture. Small communities along the John Day River are supported by agriculture, grazing, timber processing from the forests of the Ochoco and Blue Mountains and tourism.

The southeastern portion of the ecoregion, along the tributaries of the South Fork and mainstem Crooked River, is made up of more arid sagebrush steppe. Livestock grazing is the primary land use in this sparsely populated area.

Basin and Range

The Basin and Range Ecoregion is the Oregon portion of the Northern Basin and Range Ecoregion. It includes southeastern Oregon's high desert and extends south into Nevada to Reno and extreme northeastern California. The ecoregion's name reflects its topography and geology, with numerous flat basins separated by isolated, generally north-south mountain ranges. Many of the mountains are fault blocks, with gradual slopes on one side and precipitous basalt rims on the other. In Oregon, elevations range from 4,100 feet in the lowest basin to more than 9,700 feet on Steens Mountain. Soils are generally rocky and thin, low in organic matter and high in minerals.

The climate is arid, with extreme ranges of daily and seasonal temperatures -- with the Alvord Desert (Oregon's driest location) receiving less than 7 inches of rain annually. Runoff from precipitation and mountain snowpacks the basins often flows into flat, alkaline playas, where it forms seasonal shallow lakes and marshes.

Also known as the sagebrush desert or high desert, the Basin and Range Ecoregion contains many diverse habitats. The most significant of these are the sagebrush steppe types, salt desert scrub, riparian and wetland types, and mountain mahogany and aspen woodlands. Sagebrush steppe communities include Wyoming big sagebrush, basin big sagebrush, mountain big sagebrush, silver sagebrush, black sagebrush, low sagebrush and rigid sagebrush types. The region has Oregon's best examples of salt desert scrub, as well as its largest playas. The large wildlife refuges and closed basin wetlands here support some of the largest populations of pronghorn antelope, sage grouse, white pelicans, waterfowl, and are well known for their wildlife diversity.

This is the most sparsely inhabited ecoregion, with the small towns of Burns and Lakeview being the only population centers. Livestock, agriculture and tourism are the foundations of the regional economy. Lumber production, formerly a major source of employment in the Burns and Lakeview areas, has declined with lower harvests on nearby national forests.

Owyhee Uplands

The Owyhee Uplands Ecoregion covers the extreme southeast corner of Oregon, occupying the entire Owyhee River drainage, as well as the lower basin of the Malheur River. The ecoregion also extends into southwestern Idaho and northern Nevada. The ecoregion has similar vegetation as the adjacent Basin and Range Ecoregion, but differs markedly in its terrain. The

Owyhee Uplands landscape is basically a broad, undulating plateau cut by deep riverine canyons. Elevations range from 2,100 to 6,500 feet, with the average elevation of the plateau at about 4,000 feet. The climate is one of extremes, with generally moist springs and cold winters bringing moisture in the form of snow, resulting in annual precipitation of only 8-12 inches. Summers are hot and dry with temperatures regularly exceeding 90º F, and the occasional thunderstorms producing more lightning than rain.

Another important influence in the ecoregion is the geology, which is mostly of volcanic origin. Over large portions of the landscape, soils have been derived from underlying layers of basalt and rhyolite, or occasionally from sedimentary layers that have been exposed by erosion. Of more interest than these ?normal soils” are soils derived from volcanic ash and welded tuffs, which are found in distinct sites such as Leslie Gulch and Succor Creek near the Idaho border, or the extensive recent lava flows such as Jordan Craters or Saddle Butte Lava Field.

The weathering of the exposed volcanic ash has resulted in unique soils with a high clay content and an unusual chemical composition. The adaptational challenge these peculiar soils present for plants has given rise to a relatively rich flora of endemic species. The welded tuffs in these areas have also produced remarkable rock formations that rival more well-known erosional formations in the national parks of Utah’s Colorado Plateau country.

Diverse sagebrush steppe communities dominate most of the ecoregion, including Wyoming big sagebrush, basin big sagebrush, mountain big sagebrush, silver sagebrush, black sagebrush, low sagebrush and rigid sagebrush communities. Curl-leaf mountain mahogany woodlands achieve their greatest diversity in the Mahogany Mountain area of this ecoregion.

The ecoregion’s population is concentrated in the northeastern corner, where irrigated agriculture in the fertile lowlands along the Snake and Malheur Rivers is the foundation of the local economy. This area is occasionally considered part of a separate ecoregion called the Snake River Plains. In the remainder of the region, the economy is almost entirely based on local ranching.

Appendix 1.3. National Gap Analysis Project Standards - 10/26/1999

Patrick Crist and Michael Jennings
Idaho Cooperative Fish and Wildlife Research Unit
University of Idaho, Moscow, ID

Introduction

This document provides a summary of standards for conducting a Gap Analysis Project. As a collaborative "bottom-up" effort, the National Gap Analysis Program recognizes the need for a flexible approach at the state level. However, in order to provide ecologically meaningful information at the bioregional and national levels, certain minimum project standards are essential. The standards described below apply to all products delivered to the national program. Detailed descriptions of standards for individual components are provided in the Handbook for Gap Analysis (Scott and Jennings 1994), but note that this section references information in specific chapters that may be in progress and therefore not yet available. For clarification, contact the National GAP office. Projects shall indicate in their proposals, contracts, and modifications the standards in effect at the time the agreement is developed (version number and date). They will not be subject to later revisions of the standards but are strongly encouraged to meet the standards in effect at the time of project completion when doing so will not result in delay of completion or increase in project cost. In particular, this applies to file and database field names and attribute codes which are easily revised and critical for regionalization of the data.

A note on terminology: Because this is a summary chapter, we do not define terms or provide citations or sources of information that are already provided in the Handbook chapters for those specific items. See also the Glossary in the Handbook for definitions of many terms and acronyms. We introduce with this chapter the use of the term "resolution" which replaces Minimum Mapping Unit (MMU). GAP previously required land cover to be aggregated to a MMU of 100 ha which suggested that nothing smaller than 100 ha should be portrayed. We no longer make that requirement and instead state that "the resolution of this coverage is at least X ha" to indicate the smallest mapped unit that a project should be able to portray, but it may portray smaller features as well. This is further explained in this chapter and will be treated in detail in the forthcoming revision of the Land Cover chapter (see Handbook table of contents for chapter status).

<u>Basic GAP Components and Deliverables:</u>

The basic GIS coverages and associated databases required to complete Gap Analysis are identified below. The list of deliverables is substantially expanded to: a) support data regionalization and analyses, b) provide a permanent archive for the entire set of data needed for replication, and c) provide an adequate starting point should a different facility be required to complete the project, and d) provide a more user-friendly and complete CD-ROM distribution product. All items are required deliverables unless otherwise described:

1. Land Cover Data:

a. A GIS coverage of actual land cover by NVCS (alliance level or aggregation of alliances).
b. The digital reference data (ground points, aerial video, etc.) used to label and assess the map. Generally these are a deliverable if they can be delivered in a compact digital form (CD or tape). Consult with National GAP for your particular situation.
c. A digital manual describing the mapped land cover types.
d. Any imagery obtained with project funds and not included in the MRLC set.

2. Animal Modeling Data:

a. A database file of predicted species occurrence in EMAP hexagons.
b. A database of specimen collection or sighting localities, if available.
c. A database of species habitat associations with references.
d. GIS coverages of the individual predicted distributions of each terrestrial vertebrate species.
e. A "hyperdistribution" of all species in a single coverage.

3. Land Stewardship Data:

a. A GIS coverage of land stewardship (ownership and management).
b. A database or lookup table of all status 1 & 2 management areas with reference data.

4. Analysis Data:

a. A database of the analysis statistics for land cover and animal species.

5. Ancillary GIS coverages and digital tabular data used to create GAP coverages, including the USGS 30 x 60 minute quadrangle coverage.

6. A paper and digital copy of the final project report according to the standard template.

7. Graphic image files of all coverages, including all individual animal species distribution maps, tables, charts, and outcome analyses maps produced for the written report.

<u>Additional General Requirements:</u>

The following are not meant to replace specific project contract language but to inform potential GAP investigators of performance expectations.

1.Projects shall deliver a CD-ROM of all interim or completed data with their annual and final reports. Annual deliveries prior to the final delivery do not require ancillary data or imagery, only data actually produced by the project.

2.Projects shall deliver all coverages according to the standards in the Data Delivery Standards, (Appendix 1.3).

3.Projects shall follow all applicable rules of the USGS Biological Resources Division (BRD) as stated in their RWO or Cooperative Agreement when conducting Gap Analysis.

4.Projects shall make substantial efforts to involve all organizations that can likely contribute to the project in financial, in-kind, or advisory roles. At a minimum, workshops should be held for all potential cooperators with invitations going to the directors as well as key program and GIS leaders within the institutions. A newsletter is also highly recommended. They must also participate in regional GAP coordination efforts to achieve thematic and cartographic match between states.

5.Projects shall make substantial effort to identify an institution in-state to serve and maintain the GAP data. Data distribution shall include metadata and the final report, including the BRD data disclaimer.

6.Projects shall maintain a fire-safe backup of all data current to within one week of the last update.

7.In addition to the final report, projects shall produce progress reports according to their project agreement. The Principal Investigator will also modify the Online GAP Tracking Survey whenever there is a significant change in the status of: principal and secondary investigators; staff and affiliated investigators; cooperators; project funding; equipment and imagery; mapping; and analysis and data archive.

8.Projects shall follow the project close-out protocol to achieve sign-off on project completion.

Data Production Standards:

General:

a. Follow the overall Gap Analysis process described in A Handbook of Gap Analysis using the version current on the GAP home page (http://www.gap.uidaho.edu/gap/) or in consultation with the national office if a chapter is not current or available.
b. Projects may exceed these standards (e.g., use finer resolution, more detailed classification levels) provided that: 1) the refinements do not increase the original project budget or are funded by others; and 2) do not cause extension of the project time-line without prior consultation with National GAP.
c. For digital spatial data (GIS coverages), geographic position accuracy will meet or exceed the standards of the USGS for 1:100,000 scale products (see http://mapping.usgs.gov/www/html/ 2nmpgds.html#dlgs), or follow standards identified in the Handbook chapters. Because production of GAP data products requires the incorporation or "overlay" of numerous data layers, it is critical that they align such that the total spatial variation between all data does not exceed that allowed by the 1:100,000 standard.
d. When digitizing, it is suggested that each 1:100,000 tile should have a maximum root mean square error tolerance of <.005 digitizing inches (±13). Imbedded, missing, or extra polygons in vector coverages must be corrected and cleaned.

1a. Land Cover Coverage:

1.Use the National Vegetation Classification System (NVCS) to identify alliances or aggregations of alliances to be mapped in the project area. Note that descriptions of alliances are currently available for the East and will be available for the West approximately end of calendar year 1998. See the Land Cover chapter for additional information on application of the NVCS, or contact the national office.

2.Use Landsat TM imagery at 30 meter pixel resolution as the data source for map development. Do not resample the imagery to a different pixel size.

3.Use the methodology and standards described in the Land Cover Mapping chapter of the Handbook for both rendering a digital base map of land cover pattern and deriving thematic data with a by-type accuracy objective of 80%.

4.Map nonvegetated cover to the minimum categories described in the Land Cover Mapping chapter of the Handbook.

5.Resolution is at least 2 ha*, although a tiled, vectorized version of the coverage must be provided that may use a coarser resolution to achieve vectorization and allow efficient operation of a tile on the current version of PC ArcView. The "Merge" program available from National GAP is recommended for aggregation as needed.

> * Note that spatial versus thematic resolution will be discussed in detail in the updated Land Cover Mapping chapter. Spatial resolution will generally be a result of the thematic level mapped and the nature of the plant community itself. The goal should be to achieve a reasonable portrayal of the mapped units geographic extent and distribution patterns which may result in variable spatial resolutions by type, ranging from a few pixels to several hundred hectares.

6.Projects shall map land cover beyond their project boundary for a distance of 10 kilometers or to the edge of their TM imagery, whichever is less, provided the entire project area is mapped. Projects may map further than this requirement if they wish and are encouraged to discuss an appropriate amount of overlap with adjoining states.

7.Conduct an accuracy assessment of the land cover map to provide a measure of accuracy by mapped type. Follow the Land Cover Assessment chapter guidelines in the Handbook.

1b. Land Cover Reference Data:

1.Obtain data that represents "ground truth" for use in map creation and assessment (see 1a above). This can be near-remote-sensing-based data such as aerial photographs or videography (digital is recommended), accuracy-assessed large-scale vegetation maps, or field-gathered data. Digital data gathered by the GAP project is considered a deliverable and should be documented and archived as described in this chapter and the Information Archiving and Distribution chapter.

1c. Land Cover Manual:

1.Produce a Land Cover Manual that describes the mapped types in the context of the hierarchical classification scheme. Refer to the Land Cover section of the Handbook for minimum Manual components.

1d. TM Imagery:

1.Generally, projects will be supplied with sufficient imagery to create the land cover map. However, many projects obtain additional imagery. If this imagery is obtained with project funds, it must be delivered to the National GAP office. For more details see the Land Cover Mapping chapter or contact the National GAP office.

2a. Database File of Predicted Species Occurrence in EMAP Hexagons:

1.Use the TNC standard list of names and codes available from the TNC home page (see the link on the GAP home page). Note that around 1/98 we anticipate switching to the Integrated Taxonomic Information System (ITIS) system (http://biology.usgs.gov/cbi2/programs/itis.html) and will update this standard at that time. This caveat applies also to all other animal naming and coding standards in this chapter.

2.Include, at a minimum, all terrestrial vertebrates that breed or use habitat for a substantial part of their life history in the study area, including migration stopovers.

3.Use the Environmental Protection Agency (EPA) Ecological Mapping and Assessment Program (EMAP) hexagon grid (~635 km2) as the geographic unit (available from the GAP home page).

4.If using the hexagons as the source for delimiting range extent in the predicted vertebrate distributions, follow the attributing protocols found as an appendix in the animal modeling chapter of the Handbook.

5.If not using the hexagons in the predicted distribution modeling process, then at a minimum intersect the predicted distribution maps with the hexagon coverage to attribute the grid with GAP-predicted occurrence of each species mapped.

6.Export the resulting INFO file to dBASE such that each hexagon cell is represented by its ID number followed by the occurrence attribute for each modeled animal species.

2b. Database of Specimen Collection or Sighting Localities (if available):

1.Obtain available digital vertebrate point locations to use in vertebrate range mapping and verification (see Vertebrate Modeling and Assessment chapters).

2.Develop a digital database of locations from hard copy tabular or map products when this can be done in partnership with other institutions.

2c. Database of Species Habitat Associations:

1.Use the peer-reviewed literature, existing habitat association databases, and expert opinion to attribute each species with its known habitat associations.

2.Enter all associations into a database such that each association for each species is referenced to the source of that information.

2d. Predicted Distributions of Terrestrial Vertebrate Species:

1.Use the ECOMAP sections or subsections as available from USFS to bound regional differences in habitat associations for each species if they are known.

2.Develop a distribution map for each species with an accuracy objective of 80% based on comparison to high-confidence checklists for sample areas.

3.Resolution will be variable and a consequence of the resolution of the various coverages used in the modeling.

4.Conduct an accuracy assessment of the species distributions according to the guidelines in the Animal Distribution Assessment chapter of the Handbook.

2e. A "hyperdistribution" of all species in a single coverage:

1.Create a raster coverage such that each cell is attributed for presence/absence of each modeled species. This coverage allows simple queries of richness or coincidence of any group of species. Other attributes are allowed but not required at this time (see the vertebrate modeling chapter).

3a. Land Stewardship Coverage:

1.Map land management authority by the major categories of

a. Publicly owned lands, attributed by the name of the agency that is responsible for managing the land parcel, and secondarily with the actual owner if different from the managing entity.
b. Privately owned lands categorized in status 3 or higher when identified voluntarily by the land owner.
c. All other privately owned lands are to be attributed "private."
d. Subdivide general ownership/management categories with internal management boundaries that will have a different management status ranking, for instance, a Research Natural Area is an internal management boundary within Forest Service lands.

2.The resolution is at least 16 ha (40 acres), but smaller units may be used.

3.The management authority and management status attributes shall occur as one GIS coverage that can be queried to produce separate maps. Use the code system in the Stewardship chapter.

4.Categorize management according to the methods described in the Stewardship chapter of the Handbook using the status levels 1-4 described therein. You may attribute with subcategories as described in that chapter.

3b. Status 1 & 2 Management Areas:

1.Document the name of the area, date of establishment under its current status (an area may have been established as a national monument and then upgraded to national park; use the date of establishment of the latter), managing entity, owner if different than the managing entity, and source of management information for status 1 & 2 areas. Documentation for status 3 tracts is encouraged but not required.

2.Enter the data in a database program.

4a. Analysis Statistics for Land Cover and Animal Species:

1.Intersect the land cover and animal distribution coverages with the stewardship coverage and export the resulting coverage table to a database file.

2.For each element (land cover type and animal species), report its total project area distribution in square kilometers and the area and percent of its total distribution for each major land steward by management status level (see example in the Analysis chapter of the Handbook). Identify elements that have less than 10%, 20%, and 50% of their distribution in status 1 & 2 areas. Identify the measured accuracy level of each element.

5. Ancillary Data Used to Create Gap Coverages:

1.All data must be obtained from a referenced source with known methods used to create it and the location where the original data may be obtained.

2.Text, tabular, and hard copy map data must be referenced as typical for literature citations (see the GAP Handbook citations for style).

3.GIS data must include metadata sufficient to determine its fitness for use in deriving GAP products.

6. The Final Project Report:

1.Develop the final project report using the standard final report template available from the National GAP office (see Report chapter in this Handbook).

2.It is recommended that projects use the template during project production phases and annual reporting so that all pertinent information is captured when it is fresh and production staff are still available.

7. Graphic Image Files of All Coverages:

1. All coverages, including individual animal ranges by hexagon and predicted distribution shall be provided as a graphic image in addition to the GIS coverages. This is for CD-ROM production.

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Appendix 2.1. Land Cover Type Descriptions, OR-GAP Version 2 Land Cover

FOREST AND WOODLAND COVER TYPES

SITKA SPRUCE-WESTERN HEMLOCK MARITIME FOREST (32)

Geographic Distribution. This conifer dominant forest extends the length of the Oregon coast but is narrowly restricted in its distribution. Frequently this cover type will be no more than a 2 mile wide from the coastal margin to its bordering cover type. This maritime forest is most widely distributed in the rolling hills and coastal plain of the northwest coast. Along the south coast this cover type is restricted to the windward sides of hills on the narrow coastal plain. Sitka spruce (*Picea sitchensis*) and to a lesser extent western hemlock (*Tsuga heterophylla*), along with various willows (*Salix* spp.) also form palustrine forests in the tidewater reaches of the northwest coast and in the islands of the Columbia River east of Astoria.

Structure and Appearance. Closed canopy, multi-story conifer forest typically with a dense understory of shrubs, forbs and ferns.

Composition. Sitka spruce and western hemlock dominate the overstory with Douglas fir (*Pseudotsuga menziesii*), and western red cedar (*Thuja plicata*), becoming more frequent as the type grades into inland forest covers.

Shrub cover is diverse and often dominates the understory. Evergreen huckleberry (*Vaccinium ovatum*), salal (*Gaultheria shallon*), vine maple (*Acer circinatum*), pacific rhododenron (*Rhododendron macrophyllum*), salmonberry (*Rubus spectabilis*), and elderberry (*Sambucus racemosa*) are common associates.

Herbaceous cover is diverse and typically contains several fern species. Swordfern (*Polystichum munitum*) is the most common fern with deerfern (*Blechnum spicant*), bracken (*Pteridium aquilinum*), and chainfern (*Woodwardia fimbriata*). Other common forbs are devils club (*Oplopanax horridum*), false lily-of-the-valley (*Maianthemum dilatatum*), inside-out-flower (*Vancouveria hexandra*), and Oregon oxalis (*Oxalis oregana*).

Landscape Setting. The Sitka spruce-western hemlock forest is bordered inland by the Douglas fir/western hemlock/western red cedar forests. This forest type is frequently battered by high winds from Pacific Ocean storms with overstory trees showing evidence of wind shear and the effects of salt spray along the coastal margin. This type will also extend inland for several miles on river floodplains.

References. Hemstrom and Logan 1986, Wiedemann *et al.* 1974, Ripley 1983.

MOUNTAIN HEMLOCK SUBALPINE FOREST (33)

Geographic Distribution. Mountain hemlock (*Tsuga mertensiana*) ranges throughout the Cascades at higher elevations (generally above 4500 ft). In the southern Cascades and Siskiyou Mountain ranges the mountain hemlock cover type grades into the Shasta red fir (*Abies magnifica* var. shastensis)/mountain hemlock forest cover type. Mountain hemlock is also found in the Wallowa Mountains of northeastern Oregon. In both the Siskiyous and Wallowas, mountains hemlock is not as common, nor as extensive, as in the Cascades.

Structure and Appearance. At the lower elevation range of mountain hemlock this cover type is a forest that can have a multi-storied canopy, although it typically tends to single story. In these conifer dominant forests tree size is considerably smaller and regeneration difficult than lower elevation conifer cover types due to persistent snowpack and short growing season. Mountain hemlock, at its upper elevation range, grades into alpine parkland. Parkland settings are considered as a mosaic of treeless openings with clumps of closed canopy trees.

Composition. Mountain hemlock typically dominates the overstory in this upper elevation conifer forest. Pacific silver fir (*Abies amabilis*), lodgepole pine (*Pinus contorta*), western white pine (*Pinus monticola*), western hemlock (*Tsuga heterophylla*), and Douglas fir (*Pseudotsuga menziesii*) may be present in the overstory. In parkland mosaics mountain hemlock may appear in pure clumps, or mixed with subalpine fir (*Abies lasiocarpa*) or whitebark pine (*Pinus albicaulis*).

Shrubs and forb layer are typically sparse and species poor. Several of the Vaccinium genus are the most commonly found shrubs, big huckleberry, (*V. membranaceum*), grouse whortleberry (*V. scoparium*), and Alaska huckleberry (*V. alaskaense*). Dwarf bramble (*Rubus lasiococcus*), and prince’s pine (*Chimaphila umbellata*) also occurs commonly in this type.

Beargrass (*Xerophyllum tenax*) is the dominant herb in most places. Other associated herbs are: sidebells pyrola (*Pyrola picta*), beadlily (*Clintonia uniflora*), and sickletop pedicularis (*Pedicularis racemosa*).

Landscape Setting. In the Cascade Range mountain hemlock occupies the elevation zone between the true fir dominant montane forests, and the alpine parkland forest types. Mountain hemlock also occurs as high elevation savanna in pure clumps or mixed with whitebark pine in the volcanic soils of the southern Cascades.

References. Atzet *et al.* 1996, Hemstrom *et al.* 1987, Volland 1985, Crawford *et al.* 1999, Johnson and Simon 1987

TRUE FIR/HEMLOCK MONTANE FOREST (34)

Geographic Distribution. Found throughout the northern and central Cascade Range at middle to higher elevations, especially west of the Cascade crest. The true fir/hemlock type reaches its southern limit in the upper Rogue River drainage, east of Prospect. This type is also found in disjunct populations in the Coast Range.

Structure and Appearance. Multi-story closed canopy forests. Trees can grow to large stature barring disturbance in these fertile, mid-elevation forests. Snags and large woody debris are commonly found. Understory vegetation is rich in species with a diversity of forms.

Composition. Canopy co-dominance of pacific silver fir (*Abies amabilis*), and/or noble fir (*A. procera*) along with both western and mountain hemlock characterize this conifer forest type. Other canopy trees found in this type include: Douglas fir (*Pseudotsuga menziesii*), western white pine (*Pinus monticola*), subalpine fir (*Abies lasiocarpa*), Alaska yellow cedar (*Chamaecyparis nootkatensis*) and grand fir (*Abies grandis*).

The shrub layer in this cover type is dense and diverse with a number of deciduous and evergreen shrubs commonly found. Shrubs associated with this cover type are: pacific rhododendron (*Rhododendron macrophyllum*), Cascade azalea (*R. albiflorum*), salal (*Gaultheria shallon*), fools huckleberry (*Menziesia ferruginea*), big huckleberry (*Vaccinium membranaceum*), Alaska huckleberry (*V. alaskaense*), dwarf Oregongrape (*Mahonia nervosa*), and vine maple (*Acer circinatum*).

The forb layer in these forests is also rich in species and abundance. Indicator species of wet and mesic sites include: skunk cabbage (*Lysichitum americanum*) devils club (*Oplopanax horridum*), beadlily (*Clintonia uniflora*), foamflower (*Tiarella unifoliata*) wild ginger (*Asarum caudatum*) Oregon oxalis (*Oxalis oregana*), vanillaleaf (*Achlys triphylla*), bunchberry (*Cornus canadensis*) and beargrass (*Xerophyllum tenax*).

Landscape Setting. This cover type is adjacent to Douglas fir/western hemlock/western red cedar at its lower elevation range and subalpine forest types at its upper limits. These are cool site, fertile soil forests with winter snowpack and moist soils during the growing season. The long droughty summers of southern Oregon are likely the limiting factor in its southern distribution.

References. Hemstrom *et al.* (1982, 1987), Atzet and Wheeler 1984, Atzet *et al.* 1996, Halvorson *et al.* 1986, Crawford *et al.* 1999.

SHASTA RED FIR-MOUNTAIN HEMLOCK MONTANE FOREST (36)

Geographic Distribution. Mid-to-upper elevation conifer forest found in the Siskiyou Mountains and southern Cascades, especially south of Crater Lake.

Structure and Appearance. Closed canopy, multi-story conifer forest typically with a dense understory of shrubs, forbs and ferns.

Composition. Overstory species include: Shasta red fir (*Abies magnifica* var. *shastensis*), mountain hemlock (*Tsuga mertensiana*), with white fir (*Abies concolor*), lodgepole pine (*Pinus contorta*),

Shrubs associated with this type are: dwarf bramble (*Rubus lasiococcus*), Oregon boxwood (*Pachistima myrsinites*), pinemat manzanita (*Arctostaphylos nevadensis*), saddler oak (*Quercus sadleriana*), and baldhip rose (*Rosa gymnocarpa*).

Herbs associated with this type are: false Solomon's seal (*Smilacina racemosa*), rattlesnake plantain (*Goodyera oblongiflora*), woods strawberry (*Fragaria vesca*), white flowered hawkweed (*Hieracium albiflorum*).

Structure and Appearance. This forest type takes on a variety of forms, ranging from multi-story closed canopy forests to open canopy alpine parkland type forest.

Landscape Setting. This montane forest cover type is found at elevations mostly above 4,000 ft. with a tendency towards north aspects, especially when occurring at lower elevations.

References. Atzet and Wheeler, 1984, Atzet *et al.* 1996, Jimerson *et al.* 1996, Frenkel and Kiilsgaard 1984.

WHITEBARK-LODGEPOLE PINE ALPINE FOREST (39)

Geographic Distribution. The whitebark-lodgepole pine type has a sporadic distribution in the high elevation zone of the eastern Cascades. The forest cover type is found mainly in the southern reaches of the eastern Cascades, especially around the Gearhart Mt. Wilderness Area.

Structure and Appearance. This conifer forest has generally open to moderately closed canopy (less than 60% crown closure). Stands are of moderate stature with sparse shrub and forb layers. Regeneration of conifer trees is minimal.

Composition. Whitebark pine (*Pinus albicaulis*) and lodgepole pine (*Pinus contorta*) dominate the overstory. Occasional white fir (*Abies concolor*) and western white pine (*Pinus monticola*) are found in the overstory.

Shrub layer is sparse with little diversity, occasional pinemat manzanita (*Arctostaphylos nevadensis*), and sticky currant (*Ribes viscosissimum*).

Forb layer is predominantly grasses, with Wheeler's bluegrass (*Poa nervosa*), western needlegrass (*Stipa occidentalis*), bottlebrush squirreltail (*Sitanion hystrix*), and long stolon sedge (*Carex pensylvanica*). Forbs are gay penstemon (*Penstemon laetus*), and tailcup lupine (*Lupinus caudatus*).

Landscape Setting. This type is not readily mapped because of its non-contiguous cover and its occurrence as a mosaic with alpine grassland and shrubland types.

References. Hopkins 1979.

PONDEROSA PINE DOMINANT- MIXED CONIFER FOREST (40)

Geographic Distribution. The ponderosa pine dominant-mixed conifer forest is found primarily in the southern half of the eastern Cascades, ranging from the California border to Bend.

Structure and Appearance. This type is typically a two story conifer forest with the predominance of the overstory canopy (greater than 60%) being ponderosa pine (*Pinus ponderosa*). White fir

(*Abies grandis* and *A. concolor*), is the other common overstory tree with occasional incense cedar (*Calocedrus decurrens*), and sugar pine (*Pinus lambertiana*). Understory regeneration can be dense, or sparse, based on intensity of cattle grazing, fire frequency, and ecological site conditions.

Composition. Overstory conifers are ponderosa pine, white fir, with lesser contribution from incense cedar and sugar pine. Understory trees are similar in composition to overstory although generally white fir predominates over ponderosa and lodgepole pine (*Pinus contorta*) is a common understory occupant.

The shrub and herb layers form a diverse and prominent ground cover component in this forest type especially when compared to adjacent cover types. Commonly associated shrubs include snowberry (*Symphoricarpos albus*), creeping snowberry (*S. mollis*), dwarf Oregongrape (*Mahonia nervosa*), wax currant (*Ribes cereum*), and serviceberry (*Amelanchier alnifolia*).

Indicator cover type herbs are: heartleaf arnica (*Arnica cordifolia*), long stolon sedge (*Carex pensylvanica*), squirreltail bottlebrush (*Sitanion hystrix*), starwort (*Stellaria jamesiana*), white hawkweed (*Hieracium albiflorum*), and broadleaf strawberry (*Fragaria virginiana*).

Landscape Setting. This mid elevation cover type occupies the zone between the drier low elevation types, primarily ponderosa-western juniper cover type, and higher elevation mixed conifer or sub-alpine types. This type, with its mesic site conditions, is transitional in its ecological setting bridging the gap between drier, low elevation types and the colder, wetter higher elevation types. This type also warrants distinction because of its lack of Douglas fir (*Pseudotsuga menziesii*) in its stands and the consistent presence, but lack of co-dominance by associated conifers.

References. Hopkins, 1979, Volland, 1988, Kovalchik, 1987.

NORTHEASTERN OREGON MIXED CONIFER FOREST (41)

Geographic Distribution. Common mid-elevation forest cover type found throughout the various mountain ranges of northeastern Oregon. More common on north and east facing slopes.

Structure and Appearance. This cover type can take on a variety of structural and canopy appearances based on site history. In its unaltered form stands are typically two storied with an overstory of ponderosa pine (*Pinus ponderosa*) over smaller ponderosa, or grand fir (*Abies grandis*), western larch (*Larix occidentalis*), lodgepole pine (*P. contorta*), western white pine (*P. monticola*), Douglas fir (*Pseudotsuga menziesii*), or Engelmann spruce (*Picea engelmannii*) depending on local environment. Selective logging, grazing, and fire suppression effects have significantly changed the appearance of this forest type.

Composition. Overstory conifers can be ponderosa pine, grand fir, western white pine, lodgepole pine, western larch, Engelmann spruce, and Douglas fir. Forest regeneration after wildfires favors recruitment of western larch and lodgepole pine. Cool, moist sites within this type typically contain Engelmann spruce and grand fir. Understory trees reflect the same species of conifers and occasionally will have western yew (*Taxus brevifolia*).

Shrub layer is prominent and diverse. Common tall shrubs include bigleaf huckleberry (*Vaccinium membranaceum*), rocky mountain maple (*Acer glabrum*), ninebark (*Physocarpus malvaceus*), Scouler's willow (*Salix scouleriana*) serviceberry (*Amelanchier alnifolia*). Mid and low shrubs include shiny-leaf spirea (*Spiraea betulifolia*), myrtle pachistima (*Pachistima myrsinites*), snowbrush (*Ceanothus velutinus*), grouse whortleberry (*Vaccinium scoparium*), bog blueberry (*V. ulignosum*), dwarf Oregon grape (*Mahonia nervosa*), and the prostrate manzanitas (*Arctostaphylos nevadensis* and *A. uva-ursi*).

Commonly encountered forbs in this cover type include: false Solomon's seal (*Smilacina racemosa*), heartleaf arnica (*Arnica cordifolia*), rattlesnake plantain (*Goodyera oblongifolia*), white hawkweed (*Hieracium albiflorum*), Wilcox's penstemon (*Penstemon wilcoxii*), bigleaf sandwort (*Arenaria macrophylla*), woods strawberry (*Fragaria vesca*), meadowrue (*Thalictrum occidentale*), sweet cicely (*Osmorhiza chilensis*), sidebells pyrola (*Pyrola picta*), and trail plant (*Adenocaulon bicolor*).

Landscape Setting. This type can extend to grassland or shrubland cover types on its low elevation end but usually it is transitional between ponderosa pine on its lower end and subalpine fir/lodgepole pine at higher elevations.

References. Hall 1973, Johnson and Simon 1987, Johnson and Clausnitzer 1989, Kagan and Caicco 1992, Chappell *et al.* 1999.

JEFFREY PINE WOODLANDS (42)

Geographic Distribution. Jeffrey pine (*Pinus jeffreyi*), while common in the mountains of California, is at the northern extension of its range in Oregon and is found only in Josephine, Curry, Jackson Counties and small, scattered patches in the south fork of the Umpqua River drainage in Douglas County. Closely associated with ultramafic rocks this open woodland is a good indicator of parent material and is most readily found west of the Illinois River by Cave Junction. Ultramafic rock, serpentine and peridotite have such high concentrations of nickel, chromium and magnesium that soils derived from this substrate are toxic to most plants. Those plants which are tolerant to the heavy metal concentrations form a unique and diverse flora within southwestern Oregon.

Structure and Appearance. Jeffery pine woodlands are open canopy, (less than 30% crown closure in most stands), single story, conifer dominant cover type. Floristic composition is diverse, but sparse in appearance. This type tends to have a lot exposed bedrock and gravel scattered amongst the vegetation.

Composition. Jeffrey pine is the dominant overstory tree species in this cover type. Incense cedar (*Calocedrus decurrens*) is commonly found but rarely does it have sufficient cover to be considered co-dominant. In moist areas Port Orford cedar (*Chamaecyparis lawsoniana*) replaces incense cedar. Understory trees are Jeffrey pine, incense cedar, Douglas fir (*Pseudotsuga menziesii*) and California laurel (*Umbellaria californica*).

Shrubs are prominent and diverse in this type. Commonly associated shrubs are coffeeberry (*Rhamnus californica*), hoary manzanita (*Arctostaphylos canescens*), whiteleaf manzanita (*A. viscida*), squaw carpet (*Ceanothus prostratus*), dwarf ceanothus (*C. pumilus*), silk tassel (*Garrya buxifolia*), and the shrub form of tanoak (*Lithocarpus densiflora*).

Grasses and forbs are also prominent. Lemmon's needlegrass (*Stipa lemmonii*), Idaho fescue (*Festuca idahoensis*), Roemer's fescue (*F. roemeri*) and California fescue (*F. californica*) are common. Commonly associated forbs are: rock fern (*Aspidotis densa*), Tolmie's mariposa (*Calochortus tolmeii*), death camas (*Zigadenus venenosus*), yarrow (*Achillea millefolium*) and beargrass (*Xerophyllum tenax*).

Landscape Setting. Because of the unique relationship this cover type has with parent material its setting is largely a function of local geology. Jeffrey pine woodlands are interspersed with the other two ultramafic rock influenced cover types, serpentine conifer woodland and Siskiyou Mountains serpentine shrubland. Jeffrey pine woodlands often are found in low to mid elevation, southerly exposure settings.

References. Plant classification and ecology works that describe this cover type include: Atzet *et al.* 1996, Jimerson *et al.* 1995, Kruckeburg 1984, Frenkel and Kiilsgaard 1984, Atzet and Wheeler 1984, and Zobel and Hawk 1980.

SERPENTINE CONIFER WOODLAND (43)

Geographic Distribution. Similar in distribution pattern and environmental relationship as the Jeffrey pine woodlands. This conifer woodland is most common in California and reaches its northern extent in southwestern Oregon.

Structure and Appearance. This cover type, responding to recent fire by serotinous cone regeneration, is relatively short lived and responds well to disturbances, or disturbed soils. Stands are open to dense, even-aged, and low in stature.

Composition. Knobcone (*Pinus attenuata*) and lodgepole pine (*P. contorta*) are the most commonly associated conifers in this type. Western white pine (*P. monticola*), sugar pine (*P. lambertiana*), Jeffrey pine (*P. jeffreyi*) incense cedar (*Calocedrus decurrens*), madrone (*Arbutus menziesii*), and occasionally, brewers spruce (*Picea breweriana*) form the regeneration and overstory layers in these short stature (most trees are less than 20 ft tall) stands.

Shrub layers typically have moderate to high cover. Huckleberry oak (*Quercus vaccinifolia*), tanoak (*Lithocarpus densiflora*), chinquapin (*Castanopsis chrysophylla*), creambrush oceanspray (*Holodiscus discolor*), and red huckleberry (*Vaccinium parvifolium*).

Forb layers are diverse and rich in species. Commonly found species being: beargrass (*Xerophyllum tenax*), western starflower (*Trientalis latifolia*), wild ginger (*Asarum hartwegii*), creeping Oregongrape (*Mahonia repens*), spreading dogbane (*Apocynum androsaemifolium*), spotted coralroot (*Corallorhiza maculata*), Tolmies mariposa lily (*Calochortus tolmiei*), fawn lily (*Erythronium grandiflorum*), and woodland tarweed (*Madia madioides*).

Landscape Setting. This type is primarily associated with the distribution of serpentine soils within southwestern Oregon. It most commonly occurs on higher elevation benches, slopes and ridges and is a pioneer forest community following fire or mining disturbance.

References. Frenkel and Kiilsgaard 1984, Jimerson *et al.* 1995, Atzet *et al.* 1996.

LODGEPOLE PINE FOREST AND WOODLAND (44)

Geographic Distribution. A common forest cover type found throughout the central and southern Cascades, east of the crest; and in smaller, scattered mosaics throughout the mountains of northeastern Oregon, and along the crest of the Cascades.

This cover type is most extensive in the same geographic area as the ponderosa-lodgepole pine on pumice type; but warrants distinction because it occurs on mid-slopes and ridges and is a forest type responding from wild fires, not soil conditions.

Structure and Appearance. Single layer, open to closed canopies, dominated by lodgepole pine (Pinus contorta). A typical post-fire successional path for this cover type is to have dense reproduction of short stature lodgepole. As the stand matures lodgepole cover thins to scattered overstory lodgepole with regeneration layers of other conifers. These other conifers, regionally important replacement trees would be: Douglas-fir (*Pseudotsuga menziesii*), grand fir (*Abies grandis*), white fir (*A. concolor*), incense cedar (*Calocedrus decurrens*), and western white pine (*Pinus monticola*) will eventually form the overstory and eliminate lodgepole from the stand entirely.

Composition. Lodgepole dominates the overstory in early to mid successional stands. Western larch (*Larix occidentalis*), another post-fire colonizing conifer, can be co-dominant in this cover type, especially in the northeastern Oregon mountains. Regeneration layers are composed of conifers listed in the structure and appearance section.

Shrubs are common and diverse in this cover type: common snowberry (*Symphoricarpos albus*), mountain snowberry (*S. mollis*), serviceberry (*Amelanchier alnifolia*), ninebark (*Physocarpus malvaceus*), shiny-leaf spirea (*Spiraea betulifolia*), bitterbrush, (*Purshia tridentata*), baldhip rose (*Rosa gymnocarpa*), myrtle pachistima (*Pachistima myrsinites*), and several huckleberries (*V. membranaceum, V. scoparium, V. uliginosum,* and *V. caespitosum*).

Grasses dominate some understories with few shrubs. Pine grass (*Calamagrostis rubescens*), Ross' sedge (*Carex rossii*), elk sedge (*Carex geyeri*), bluebunch wheatgrass (*Agropyron spicatum*), western needlegrass (*Stipa occidentalis*), Idaho fescue (*Festuca idahoensis*), prairie junegrass (*Koeleria macrantha*), and mountain brome (*Bromus carinatus*) are commonly found.

Landscape Setting. Since this forest cover type usually is the response following wild fires there is no environmental relationship that controls its distribution. This cover type appears as a mosaic within the larger, regionally important cover types.

References. Hopkins 1979, Johnson and Clausnitzer 1986, Johnson and Simon 1987, Crawford *et al.* 1999, Kagan and Caicco 1992.

SUBALPINE FIR-LODGEPOLE PINE MONTANE FOREST (45)

Geographic Distribution. A common mid to high elevation conifer forest cover type in the mountains of northeastern Oregon, and along the crest of the Cascades.

Structure and Appearance. Short stature single story canopy forests. Crown closure ranges from open to closed. At its lower elevation range, this cover type grades into various montane forest types and maintains a continuous canopy. At its upper elevation range, (which can be the timberline), the type grades into subalpine parkland, or it takes on the clumpy appearance of a parkland cover type.

Composition. Subalpine fir (*Abies lasiocarpa*) and lodgepole pine (*Pinus contorta*) dominate the canopy overstory. Engelmann spruce (*Picea engelmannii*) can be a locally important overstory tree, especially in northeastern Oregon. Understory tree composition usually is dominated by subalpine fir.

Shrub cover in this type can be extensive and is typified by big huckleberry (*Vaccinium membranaceum*), and grouse huckleberry (*V. scoparium*). Other commonly associated shrubs include: gooseberry (*Ribes lacustre*), shiny-leaf spirea (*Spiraea betulifolia*), and prince's pine (*Chimaphila umbellata*).

Forb cover is often low but diverse in species. Common indicator forbs would be strawberries, (*Fragaria vesca* and *F. virginiana*), roundleaf violet (*Viola oreganum*), heartleaf arnica (*Arnica cordifolia*), sidebells pyrola (*Pyrola secunda*), skunkleaf polemonium (*Polemonium pulcherrimum*), sweet cicely (*Osmorhiza chilensis*) and meadowrue (*Thalictrum occidentalis*).

Landscape Setting. Occupies the upper elevation range of continuous forest cover for much of northeastern Oregon. As discussed in the structure and appearance section, this type grades into, or takes on the appearance of parkland cover types. Lodgepole pine is successional to subalpine fir, but remains a common component on harsher sites and ridgetops. Successional change is slow in this cover type with its short growing season and persistent snow cover.

References. Hall 1973, Johnson and Simon 1987, Johnson and Clausnitzer 1989, Kagan and Caicco 1992.

COASTAL LODGEPOLE FOREST (46)

Geographic Distribution. Most commonly found along the south-central coastline near Florence, this type can be found throughout the length of the Oregon coast. It is uncommon to find this type more than a mile or so off the coastline and primarily located in deflation plain settings.

Structure and Appearance. Low stature, single story conifer stands, with moderate to closed canopies. Overstory is predominantly lodgepole pine (*Pinus contorta*) on newly colonized dunes and deflation plains. As the habitat matures Sitka spruce (*Picea sitchensis*) increases in abundance, becoming the successional forest. Sitka spruce will also co-dominate with lodgepole on wet places in the deflation plain. South of Coos Bay, Port Orford cedar (*Chamaecyparis lawsoniana*) can be found in this forest type in the wet deflation and dune places.

Understory vegetation is often a dense, impenetrable shrub layer in stable, late successional stands. Early succession stands, and places with active sand movement, have sparse understories.

Composition. Conifer overstories of lodgepole pine and locally abundant Sitka spruce. Shrub layer is dominated by salal (*Gaultheria shallon*), pacific rhododendron (*Rhododendron macrophyllum*), and evergreen huckleberry (*Vaccinium ovatum*). Forb layer is sparse to non-existent under the heavy shrub covers

Landscape Setting. Lodgepole pine is the early colonizer of dunes and deflation plains. This cover type can exist as a narrow strip bordering on the Sitka spruce-western hemlock type along the northern coast; or it can become fairly extensive on the dune sheets between Florence and Coos Bay.

References. Wiedemann *et al.* 1974, Ripley 1983.

DOUGLAS FIR/WESTERN HEMLOCK/WESTERN RED CEDAR FOREST(49)

Geographic Distribution. The most common low to mid elevation forest found in western Oregon. Extends from the foothills of the western Cascades to approx. 4,500 ft and is ubiquitous throughout the Coast Range to the coastal margin forests. Its distribution becomes scattered in southwestern Oregon and the southern Cascades and is replaced by Douglas fir-mixed conifer mixed deciduous types.

Structure and Appearance. In its mature form this conifer forest type contains numerous large trees, multi-story tree canopies, numerous snags and downed logs. Sub-canopies are composed of shade tolerant conifer species and deciduous trees where there is discontinuous overstory canopy cover. Early seral and commercial forests have dense accumulations of smaller trees, (typically dominated by Douglas fir, *Pseudotsuga menziesii*) and single story canopies.

Shrub and herbaceous layers are dense and rich in species in mid-to-late successional forest stands

Composition. Douglas fir dominates most of the overstory in these stands, with western hemlock (*Tsuga heterophylla*), western red cedar (*Thuja plicata*) and grand fir (*Abies grandis*) present to locally co-dominant. Western hemlock and western red cedar form the bulk of the subordinate tree and regeneration layers. Pacific yew (*Taxus brevifolia*) is another conifer that shows up in the sub-canopy tree layers. Big leaf maple (*Acer macrophyllum*), and to a lesser extent, red alder (*Alnus rubra*) are common in riparian strips and stands that do not have continuous conifer overstories.

Large stature shrubs are common in the Cascades stands. Vine maple (*Acer circinatum*), pacific rhododendron (*Rhododendron macrophyllum*), and fools huckleberry (*Menziesia ferruginea*) and red huckleberry (*Vaccinium parvifolium*) are frequently found. Coast Range shrub layers are dominated by salal (*Gaultheria shallon*), evergreen huckleberry (*V. ovatum*), elderberry (*Sambucus racemosa*) and salmonberry (*Rubus spectabilis*).

Herbaceous layers are rich in species and abundance. Swordfern (*Polystichum munitum*) and other ferns, bracken (*Pteridium aquilinum*), deer fern (*Blechnum spicant*), and lady fern (*Athyrium filix-femina*) are commonly found and can dominate the herb layer. Other forbs associated with this cover type include: inside-out flower (*Vancouveria hexandra*), twinflower (*Linnea borealis*), Siberian springbeauty (*Claytonia sibirica*), vanillaleaf (*Achlys triphylla*), bedstraw (*Galium triflorum*), western iris (*Iris tenax*), and Oregon oxalis (*Oxalis oregana*).

Landscape Setting. In the interior valleys of western Oregon at low elevations this forest type grades into agriculture, or Douglas fir/deciduous types. Bordering this cover type at upper elevations are the true fir dominant montane forest types. This type extends west of the Coast Range onto the coastal plains where it borders the coastal margin forests.

References. Hemstrom *et al.* 1987, Hemstrom and Logan 1986, Franklin and Dyrness 1974, Atzet *et al.* 1996, Atzet and McCrimmon 1990, Chappell *et al.* 1999, Halverson *et al.* 1986

DOUGLAS FIR-PORT ORFORD CEDAR FOREST (50)

Geographic Distribution. A low to mid elevation forest type found mainly in the Coast Range and Siskiyou Mountains of Curry County of southwestern Oregon. This type does not grow north of Coos Bay on the Oregon coast and Roseburg in the interior valleys. Common west of the Coast Range Crest, but is largely restricted to moist ultramafic soil environments inland. This cover type is mostly confined to moist habitats of moderate elevation and steep riparian situations.

Structure and Appearance. This conifer forest type is characterized by, multi-story tree canopies, co-dominated by Port Orford cedar (*Chamaecyparis lawsoniana*) and Douglas fir (*Pseudotsuga menziesii*). Sub-canopies are composed of conifers and evergreen deciduous trees where there is discontinuous overstory canopy cover.

Composition. Douglas fir and Port Orford cedar dominate canopy overstory in these stands. Western hemlock (*Tsuga heterophylla*) is common west of the Coast Range, and sugar pine (*Pinus lambertiana*) and grand fir (*Abies grandis*) present in the overstory of interior stands.

Understory conifers are Douglas fir, western hemlock, western yew (*Taxus brevifolia*) and Port Orford cedar. On ultramafic substrates, sugar pine and western white pine (*Pinus monticola*) are frequent associates. Evergreen deciduous trees are California laurel (*Umbellaria californica*), tanoak (*Lithocarpus densiflora*), and chinquapin (*Castanopsis chrysophylla*).

Large stature shrubs are common west of the Coast Range crest, vine maple (*Acer circinatum*), pacific rhododendron (*Rhododendron macrophyllum*), and red huckleberry (*Vaccinium parvifolium*), and evergreen huckleberry (*V. ovatum*). Interior stands shrub layers contain western azalea (*Rhododendron occidentalis*), Sadler oak (*Quercus sadleriana*), and dwarf Oregongrape (*Mahonia nervosa*).

Herbaceous layers are rich in species and abundance. Swordfern (*Polystichum munitum*) and other ferns, bracken (*Pteridium aquilinum*), deer fern (*Blechnum spicant*), and lady fern (*Athyrium filix-femina*) are common. Other forbs include: vanillaleaf (*Achlys triphylla*), bedstraw (*Galium triflorum*), western iris (*Iris tenax*), Oregon oxalis (*Oxalis oregana*), redwoods violet (*Viola sempervirens*), western starflower (*Trientalis latifolia*), rattlesnake plantain (*Goodyera oblongifolia*), and white trillium (*Trillium ovatum*).

Landscape Setting. This cover type is under-represented in the mapping effort because it often exists as a coniferous riparian type that is not extensive enough to be mapped. It is largely transitional to the other Douglas fir conifer types found in the region.

References. Atzet and Wheeler 1983, Jimerson *et al.* 1995, Atzet *et al.* 1996, Frenkel and Kiilsgaard 1984, Hawk 1978, Hawk and Zobel 1980

DOUGLAS FIR / MIXED DECIDUOUS FOREST (51)

Geographic Distribution. Low to mid-elevation conifer and mixed deciduous forest. Found primarily in the southwestern Oregon counties of Douglas, Coos, northern Curry, Josephine, and Jackson. Also extends north into southern Lane County. This type is most common on the eastern side of the Coast Range and in mesic microsites in the Siskiyou Mountains.

Structure and Appearance. This conifer/mixed deciduous forest type in its mature form is a large structure multi-canopy forest. Upper tree layer always contains Douglas fir (*Pseudotsuga menziesii*). Sub-canopies are mixes of shade tolerant conifers, with deciduous and evergreen deciduous trees in discontinuous conifer canopies. Shrub and herb layers are prominent and rich in species.

Composition. The overstory canopy is largely Douglas fir (*Pseudotsuga menziesii*). Sub-canopy trees include: tanoak (*Lithocarpus densiflora*), madrone (*Arbutus menziesii*), chinquapin (*Castanopsis chrysophylla*), and pacific dogwood (*Cornus nuttallii*) in the Siskiyou Mountains. Deciduous sub-canopies in the Coast Range will also include madrone, some chinquapin, and some Oregon white oak (*Quercus garryana*) but will mostly contain big leaf maple (*Acer macrophyllum*), and red alder (*Alnus rubra*).

Indicative shrubs of this cover type include: dwarf Oregongrape (*Mahonia nervosa*), pacific blackberry (*Rubus ursinus*), oceanspray (*Holodiscus discolor*), California hazelnut (*Corylus cornuta*), baldhip rose (*Rosa gymnocarpa*), pacific rhododendron (*Rhododendron macrophyllum*), salal (*Gaultheria shallon*), red huckleberry (*Vaccinium parvifolium*), creeping snowberry (*Symphoricarpos mollis*), and snow bramble (*Rubus nivalis*).

Commonly associated herbs include: cutleaf goldthread (*Coptis laciniata*), coolwort foamflower (*Tiarella trifoliata*), white trillium (*Trillium ovatum*), western starflower (*Trientalis latifolia*), swordfern (*Polystichum munitum*), trail plant (*Adenocaulon bicolor*), prince's pine (*Chimaphila umbellata*), Scouler's harebell (*Campanula scouleri*), vanillaleaf (*Achlys triphylla*), streamside violet (*Viola glabella*), Oregon fairybell (*Disporum hookeri*), and inside-out-flower (*Vancouveria hexandra*).

Landscape Setting. This cover type occurs at intermediate elevations with moderate amounts of precipitation. The abundant understory and sub-canopy layer distinguishes this type from other regional conifer/deciduous cover types.

References. Atzet *et al.* 1996, White 1996, Frenkel and Kiilsgaard 1984, Smith *et al.* 1987.

DOUGLAS FIR-WHITE FIR/TANOAK-MADRONE MIXED FOREST (52)

Geographic Distribution. Low to mid-elevation mixed conifer and mixed deciduous forest. Found primarily in Jackson, Curry, and Josephine Counties of southwestern Oregon. This type is common in the Siskiyou and Klamath Mountains and to a lesser extent, the southern Cascades.

Structure and Appearance. This mixed conifer/mixed deciduous forest type in its mature form is a large structure multi-canopy forest. Upper tree layer always contains Douglas fir (*Pseudotsuga menziesii*), with co-dominant to lesser amounts of fir (*Abies grandis* or *Abies concolor*) and usually some representation of incense cedar (*Calocedrus decurrens*). Sub-canopies are mixes of shade tolerant conifers with evergreen deciduous and deciduous trees. Shrub and herb layers are well represented.

Composition. The proportion of overstory composition may vary by microsite and disturbance history, but there will always be some mix of Douglas fir, white fir, and incense cedar in the stand. Sugar pine (*Pinus lambertiana*) and western white pine (*P. monticola*) are infrequent overstory occupants. Sub-canopy trees include: tanoak (*Lithocarpus densiflora*), madrone (*Arbutus menziesii*), chinquapin (*Castanopsis chrysophylla*), and lesser amounts of pacific dogwood (*Cornus nuttallii*) and California laurel (*Umbellaria californica*).

Indicative shrubs of this cover type include: baldhip rose (*Rosa gymnocarpa*), dwarf Oregongrape (*Mahonia nervosa*), pacific blackberry (*Rubus ursinus*), oceanspray (*Holodiscus discolor*), California hazelnut (*Corylus cornuta*), and hairy honeysuckle (*Lonicera hispidula*).

Commonly associated herbs include: western starflower (*Trientalis latifolia*), rattlesnake plantain (*Goodyera oblongifolia*), trail plant (*Adenocaulon bicolor*), prince's pine (*Chimaphila umbellata*), Scouler's harebell (*Campanula scouleri*), vanillaleaf (*Achlys triphylla*), whipplevine (*Whipplea modesta*), and Oregon fairybell (*Disporum hookeri*).

Landscape Setting. Common California mid-elevation forest type that reaches it northern extent in southwestern Oregon. Logging, fires, and other stand disturbances promote the deciduous tree component. Shasta red fir types typically border the type at its upper elevation. Lower elevation by deciduous dominant cover types.

References. Atzet *et al.* 1996; Atzet and McCrimmon 1990; Jimerson *et al.* 1996

DOUGLAS FIR-OREGON WHITE OAK FOREST (53)

Geographic Distribution. Foothills forest type found in the Willamette and western interior valleys of western Oregon. The type is also found in diminishing frequency in the Puget Trough of western Washington. This particular cover type description will pertain to the Willamette Valley communities.

Structure and Appearance. Mosaic cover type where patterns of dominance and co-dominance between Douglas fir (*Pseudotsuga menziesii*) and Oregon white oak (*Quercus garryana*) vary based on local environment and stand history. Understory vegetation conditions range widely as well. Ungrazed stands can have prominent shrub and herbaceous layers, while stands that are part of unmanaged pasture mosaics typically have understories where introduced annual grasses dominate.

Composition. Douglas fir and Oregon white oak are the dominant overstory trees. Grand fir (*Abies grandis*) and Pacific madrone (*Arbutus menziesii*) may be present, but limited in numbers. Sub-canopy tree layers can be dense in some stands and dominated by California hazelnut (*Corylus cornuta*), the invasive sweet cherry (*Prunus avium*), black hawthorn (*Crataegus douglasii*), and Indian plum (*Oemleria cerasiformis*).

Commonly associated shrubs for this type include poison oak (*Rhus diversiloba*), tall Oregongrape (*Mahonia aquifolium*), snowberry (*Symphoricarpos mollis*), trailing blackberry (*Rubus ursinus*), serviceberry (*Amelanchier alnifolia*), and baldhip rose (*Rosa gymnocarpa*).

The grass and forb layer typically includes cleavers (*Galium aparine*), blue wildrye (*Elymus glaucus*), western iris (*Iris tenax*), bracken (*Pteridium aquilinum*), hairy honeysuckle (*Lonicera hispidula*), and a variety of introduced grasses that seed in from adjacent pasturelands.

Landscape Setting. Hot, dry forests on the fringe between coniferous and valley bottom. Moisture is probably the most limiting characteristic. Douglas fir is invading these predominantly white Oak stands so stand composition typically grades from white oak dominance at lower treeline to co-dominance as the type merges with adjacent conifer forests. The hot, dry conditions of this cover type preclude seedling establishment of shade tolerant conifers, i.e. western hemlock (*Tsuga heterophylla*) and western red cedar (*Thuja plicata*). It is the lack of regeneration (and eventual stand succession), of shade tolerant species that distinguishes this cover type from the more mesic upslope conifer forest types.

References. Chappell *et al*. 1998

PONDEROSA PINE FOREST AND WOODLAND (54)

Geographic Distribution. This conifer forest and woodland is a major cover type in mid to lower elevation zones along the flanks of the eastern Cascades and the mountain ranges of central and northeastern Oregon.

Structure and Appearance. In its mature form this forest type is typified by large structure, widely spaced ponderosa pine (*Pinus ponderosa*). The overstory is predominantly ponderosa with white fir (*Abies concolor*), grand fir (*A. grandis*), incense cedar (*Calocedrus decurrens*), and Douglas fir (*Pseudotsuga menziesii*) minor overstory trees based on location within the state.

Regeneration and understory tree layers are comparatively sparse in this cover type with regards to other regional forest cover types. A variety of forest related grasses and grass-like forbs are frequently found in this type.

Composition. Overstory tree along low elevation is exclusively ponderosa pine. At higher elevation margin and transition to mixed conifer types, overstory conifers can be white fir, grand fir, western larch (*Larix occidentalis*), incense cedar, Douglas fir, sub-alpine fir (*Abies lasiocarpa*), and Engelmann spruce (*Picea engelmannii*). Understory and regeneration layers reflect similar composition as overstory.

Shrubs are commonly found and reflect the same environmental trend as associated conifers; lower elevations have fewer shrubs and sparse appearance, increasing in diversity and abundance with elevation and improved soil moisture conditions. Indicative shrubs are bitterbrush (*Purshia tridentata*), big sagebrush (*Artemisia tridentata*), snowberry (*Symphoricarpos albus*), serviceberry (*Amelanchier alnifolia*), mountain mahogany (*Cercocarpus ledifolius*), greenleaf manzanita (*Arctostaphylos patula*), and squaw carpet (*Ceanothus prostratus*).

Grasses and grass-like vegetation are common and dominate the understory in many stands. Idaho fescue (*Festuca idahoensis*), prairie junegrass (*Koeleria macrantha*), bluebunch wheatgrass (*Agropyron spicatum*), Kentucky bluegrass (*Poa pratensis*), mountain brome (*Bromus carinatus*), elk sedge (*Carex geyeri*), Ross' sedge (*C. rossii*) and western needlegrass (*Stipa occidentalis*).

Landscape Setting. Ponderosa pine is the most tolerant of hot, dry environments of Oregon's conifers and forms the boundary zone between forest and rangeland cover types for much of Oregon. Its presence along the transition zone at lower elevations usually marks the adequacy of soil moisture to grow large stature vegetation. The exception to ponderosa pines types forming the forest/rangeland boundary is in central Oregon where western Juniper (*Juniperus occidentalis*) occupies the transition between sagebrush and ponderosa pine cover types.

Ponderosa pine can also tolerate cold conditions so it occupies a wide elevational range, but in the higher elevations it is restricted to southerly aspects. At these higher elevations ponderosa stands usually are not large enough to form mappable units. Similarly, ponderosa pine stands can be found in the low elevation, western Cascade forests but are not large enough to be mapped.

References. Volland, 1985, Johnson and Simon, 1987, Topik *et al.*, 1988, Hopkins, 1979, Atzet *et al.*, 1996.

DOUGLAS FIR DOMINANT/MIXED CONIFER FOREST (56)

Geographic Distribution. Common mid elevation forest type in southwestern Oregon. This type also extends north to the Columbia River in a narrow band along the eastern side of the Cascades.

Structure and Appearance. Stand structure can be diverse in undisturbed late seral stands although single story forest canopies typify the type. Overstory tree layer ranges widely in canopy closure based on management practice, disturbance history, and microsite. Understory vegetation is usually diverse and rich in species.

Composition. This cover type contains a diverse array of conifers that complement the ever-present Douglas fir (*Pseudotsuga menziesii*). Fir (*Abies grandis* and/or *A. concolor*), incense cedar (*Calocedrus decurrens*), western white pine (*Pinus monticola*), and ponderosa pine (*P. ponderosa*) are found throughout the range. Sugar pine (*P. lambertiana*) occurs only in southwestern Oregon, and western red cedar (*Thuja plicata*), and Engelmann spruce (*Picea engelmannii*) only in the central and northern regions of the Cascades. Sub-canopy layer generally has the shade tolerant components of the overstory. Western yew (*Taxus brevifolia*) is a frequent sub-canopy component in southwestern Oregon.

Indicator shrubs in this cover type include: vine maple (*Acer circinatum*), Rocky mountain maple (*A. glabrum* var. *douglasii*), serviceberry (*Amelanchier alnifolia*), greenleaf manzanita (*Arctostaphylos patula*), pinemat manzanita (*A. nevadensis*), red huckleberry (*Vaccinium parvifolium*), Oregon grape (*Mahonia nervosa*), snowberry (*Symphoricarpos albus*), oceanspray (*Holodiscus discolor*), sticky currant (*Ribes viscosissimum*), and squaw currant (*R. cereum*).

Common herbs in this cover type include western yarrow (*Achillea millefolium*), silvery lupine (*Lupinus argenteus*), tailcup lupine (*L. caudatus*), strawberry (*Fragaria virginiana*), bull thistle (*Cirsium vulgare*), heartleaf arnica (*Arnica cordifolia*), peavine (*Lathyrus lanszwertii*), starry solomon-plume (*Smilacina stellata*), and white vein pyrola (*Pyrola picta*).

Landscape Setting. In southwestern Oregon this mid-elevation forest transitions between the deciduous dominant foothill forests and the true fir dominant montane conifers. Along the slopes of the eastern Cascades it is also transitional to the ponderosa pine and ponderosa/western juniper at its low end and montane forests at upper elevations.

References. Hopkins and Rawlings 1985, Atzet *et al.* 1996, Atzet and Wheeler 1983, Chappell *et al.* 1999, Kovalchik 1986, Volland 1985.

PONDEROSA PINE-OREGON WHITE OAK FOREST (57)

Geographic Distribution. A low elevation forest found on the eastern flanks of Mount Hood and into the Columbia River Gorge. The type extends south to the Mutton Mountains of Wasco County. This type is also found in the foothills vegetation of southwestern Oregon, especially in the Rogue River Valley around White City.

Structure and Appearance. Open to closed canopy forest with small stature ponderosa pine (*Pinus ponderosa*), co-dominant with Oregon white oak (*Quercus garryana*). Ponderosa may be the canopy dominant but is considerably smaller than ponderosa grown in other environments. Except for an occasional Douglas fir (*Pseudotsuga menziesii*) around Mt. Hood and incense cedar (*Calocedrus decurrens*) in the Rogue River Valley other trees are absent from this type. Locally, white oak can be very dense. Shrub cover is typically sparse in this type, but rich in herbs and grasses.

Composition. Overstory tree species are ponderosa and white oak. Commonly associated shrubs with the type include: squaw carpet (*Ceanothus prostratus*), deerbrush (*C. integerrimus*), snowberry (*Symphoricarpos mollis*), serviceberry (*Amelanchier alnifolia*) and bitterbrush (*Purshia tridentata*).

Commonly associated forbs include western yarrow (*Achillea millefolium*), hawkweed (*Hieracium albiflorum*), smooth prariestar (*Lithophragma glabra*), American vetch (*Vicia americana*), tailcup lupine (*Lupinus caudatus*), arrowleaf balsamroot (*Balsamorhiza sagittata*), and nineleaf lomatium (*Lomatium triternatum*). Indicator grasses include: prairie junegrass (*Koeleria macrantha*), Idaho fescue (*Festuca idahoensis*), California brome (*Bromus carinatus*), cheatgrass (*B. tectorum*), bluebunch wheatgrass (*Agropyron spicatum*), elk sedge (*Carex geyeri*), and bulbous bluegrass (*Poa bulbosa*).

Landscape Setting. The ponderosa/white oak type is an indicator of warm, dry environments. This type usually forms the lower treeline zone and grades into unimproved pastures that were formerly grasslands. Grazing and selective logging pressure is high in these easily accessible environments. Frequent disturbance will decrease abundance of ponderosa and promote the spread of white oak.

References. Eyre 1980, Kagan and Caicco 1992, Topik *et al.* 1988, Williams, 1978.

PONDEROSA PINE/WESTERN JUNIPER WOODLAND (58)

Geographic Distribution. Widespread conifer woodland forest type in eastern Oregon. This cover type is usually found in the foothills margin bordering upland conifer types and sagebrush dominant lowlands for most of the regions mountain ranges.

Structure and Appearance. Woodland conifer forest cover type. Two-story canopy with widely spaced overstory ponderosa pine (*Pinus ponderosa*) over the sub-canopies of western juniper

(*Juniperus occidentalis*). Combined canopy layers generally ranges from 10-50 percent. The shrub layer, interspersed with annual and bunch grasses typically dominates understory vegetation.

Composition. Ponderosa pine and western juniper dominate the overstory in this cover type. Dominance of the tree layer between Ponderosa and juniper shifts by microsite and elevation. Improved site productivity favors dominance by Ponderosa. In lower elevations with warmer, drier microclimates, or sites with thin soils, dominance shifts to western juniper.

Indicator shrubs in this type include big sagebrush (*Artemisia tridentata*), low sagebrush (*A. arbuscula*), rabbitbrush (*Chrysothamnus nauseous* and *C. viscidiflorus*), mountain mahogany (*Cercocarpus ledifolius*), and bitterbrush (*Purshia tridentata*).

Grasses dominate the herbaceous layer. Overgrazing in the cover type usually leads to the proliferation of cheatgrass (*Bromus tectorum*), bottlebrush squirreltail (*Sitanion hystrix*), or bulbous bluegrass (*Poa bulbosa*). Native bunchgrasses commonly found in this cover type include: Sandberg's bluegrass (*Poa secunda*), Idaho fescue (*Festuca idahoensis*), bluebunch wheatgrass (*Agropyron spicatum*), Great Basin wildrye (*Elymus cinereus*), and Indian ricegrass (*Oryzopsis hymenoides*).

Landscape Setting. Similar to the western juniper woodland cover type, the ponderosa/juniper type occupies the transition between upland conifer forests and lowland sagebrush communities.

References. Shiftlet, 1994, Johnson and Clausnitzer 1992, Johnson and Simon, 1987, Dealy *et al.* 1981.

PONDEROSA-LODGEPOLE PINE ON PUMICE (59)

Geographic Distribution. The most common forest and/or woodland cover type in the southern half of the eastern Cascades ecoregion. The long taproots of lodgepole (*Pinus contorta*) and ponderosa (*P. ponderosa*) make them especially well adapted to the droughty pumice soils of this region. Pumice soils are derived from the volcanic eruptions of prehistoric Mount Mazama and numerous cinder cones throughout the region. This forest type forms a nearly continuous cover from LaPine to the northern edge of the Klamath Marsh.

Structure and Appearance. Ponderosa and lodgepole dominate the overstory canopy and regeneration layers in these forests. In its mature, undisturbed form, these forests are distinctly two story canopies with large ponderosa over the shorter lodgepole. Due to extensive selective logging in this type most of the large ponderosa have been removed leaving large tracts of single story lodgepole forests. Regeneration and tree growth are slow in these infertile forests. These forests have an active fire history and have evolved with frequent fires.

Shrub and herb layers are poorly developed in this forest type.

Composition. Ponderosa and lodgepole are the most commonly encountered trees. In wet places and riparian strips, Engelmann spruce (*Picea engelmannii*), quaking aspen (*Populus tremuloides*), and white fir (*Abies concolor*) can be found.

The shrub layer in this cover type is poorly developed. The most commonly associated shrubs are bitterbrush (*Purshia tridentata*), greenleaf manzanita (*Arctostaphylos patula*), kinnikinnik (*A. uva-ursi*), and serviceberry (*Amelanchier alnifolia*).

The herb layer in most stands has sparse cover with few species. Several grasses, western needlegrass (*Stipa occidentalis*), squirreltail (*Sitanion hystrix*), Wheeler's bluegrass (*Poa nervosa*), and Idaho fescue (*Festuca idahoensis*) are commonly found. Other forbs can be: wooly wyethia (*Wyethia mollis*), white hawkweed (*Hieracium albiflorum*), and Ross' sedge (*Carex rossii*).

Landscape Setting. The distribution of the ponderosa-lodgepole pine on pumice cover type closely corresponds to the distribution of deep tephra layers from the regions volcanic activity. As such, it doesn't necessarily relate to environment or climatic conditions.

References. Volland 1988, Kovalchik 1987, Hopkins 1979.

WESTERN JUNIPER WOODLAND (61)

Geographic Distribution. Western juniper (*Juniperus occidentalis*) is a common foothills vegetation type for many of the mountain ranges of eastern Oregon. Juniper reaches its greatest extent in the High Lava Plains Ecoregion centered on Bend, Oregon.

Structure and Appearance. This woodland type is typified by its open canopy (less than 30% crown closure), single story, short stature (6-20 feet tall) trees. Understory vegetation in these stands tends to be dominated by sagebrush species, although introduced annual grasses and native bunchgrasses can be important depending on site history and disturbance. As site productivity conditions improve, or as soil moisture availability increases, the pure stands of juniper give way to mixed stands of juniper and ponderosa pine (*Pinus ponderosa*).

Composition. In most stands western juniper dominates the tree layer. The most frequently encountered shrubs in this cover type are sagebrush species. Big sagebrush (*Artemisia tridentata*) is the most common with rigid sagebrush (*A. rigida*) and low sagebrush (*A. arbuscula*) also commonly found. Other shrubs associated with this type are mountain mahogany (*Cercocarpus ledifolius*), bitterbrush (*Purshia tridentata*), and rabbitbrush (*Chrysothamnus nauseous* and *C. viscidiflorus*).

Grasses characterize the herbaceous layer. Cheatgrass (*Bromus tectorum*) and bottlebrush squirreltail (*Sitanion hystrix*) are typical and dominant on overgrazed or disturbed sites. Native bunchgrasses can usually be found. Idaho fescue (*Festuca idahoensis*), bluebunch wheatgrass (*Agropyron spicatum*), Thurber's needlegrass (*Stipa thurberiana*), and Sandberg's bluegrass (*Poa secunda*) are the most commonly encountered.

Landscape Setting. Western juniper occupies the transition zone between conifer dominant uplands and the shrub-steppe basins of eastern Oregon. In the driest mountain ranges of southeastern Oregon, i.e. the Trout Creek and Pueblo Mountains, juniper is found at all elevational ranges. Western juniper's range is increasing in Oregon. Overgrazing and fire suppression are considered to be the primary factors for the spread of this type.

References. Crawford and Chappell 1999, Dealy *et al.* 1981, Monzingo 1986, Kagan and Caicco 1991.

RED ALDER (63) & RED ALDER/BIG LEAF MAPLE FOREST (64)

Geographic Distribution. Lowland riparian and low montane forest common in northwestern Oregon and found throughout the Coast Range mountains and the low elevation forests along the western margin of the Cascades. Big leaf maple (*Acer macrophyllum*) is most prevalent in the foothills region of the Cascades and the eastern side of the Coast Range. Maple is a minor deciduous component along the coastal margin.

Structure and Appearance. Moderate height (20-50 feet) closed canopy deciduous forest. Upland red alder (*Alnus rubra*) and alder/big leaf maple forests are early seral forests to the low elevation conifer forests of Douglas fir (*Pseudotsuga menziesii*), western hemlock (*Tsuga heterophylla*), and western red cedar (*Thuja plicata*). Red alder also is a common overstory tree along many streamside corridors within the Coast Range.

Composition. In early seral stages red alder and big leaf maple dominate the overstory. As the stand matures conifers overtop the deciduous trees and dominate the crown layer. In this advanced forest successional stage maintain a hold within the stand as sub-canopy trees in the large gaps among the overstory conifers.

Understory vegetation is prominent and diverse. Indicator shrubs are vine maple (*Acer circinatum*), salmonberry (*Rubus spectabilis*), thimbleberry (*R. parviflorus*), evergreen huckleberry (*Vaccinium ovatum*), and salal (*Gaultheria shallon*).

Herbaceous layer is rich in species and usually has one or more of the following moist site indicators: oxalis (*Oxalis oregana*), swordfern (*Polystichum munitum*), foamflower (*Tiarella trifoliata*), vanillaleaf (*Achlys triphylla*), beadlily (*Clintonia uniflora*), skunk cabbage (*Lysichitum americanum*), coltsfoot (*Petasites frigidus*), and twinflower (*Linnaea borealis*).

Landscape Setting. Alder stands are important colonizers of sites following timber harvest and act to stabilize hill slopes and retard erosion. Alder and big leaf maple stands are indicative of warm, moist sites. Alder regeneration and establishment is always better on southerly exposures.

ALDER-COTTONWOOD (65) & COTTONWOOD RIPARIAN GALLERY FOREST (68)

Geographic Distribution. Alder-cottonwood riparian forest is found along the margin of flowing streams in the foothills and mountains throughout much of Oregon. West of the Cascade crest the alder species is red alder (*Alnus rubra);* east of the crest it is typically white alder (*Alnus rhombifolia*). The type is especially prevalent along high gradient stream systems that flood frequently and deposit bed-load sand and gravel. The description of this type follows closely that of palustrine forest.

Structure and Appearance. Tall deciduous forest with partial-to-closed overstory canopy. Stands are often multi-layered. Cottonwood riparian stands are often mosaics of partial overstory canopy with dense understory reproduction to open areas dominated by willows (*Salix* spp.) to closed forests that may include conifers in the overstory.

Composition. Black cottonwood (*Populus trichocarpa*) is always present in the overstory. West of the Cascade crest red alder and big leaf maple (*Acer macrophyllum*) can be co-dominant with cottonwood. Conifers found in the western Oregon version of this type are Douglas fir (*Pseudotsuga menziesii*), western hemlock (*Tsuga heterophylla*), western red cedar (*Thuja plicata*), and Port Orford Cedar (*Chamaecyparis lawsoniana*) in southwestern Oregon.

Eastern Oregon deciduous overstory trees besides cottonwood include white alder, mountain alder (*Alnus incana*), pacific willow (*Salix lasiandra*), non-native black locust (*Robinia pseudo-acacia*), and quaking aspen (*Populus tremuloides*). Conifers associated with the eastern Oregon cottonwood gallery forests are ponderosa pine (*Pinus ponderosa*), Douglas fir, and in mountain settings Engelmann spruce (*Picea engelmannii*), and lodgepole pine (*Pinus contorta*).

Shrub and herb layers are prominent and diverse. Douglas spiraea (*Spiraea douglasii*), red osier dogwood (*Cornus sericea*), Nutka rose (*Rosa nutkana*), chokecherry (*Prunus virginiana*), and a variety of willow species (*Salix boothii*, *S. exigua, S. geyeriana, S. lemmonii*, and *S. bebbiana*). Forbs include speedwell (*Veronica americana*), cow parsnip (*Hieracleum lanatum*), skunk cabbage (*Lysichitum americanum*), pioneer violet (*Viola glabella*), stinging nettle (*Urtica dioica*), wide-fruit sedge (*Carex eurycarpa*) and wooly sedge (*C. lanuginosa*).

Landscape Setting. Generally a narrow, linear cover type. Mostly bordering agriculture, the type also fingers into uplands and mountains along the larger watercourses.

References. Kovalchik 1986, Crawford *et al.* 1999, Kagan and Caicco 1992.

ASPEN GROVES (66)

Geographic Distribution. Scattered throughout the coniferous forests of eastern Oregon in clonal clumps that are too small to map in most cases. Aspen (*Populus tremuloides*) groves are most extensive in the Steens Mountains of southeastern Oregon.

Structure and Appearance. Short stature (most aspen are less than 50 feet tall) deciduous trees that dominate the overstory. Lacking cattle grazing pressure aspen groves can be dense with numerous stems, most stands however are open with widely spaced aspen clumps with well-developed shrub and forb layers.

Composition. Aspen is the dominant tree in this cover type, although scattered conifers, or western juniper (*Juniperus occidentalis*) may be present.

Shrub layer is conspicuous and usually includes snowberry (*Symphoricarpos mollis*) and serviceberry (*Amelanchier alnifolia*). Other shrubs can be mountain big sagebrush (*Artemisia tridentata* var. *vaseyana*), bitterbrush (*Purshia tridentata*), and mountain mahogany (*Cercocarpus ledifolius*).

Forb layer is dominated by grasses, both native and introduced. Bluebunch wheatgrass (*Agropyron spicatum),* pinegrass (*Calamagrostis rubescens*), California brome (*Bromus carinatus*), blue wildrye (*Elymus glaucus*) and Idaho fescue (*Festuca idahoensis*), along with a variety of introduced grasses are common.

Landscape Setting. Aspen groves can be found in a variety of environmental settings in eastern Oregon. However, they mostly occupy mid to upper elevation ranges on the various mountain ranges.

References. Franklin and Dyrness 1973, Kagan and Caicco 1992, Kovalchik, 1987.

CONIFER-DECIDUOUS FOREST (67)

Geographic Distribution. Low to mid elevation early successional forest found throughout the Coast Range and Cascade Mountains of western Oregon.

Structure and Appearance. Overstory canopy is composed of co-dominant conifer (generally Douglas fir (*Pseudotsuga menziesii*) and deciduous (generally red alder (*Alnus rubra*), and/or big leaf maple (*Acer macrophyllum*) trees. This type is classed as an old clear-cut, or young forest. Canopies are single story and closed. The deciduous component is a remnant of earlier clear-cut succession where red alder and big leaf maple can dominate the overstory. Over time conifers out compete the deciduous trees relegating them to a minor component in the mature conifer forests of western Oregon.

Composition. The most common overstory conifer in this type is Douglas fir as it is replanted in monotypic stands following timber harvest. Western hemlock (*Tsuga heterophylla*), western red cedar (*Thuja plicata*), grand fir (*Abies grandis*), and Sitka spruce (*Picea sitchensis*) will naturally reseed into the clear-cuts depending on geographic location within the types regional distribution. Deciduous trees are primarily red alder and big leaf maple.

Understory vegetation is negligible as the tightly crowded canopy casts deep and continuous shade upon the forest floor.

Landscape Setting. Common throughout the Coast Range and its coastal plain forests. Also common in the Douglas fir dominant- low elevation forests of the Cascades. Exists as a patchwork mosaic with younger clear-cuts and established forests.

SISKIYOU MOUNTAINS MIXED DECIDUOUS (72)

Geographic Distribution. A common foothills forest type in the interior valleys of southwestern Oregon. Most readily found in the Rogue River valley between Grants Pass and Ashland. This type is also common in the Illinois River and other valley stream courses south to the California border. North of Grants Pass the type can be found in diminishing frequency in Douglas County to the Drain/Curtin divide.

Structure and Appearance. Dominant canopy layer is a low to mid stature (20-60 feet) deciduous and evergreen deciduous trees. Widely scattered emergent conifers, Douglas fir (*Pseudotsuga menziesii*) and incense cedar (*Calocedrus decurrens*) are common in stands that have not been selectively harvested, or have had recent fire activity.

Composition. Pacific madrone (*Arbutus menziesii*) and Oregon white oak (*Quercus garryana*) are generally co-dominant with less frequent representation from canyon live oak (*Q. chrysolepis*), black oak (*Q. kelloggii*), tan oak (*Lithocarpus densiflorus*), California laurel (*Umbellaria californica*), and chinquapin (*Castanopsis chrysophylla*).

Deciduous shrubs that are commonly associated with this cover type are poison oak (*Rhus diversiloba*), baldhip rose (*Rosa gymnocarpa*), common snowberry (*Symphoricarpos albus*), California hazelnut (*Corylus cornuta*), buckbrush (*Ceanothus cuneatus*), and hairy honeysuckle (*Lonicera hispidula*).

Commonly associated herbs include sweet cicely (*Osmorhiza chilensis*), bedstraw (*Galium aparine*), Sierra sanicle (*Sanicula graviolens*), blue wildrye (*Elymus glaucus*), bottlebrush squirreltail (*Sitanion hystrix*), and an assortment of naturalized annual grasses including the often dominant hedgehog dogtail (*Cynosorus echinatus*).

Landscape Setting. Siskiyou Mountains mixed deciduous forest is a transition forest type to associated regional upland conifer types. Its presence denotes warm, dry microclimates. Fire and grazing are frequent perturbations in this cover type.

References. Atzet and Wheeler 1983, Atzet *et al.* 1996, Jimerson *et al.* 1996, Hawk and Zobel 1983.

OREGON WHITE OAK FOREST (75)

Geographic Distribution. Common throughout the western Oregon interior valleys of the Rogue, Umpqua and Willamette River valleys and the eastern end of the Columbia River Gorge. Oregon white oak (*Quercus garryana*) is a low elevation, warm site deciduous tree species. This cover type is rapidly disappearing throughout its range in Oregon due to urban expansion.

Structure and Appearance. Oregon white oak dominates the overstory in this deciduous forest that ranges from woodland to forest based on ecological site and site history. Understories in these forests typically contain tall deciduous shrubs and smaller stature deciduous trees. In southwestern Oregon the subcanopy is often California black oak (*Quercus kelloggii*), while in the Willamette Valley it is sweet cherry (*Prunus avium*).

Composition. The canopy layer is dominated by Oregon white oak. Other canopy trees can be Douglas fir (*Pseudotsuga menziesii*), ponderosa pine (*Pinus ponderosa*) in upland settings. On the valley floor, overstories can be mixed with Oregon ash (*Fraxinus latifolia*), cottonwood (*Populus trichocarpa*), and big leaf maple (*Acer macrophyllum*).

Shrub layer is prominent and diverse. Commonly encountered shrubs being: poison oak (*Rhus diversiloba*), baldhip rose (*Rosa gymnocarpa*), California hazelnut (*Corylus cornuta*), common snowberry (*Symphoricarpos albus*), oceanspray (*Holodiscus discolor*), Indian plum (*Oemleria cerasiformis*), and trailing blackberry (*Rubus ursinus*).

Landscape Setting. Through most of the interior western valley settings Oregon white oak is the transitional forest from the agriculture dominant valley floor to the conifer forest uplands. Oregon white oak is a vigorous sprouter after fires and this cover type benefited from frequent fires. Increased fire suppression in this last century has led to invasion of the Oregon white oak stands by upland conifers. Oregon white oak produces an abundance of acorns and is a highly desirable wildlife habitat.

References. Atzet *et al.* 1996, Kagan and Caicco 1992, Franklin and Dyrness 1973, Habeck 1961.

SOUTH COAST MIXED DECIDUOUS (77)

Geographic Distribution. Low to middle elevation deciduous forest restricted to the western side of the Coast Range from Coos Bay south to the California border. This type is most prevalent in coastal northwestern California.

Structure and Appearance. Multi-story canopy composed of well-spaced large bole conifers (primarily Douglas fir (*Pseudotsuga menziesii*), over a densely stocked evergreen deciduous and deciduous sub-canopy. Understory is diverse and dominated by the shrub layer.

Composition. Overstory conifer is usually Douglas fir although western hemlock (*Tsuga heterophylla*), and Port Orford cedar (*Chamaecyparis lawsoniana*) can be important. Sub-canopy deciduous trees are tanoak (*Lithocarpus densiflorus*), California laurel (*Umbellaria californica*), Pacific dogwood (*Cornus nuttallii*), golden chinquapin (*Castanopsis chrysophylla*) and to a lesser extent, big leaf maple (*Acer macrophyllum*).

Representative shrubs are evergreen huckleberry (*Vaccinium ovatum*), Pacific rhododendron (*Rhododendron macrophyllum*), Oregon grape (*Mahonia nervosa*), salal (*Gaultheria shallon*), California hazelnut (*Corylus cornuta*), and red huckleberry (*Vaccinium parvifolium*).

Western sword fern (*Polystichum munitum*) dominates the herb layer and often is the only prominent herbaceous species due to the dense cover of shrubs.

Landscape Setting. The south coast mixed deciduous cover type is common in the southwestern Coast Range where frost, drought and fire are less likely to occur, namely the coastal margin and low elevation forests. Tanoak, California laurel, and Pacific dogwood are susceptible to frost and cannot compete with higher elevation forest types when they are continually set by frost damage. Similarly, the Coast Range north of Coos Bay is too cold for this cover type to thrive.

References. Atzet and Wheeler 1984, Atzet .*et al.* 1996, Jimerson *et al.* 1996, Frenkel and Kiilsgaard 1984.

SHRUBLAND AND GRASSLAND TYPES

SISKIYOU MOUNTAINS SERPENTINE SHRUBLAND (85)

Geographic Distribution. Occurs throughout southwestern Oregon in scattered mosaics with the Jeffrey Pine type. Most abundant in the foothills of the Illinois River Valley, also found in the Rogue Valley. This type is also associated with serpentine soil plant communities and its distribution and occurrence closely follows the Jeffrey Pine Forest and Woodlands type.

Structure and Appearance. Medium to tall shrubland that may have shrub canopy closures greater than 60% although most stands have canopies that are less dense with dispersed overstory. Scattered Jeffrey pine (*Pinus jeffreyi*) and incense cedar (*Calocedrus decurrens*) commonly occur in the type, at less than 10% canopy cover.

Forb layer is diverse, but sparse in appearance. Like the Jeffrey Pine type, these shrublands tend to have a lot of exposed bedrock and gravel scattered among the vegetation.

Composition. Shrub layer is dominated by hoary manzanita (*Arctostaphylos canescens*), white leaf manzanita (*A. viscida*), and buckbrush ceanothus (*Ceanothus cuneatus*). Other associated shrubs are huckleberry oak (*Quercus vaccinifolia*), dwarf ceanothus (*Ceanothus pumilus*) and coffeeberry (*Rhamnus californica*).

Forbs are diverse, but most of forb cover comes from grasses. Red fescue (*Festuca rubra*), Idaho fescue (*F. idahoensis*), Lemmon's needlegrass (*Stipa lemmonii*), blue wildrye (*Elymus glaucus*), big squirreltail (*Sitanion jubatum*), and pacific bluegrass (*Poa gracillima*) are commonly found. Other forbs are rock fern (*Aspidotis densa*), common yarrow (*Achillea millefolium*), spreading phlox

(*Phlox diffusa*), deadly zigadenus (*Zigadenus venenosus*), and sulphurflower (*Eriophyllum umbellatum*).

Landscape Setting. These shrublands typically are found at low elevations on southerly aspects. They are successional to Jeffrey Pine woodlands. However, slow plant growth due to general poor site quality and an active fire frequency maintain these shrublands as persistent features in the regions vegetation.

References. Jimerson *et al.* 1995, Atzet *et al.* 1996, Frenkel and Kiilsgaard 1984, Kagan and Caicco 1992.

WILLOW-HAWTHORN SHRUBLAND (87)

Geographic Distribution. Valley bottom riparian shrubland formerly widespread along low gradient streams. Currently most prevalent in the Willamette and Grand Ronde River Valleys.

Structure and Appearance. Tall shrubland with dense cover of willows (*Salix* spp.) and/or black hawthorn (*Crataegus douglasii*). Shrubs are interspersed with dense patches of spirea and sedge meadows in poorly drained reaches and tufted hairgrass (*Deschampsia caespitosa*) prairie on better drained soils.

Composition. Overstory willow species include (*Salix sitchensis, S. rigida, S. fluviatilis*, in western Oregon, and *S. lasiandra*, *S. exigua*, *S. geyeriana*, and *S. lutea*) in eastern Oregon. Black hawthorn is generally present in varying degrees of dominance. Other western Oregon shrubs include blackberry (*Rubus ursinus* and *R. spectabilis*), sticky currant (*Ribes lacustre*), Indian plum (*Oemleria cerasiformis*), and Douglas spirea (*Spiraea douglasii*).

Eastern Oregon shrubs include western birch (*Betula occidentalis*), snowberry (*Symphoricarpos albus*), mockorange (*Philadelphus lewisii*), and red osier dogwood (*Cornus sericea*).

Forbs and grasses common to this type include cowparsnip (*Hieracleum lanatum*), stinging nettle (*Urtica dioica*), common rush (*Juncus effusus*), horsetail (*Equisetum arvense*), camas (*Camassia quamash*), tufted hairgrass, buttercup (*Ranunculus occidentalis*), marsh sedge (*Carex obnupta*), bluejoint reedgrass (*Calamagrostis canadensis*), and blue wildrye (*Elymus glaucus*).

Landscape Setting. This type occurs on broad, low elevation floodplains that seasonally flood and maintain high water tables. Agriculture or other wetland/riparian types usually border this shrub dominant type.

References. Klock 1998, Chappell *et al.* 1998, Kagan and Caicco 1992, Kovalchik 1986.

MANZANITA DOMINANT SHRUBLAND (89)

Geographic Distribution. This is a primary colonizing vegetation type following fires both wild in southern margin of the eastern Cascades, and to lesser extent in the Siskiyou Mountains along the California border.

Structure and Appearance. Shrub layer dominates the early successional development of this cover type. Older stands have emergent conifers gradually to be replaced by conifer overstory.

Composition. Greenleaf manzanita (*Arctostaphylos patula*) dominates the shrub layer in this cover type. Other associated shrubs would be bitterbrush (*Purshia tridentata*), chokecherry (*Prunus virginiana*), pinemat manzanita (*A. nevadensis*), and snowbrush (*Ceanothus velutinus*).

Landscape Setting. Forms a mosaic with mixed conifer, lodgepole, and ponderosa pine forest cover types. This type is not prominent on the map because many of the stands are excluded because they are less than 250 acres in size.

References. Hopkins 1979, Mozingo 1986.

MOUNTAIN MAHOGANY SHRUBLAND (90)

Geographic Distribution. Mainly found in the mountain ranges of southeastern Oregon, i.e. Steens, Trout Creek and Pueblo Mountains. This cover type is commonly encountered but generally exists as units that are too small to be mapped. The most extensive representation of this is found on the rimrock canyons of the Steens Mountain.

Structure and Appearance. Widely dispersed tall shrubland with rock talus and rock outcrops between shrubs. Mountain mahogany (*Cercocarpus ledifolius*) grows in the soil pockets within the rocky slopes along with big sagebrush (*Artemisia tridentata*), bitterbrush (*Purshia tridentata*) and purple sage (*Salvia dorrii*).

Composition. Mountain mahogany is the dominant overstory vegetation with occasional western juniper (*Juniperus occidentalis*). Shrub layer also contains big sagebrush, bitterbrush, purple sage, low sage (*Artemisia arbuscula* or *A. cana*), and several buckwheats (*Eriogonum strictum* and *E. caespitosum*).

Landscape Setting. Occurs on the steep, rocky slopes of mountains in southeastern Oregon. It usually appears as a minor component within the western juniper woodland type, or it grades in and out of sagebrush steppe.

References. Kagan and Caicco, 1992, Mozingo 1986.

SAGEBRUSH STEPPE (91)

Geographic Distribution. The predominant cover type of the Owyhee Uplands ecoregion of southeastern Oregon. Sagebrush steppe is a common vegetation element in the watersheds of the Malheur, Powder, and Burnt Rivers. Sagebrush steppe is also commonly found in the non-cultivated portions of the Columbia River basin.

Structure and Appearance. Complicated mosaic of grasses (mostly introduced) and shrubs (mostly the differing varieties of big sagebrush). Historically, this type contained a predominance of bunchgrasses with scattered shrubs. Overgrazing has shifted the composition to favor sagebrush.

Composition. Shrub layer always contains some mixture of sagebrush and sagebrush-like vegetation. The three common subspecies of big sagebrush, Wyoming (*Artemisia tridentata* var. *wyomingensis*), basin (*A. tridentata* var. *tridentata*), and mountain (*A. tridentata* var. *vaseyana*) will grow with shorter varieties of sagebrush (rigid (*Artemisia rigida*), low (*A. arbuscula*), silver (*A. cana*) and three-tip (*A. tripartata*)) along with rabbitbrush (*Chrysothamnus viscidiflorus* and *C. nausosus*), based on local environment and site history.

A variety of bunchgrasses are associated with this type although they rarely comprise much of the stand due to grazing pressure. Some of the characteristic native grasses of this type are Great Basin wildrye (*Elymus cinereus*), Thurber needlegrass (*Stipa thurberiana*), Indian ricegrass (*Oryzopsis hymenoides*), blue bunch wheatgrass (*Agropyron spicatum*), Idaho fescue (*Festuca idahoensis*), bluegrass (*Poa secunda*), and sand dropseed (*Sporobolus cryptandrus*). In many areas, these have given way to cheatgrass (*Bromus tectorum*), and crested wheatgrass (*Agropyron cristatum*).

Landscape Setting. The sagebrush steppe primarily is adjacent to the big sagebrush type. These two types may, in fact, weave together in complicated mosaics at the edges of the Basin and Range ecoregion and in the interior uplands. Distinction between the two types is complicated and therefore somewhat crude and inexact in its depiction on the map.

References. Johnson and Simon 1986, Johnson and Clausnitzer 1987, Crawford *et al.* 1999, Franklin and Dyrness 1973.

LOW-DWARF SHRUBLAND (93)

Geographic Distribution. These dwarf sagebrush types are sporadically found throughout eastern Oregon, generally on areas with shallow basalt soils. The low sagebrush (*Artemisia arbuscula*) cover type is most extensive east of the Guano Valley in Lake and Harney counties and in the ancient pluvial lake basins of northern Lake County. Rigid sagebrush (*Artemisia rigida*) is common in Oregon’s Basin and Range along the Columbia River between Arlington and Boardman, and along the margins of the Blue Mountains. Black sagebrush (*Artemisia nova*) dominates scabland flats in extreme southeastern Oregon, in Malheur and southeastern Harney Counties. Low and rigid sagebrush are both infrequently found in the forests of the eastern Cascades and northeastern Oregon, where soils are too shallow to permit tree growth.

Structure and Appearance. Low sagebrush (*A. arbuscula*) or rigid sagebrush (*Artemisia rigida*) are the primary dominants and often the only shrubs in the stand. Sandberg bluegrass (*Poa secunda*) is common.

Composition. A dwarf sagebrush shrub (black sagebrush, rigid sagebrush, low sagebrush, or silver sagebrush [*Artemisia cana*]) dominates the shrub layer with occasional big sagebrush (*A. tridentata*) and bitterbrush (*Purshia tridentata*). Several shrubby buckwheat species (*Eriogonum douglasii* and *E. strictum*) and purple sage (*Salvia dorrii*) are prominent on steep, rocky slopes within the cover type.

The forb layer is diverse, but usually composed of ephemeral annual forbs, or scabland perennials (*Lomatium cous, Balsamorhiza serrata, B. hookeri, Lewisia rediviva, Erigeron* and *Phlox* spp.), although grasses provide most of the forb cover. Cheatgrass, Sandberg bluegrass, bottlebrush squirreltail (*Sitanion hystrix*) and onespike oatgrass (*Danthonia unispicata*) are the most frequently encountered.

Landscape Setting. The dwarf sagebrush usually are the dominant vegetation in shallow soil, rocky conditions that exclude the formation of other sagebrush and shrub types. In most cases, they do not form extensive landscape-level covers but rather are part of the larger big sagebrush and sagebrush steppe mosaic.

References. Hopkins 1979, Kagan and Caicco 1992, Shiftlet 1994, Dealy *et al.* 1981.

SALT DESERT SCRUB SHRUBLAND (95)

Geographic Distribution. Most extensive in the alkaline playa lake basins of the Great Basin ecoregion of Harney, Lake and Malheur Counties. Especially prominent around Lake Abert, Malheur, Alvord, and the Warner Lakes.

Structure and Appearance. Low to tall shrub communities comprised of dispersed alkali-tolerant vegetation. Salt desert scrub is a catchall term that describes several differing environments. On the most saline sites, that also are seasonally flooded, black greasewood (*Sarcobatus vermiculatus*) and winterfat (*Erotia lanata*) dominate. Sites with better drainage support a variety of shrubs and several grasses.

Composition. Characteristic shrubs that are commonly associated with salt desert scrub complexes are shadscale (*Atriplex confertifolia*), hopsage (*Grayia spinosa*), budsage (*Artemisia spinescens*), Mormon tea (*Ephedra viridis*), rabbitbrush (*Chrysothamnus nauseous*), saltbush (*Atriplex nuttallii*) and greenmolly (*Kochia americana*).

Landscape Setting. Salt desert scrub is surrounded by big sagebrush or sagebrush steppe cover types. The most extensive areas are always associated with the large, ephemeral lakes of the region. However, there are numerous, small pockets of this cover type scattered sporadically throughout southeastern Oregon.

References. Mozingo 1986, Demming *et al.* 1978, Shiftlet 1994, Dealy *et al.* 1981.

BIG SAGEBRUSH SHRUBLAND (96)

Geographic Distribution. The most common vegetative cover type in eastern Oregon. It appears as a mosaic with shrub-steppe communities along mountain range foothills, basins and along the valley floor.

Structure and Appearance. Medium to tall shrub community dominated by the three varieties of big sagebrush, mountain big sagebrush (*Artemisia tridentata* var. *vaseyana*), basin big sage (*A. tridentata* var. *tridentata*), and Wyoming big sage (*A. tridentata* var. *wyomingensis*). Some stands support a diversity of forbs and grass species; however, due to grazing pressure the dominant forb is cheatgrass (*Bromus tectorum*). Crested wheat grass (*Agropyron cristatum*) from nearby CRP (Crop Reserve Program) lands can seed into these stands.

Composition. *Artemisia tridentata* varieties dominate the canopy layer. Other shrubs found in this type include: bitterbrush (*Purshia tridentata*), rabbitbrush (*Chrysothamnus nauseous* and *C. viscidiflorus*), threetip sagebrush (*Artemisia tripartata*), silver sagebrush (*Artemisia cana*) and shadscale (*Atriplex confertifolia*).

Herbaceous plants found in this type include pussytoes (*Antennaria corymbosa*), spreading phlox (*Phlox diffusa*), Hoods phlox (*P. hoodii*), and longleaf phlox (*P. longifolia*), starved milk vetch (*Astragalus miser*), bigseed lomatium (*Lomatium macrocarpum*), nineleaf lomatium (*Lomatium triternatum*) Cusick's penstemon (*Penstemon cusickii*), and arrowleaf balsamroot (*Balsamorhiza sagittata*).

Native grasses range from present to abundant based on site history and beneficial soil/water relations. Commonly encountered native bunchgrasses include bluebunch wheatgrass (*Agropyron spicatum*), Sandberg's bluegrass (*Poa secunda*), junegrass (*Koeleria macrantha*), Idaho fescue (*Festuca idahoensis*), Great Basin wildrye (*Elymus cinereus*) and in more disturbed situations bottlebrush squirreltail (*Sitanion hystrix*). Introduced annual grasses are primarily cheatgrass and crested wheatgrass.

Landscape Setting. Big sagebrush occurs throughout the arid basins and valleys of western United States. In Oregon, it is the 2nd largest (to Douglas fir/western hemlock/western red cedar) cover type mapped in this study. Big sagebrush thrives in regions of low precipitation (mostly in the 8 to 14 inch range). The big sage type is bordered on its upland margin by western juniper, eastside mixed conifer, or ponderosa pine types.

References. Tisdale 1994, Shiftlet 1994, Dealy et al 1981, Dobler *et al.* 1996.

BIG SAGEBRUSH - BITTERBRUSH SHRUBLAND (97)

Geographic Distribution. Occurs throughout eastern and central Oregon east of the Cascade crest. While widespread in its occurrence, the big sagebrush (*Artemisia tridentata*)-bitterbrush (*Purshia tridentata*) is largely restricted to porous, well-drained, sandy soils.

Structure and Appearance. Medium-tall shrubland steppe with grass dominant understory. Big sagebrush and bitterbrush are co-dominant in the canopy layer.

Composition. Other shrubs commonly encountered in this type besides big sagebrush and bitterbrush would be low sagebrush (*Artemisia arbuscula*), rigid sage (*A. rigida*), gray and green rabbitbrush (*Chrysothamnus nauseosus* and *C. viscidiflorus*). Mountain mahogany (*Cercocarpus ledifolius*) and purple sage (*Salvia dorrii*) are associated with this type in southwestern Oregon.

The herbaceous layer in this type ranges widely in composition and coverage. Associated plants include northern mule ears (*Wyethia amplexicaulis*), cluster tarweed (*Madia glomerata*), line-leaf fleabane (*Erigeron filifolius*), sagebrush mariposa (*Calochortus macrocarpus*), death-camas (*Zigadenus venenosus*), primrose (*Oenothera pallida*), desert parsley (*Lomatium macrocarpum*), and several species of buckwheat (*Eriogonum* spp.). Commonly encountered grasses are several species of wheatgrass, crested, downy and bluebunch (*Agropyron cristata*, *A. dasytachyum*, and *A. spicatum*), cheatgrass (*Bromus tectorum*), Indian ricegrass (*Oryzopsis hymenoides*), needle-and-thread grass (*Stipa comata*), and Sandberg's bluegrass (*Poa secunda*).

Landscape Setting. Because of the close relationship this cover type has with sandy, alluvial soils it is mostly found on deposition features; primarily alluvial terraces above streams and on bajadas at the base of the arid mountain ranges in southeastern Oregon. The type generally appears as a small component of the larger big sagebrush and sagebrush-steppe types.

References. Shiftlet 1994, Taylor 1994, Mozingo 1986, Kagan and Caicco 1992, Dealy *et al.* 1981.

NORTHEASTERN OREGON CANYON GRASSLAND AND SHRUBLAND (103)

Geographic Distribution. Occurs on steep canyon slopes in the mountains of northeastern Oregon. This type is most extensive in the Hell's Canyon and the Grand Ronde River canyon of Baker and Wallowa Counties.

Structure and Appearance. Bunchgrasses and shrub dominant patches form a mosaic vegetation cover type. On steep slopes with poor soil development, grasses dominate with stringers of shrubs, especially mockorange (*Philadelphus lewisii*), oceanspray (*Holodiscus discolor*), and Rocky Mountain maple (*Acer glabrum*). Where deeper soils exist, shrub development is usually more extensive along with widely scattered ponderosa pine (*Pinus ponderosa*) and Douglas fir (*Pseudotsuga menziesii*).

Composition. Predominant grasses found in this cover type are Idaho fescue (*Festuca idahoensis*), blue bunch wheatgrass (*Agropyron spicatum*), Wheeler's bluegrass (*Poa nervosa*), Sandberg's bluegrass (*P. secunda*), mountain brome (*Bromus carinatus*), cheatgrass (*B. tectorum*), junegrass (*Koeleria nitida*), western needlegrass (*Stipa occidentalis*), sand dropseed (*Sporobolus cryptandrus*) and red three awngrass (*Aristida longiseta*).

Predominant shrubs are: mountain big sagebrush (*Artemisia tridentata* var. *vaseyana*), bitterbrush (*Purshia tridentata*), ninebark (*Physocarpus malvaceus*), hackberry (*Celtis reticulata*), snowberry (*Symphoricarpos albus*), buffaloberry (*Shepherdia canadensis*), and sumac (*Rhus glabrum*),

Landscape Setting. Occupies the hot, dry environments of the river canyons of northeastern Oregon. This type grades in and out of ponderosa pine and/or mixed conifer forest that occupy the benches and more suitable environments.
References. Johnson and Simon 1987, Kagan and Caicco 1992.

ALPINE GRASSLANDS AND SHRUBLANDS (105)

Geographic Distribution. This cover type depicts the vegetated areas above upper treeline in the highest mountains throughout Oregon.

Structure and Appearance. Dwarf shrubs dominate this cover type, and thickly compacted *Carex* species that form a grass-like cover called sedge turf. Widely scattered, low stature conifers are also common in this type.

Composition. Shrub layer is dominated by several prostrate shrubs; red mountain heather (*Phyllodoce empetriformis*), green mountain heather (*P. glanduliflora*), white mountain heather (*Cassiope mertensiana*), or crowberry (*Empetrum nigrum*). Other dwarf shrubs found in this cover type include cinquefoil (*Potentilla fruticosa*), juniper (*Juniperus communis*), bearberry (*Arctostaphylos uva-ursi*) and willows (*Salix* spp.).

Alpine sedge turf usually contains one or more of the following: alpine black sedge (*Carex nigricans*), capitate sedge (*C. capitata*), dunhead sedge (*C. phaeocephala*), or showy sedge (*C. spectabilis*).

Landscape Setting. This cover type always occurs above timberline. Typically this type occurs as a mosaic with alpine parkland and alpine fell and snowfields. These types usually are not very extensive and therefore not mapped.

FOREST GRASSLAND MOSAIC (106)

Geographic Distribution. Common in ponderosa pine and mixed conifer types of northeastern Oregon, and in the eastern Cascades.

Structure and Appearance. Mosaic of bunchgrass grasslands and conifer forest. Most common in the foothills and lower elevation ranges, this type is indicative of the hottest and driest forested conditions. In mid elevations this type is almost always found on southerly aspects.

Composition. Ponderosa pine (*Pinus ponderosa*), Douglas fir (*Pseudotsuga menziesii*), lodgepole pine (*P. contorta*) and grand fir (*Abies grandis*) are the most common overstory trees in northeastern Oregon. While in the eastern Cascades, ponderosa pine, Douglas fir, white fir (*Abies concolor*), and incense cedar (*Calocedrus decurrens*) are the common overstory conifers.

The shrub layer is poorly represented in this type. Birchleaf spirea (*Spiraea betulifolia*), baldhip rose (*Rosa gymnocarpa*), and snowberry (*Symphoricarpos albus*) can be found but typically are not present in significant amounts.

Grasses and grass-like plants dominate the forb layer. Idaho fescue (*Festuca idahoensis*) usually is the dominant grass. Other grasses that in combination can form co-dominance within the stand are bluebunch wheatgrass (*Agropyron spicatum*), junegrass (*Koeleria macrantha*), Sandberg bluegrass (*Poa secunda*) and western needlegrass (*Stipa occidentalis*). Cheatgrass (*Bromus tectorum*), and bottlebrush squirreltail (*Sitanion hystrix*) are also present to co-dominant in most stands, especially those stands which are heavily grazed by cattle. Ross' and elk sedge (*Carex rossii* and *C. geyeri*) are common associates in this type.

Landscape Setting. The type can inter-grade with several conifer forest and woodland types, typically those most tolerant of hot, dry conditions. At lower elevations the type can grade into western juniper woodlands, particularly in the eastern Cascades.

References. Volland 1985, Johnson and Simon 1987, Topik *et al.* 1988, Hopkins 1979, Atzet *et al.* 1996.

SUBALPINE PARKLAND (110)

Geographic Distribution. The highest elevation forest zone in the Cascades, Blues, and Wallowa Mountain ranges of Oregon.

Structure and Appearance. Subalpine parkland is distinctive from subalpine grassland and shrublands due to the presence of the clumpy, scattered tree pockets throughout the cover type. Conifer overstory typically ranges from 10 to 30% cover. Ground layer can be a dense layer of low-lying shrubs, sedge or grass turf, or montane wetland bogs.

Composition. Subalpine parkland conifer composition varies by region. In the Blues and Wallowas the parkland is usually subalpine fir (*Abies lasiocarpa*), Engelmann spruce (*Picea engelmannii*), or lodgepole pine (*Pinus contorta*). In the Cascades, mountain hemlock (*Tsuga mertensiana*), subalpine fir, silver fir (*Abies amabilis*), and to a lesser extent Alaska yellow cedar (*Chamaecyparis nootkatensis*). In the southern Cascades mountain hemlock, Shasta red fir (*Abies magnifica* var. *shastensis*), and whitebark pine (*Pinus albicaulis*).

The shrub layer is similar in composition to the subalpine shrubland and grassland cover type, where commonly associated shrubs are: red mountain heather (*Phyllodoce empetriformis*), green mountain heather (*P. glanduliflora*), white mountain heather (*Cassiope mertensiana*), or crowberry (*Empetrum nigrum*). Other dwarf shrubs found in this cover type include cinquefoil (*Potentilla* *fruticosa*), juniper (*Juniperus communis*), bearberry (*Arctostaphylos uva-ursi*) and willows (*Salix* spp.).

Alpine sedge turf usually indicates poorly drained soils, or persistent snow pack well into the growing season, and contains one or more of the following; alpine black sedge (*Carex nigricans*), capitate sedge (*C. capitata*), dunhead sedge (*C. phaeocephala*), or showy sedge (*C. spectabilis*).

On drier sites, the forb layer is characterized by either elk or Ross' sedge (*Carex geyeri* or *C. rossii*), smooth woodrush (*Luzula hitchcockii*), Drummond's rush (*Juncus drummondii*), or green fescue (*Festuca viridula*).

Landscape Setting. Forms the high elevation limit to tree growth. Usually is a mosaic with alpine fell and snowfields and the alpine shrubland and grassland.

References. Hopkins 1979, Johnson and Simon 1986, Johnson and Clausnitzer 1987, Hemstrom *et al.* 1987, Volland 1988, Atzet *et al.* 1996, Crawford *et al.* 1999.

MODIFIED GRASSLAND (112)

Geographic Distribution. Extensive grasslands of northeastern Oregon that formerly were composed of native bunchgrasses. Presently, these grasslands are used primarily for pasture. Most lands in this type are seeded to cultivated grasses. This type is common in the foothills of the Wallowa and Blue Mountains in Grant, Union, and Wallowa Counties.

Structure and Appearance. Medium-tall grasslands composed of a variety of orchard and perennial bunch grasses. Shrubs are virtually nonexistent and a negligible part of total plant cover. Forbs can be diverse, but largely inconspicuous amongst the grasses.

Composition. Undisturbed remnants of this type are typically dominated by bluebunch wheatgrass (*Agropyron spicatum*). Idaho fescue (*Festuca idahoensis*), Sandberg's bluegrass (*Poa secunda*), and prairie junegrass (*Koeleria macrantha*) are common associates. Less abundant, but common in the type are sand dropseed (*Sporobolus cryptandrus*), threeawn (*Aristida longiseta*), and needle-and-thread grass (*Stipa comata*).

Native forbs commonly found in this type include yarrow (*Achillea millefolium*), milk vetch (*Astragalus* spp.), arrowleaf balsamroot (*Balsamorhiza sagittata*), biscuitroot (*Lomatium macrocarpum*), and spreading phlox (*Phlox longifolia*). Common, exotic species include salsify (*Tragopogon dubius*), mullein (*Verbascum thapsus*), knapweed (*Centurea* spp.), cheatgrass (*Bromus tectorum*) and Kentucky bluegrass (*Poa pratensis*).

Landscape Setting. Generally restricted to foothill margins of northeastern Oregon mountains. Native bunchgrasses are more prevalent on steep hillsides and remote sections of the type. With gentle terrain and proximity to valley bottom agriculture grass species composition shifts to introduced orchard grasses.

References. Mayfield and Kjelmyr 1982, Johnson and Simon 1987, Johnson and Klausnitzer, Tisdale 1994, Johnson 1994

COASTAL STRAND AND HEADLANDS (113)

Geographic Distribution. This narrow strip of vegetation borders the coastline from Oregon to California.

Structure and Appearance. This cover type combines several distinct vegetation types, deflation plains, and headlands. Deflation plain vegetation types can be lumped into two general situations, 1) dry meadow, and 2) marsh community. Hummocky ridges of European beach grass (*Ammophila arenaria*) and wet reaches, which contain a variety of herbaceous plants and willows, characterize deflation plains. Headland vegetation is a mosaic of grass and shrublands that grow on promontories adjacent to the shoreline and grade into coastal forest cover types.

Composition. The hummocky ridges that separate the sandy beaches from the wet deflation plains are dominated by European beach grass, an introduced grass that was originally planted for dune stabilization purposes and has spread throughout the coastal strand to become a dominating influence on vegetation development. Other herbaceous vegetation commonly found on these ridges is seashore bluegrass (*Poa macrantha*), beach pea (*Lathyrus littoralis*), and seashore lupine (*Lupinus littoralis*). The marshy deflation plain vegetation includes: Hooker's willow (*Salix hookeriana*), slough sedge (*Carex obnupta*), Pacific silver weed (*Potentilla pacifica*), and salt rush (*Juncus lesueurii*).

Headland vegetation shrub layer includes: salal (*Gaultheria shallon*), evergreen huckleberry (*Vaccinium ovatum*), salmonberry (*Rubus spectabilis*), and elderberry (*Sambucus racemosa*). South coast shrublands will also contain, or be dominated by, coyote bush (*Baccharis pilularis*) and the introduced gorse (*Ulex europaeus*) and Scotch broom (*Cytisus scoparius*).

Grasses dominate the forb layer in headland vegetation. Native dominant grasses are red fescue (*Festuca rubra*), and pacific reedgrass (*Calamagrostis nutkatensis*). Blue wildrye (*Elymus glaucus*), California danthonia (*Danthonia californica*), and Sitka brome (*Bromus sitchensis*) can be found. These grasslands also contain a variety of introduced grasses as they were managed for sheep grazing earlier in this century.

Landscape Setting. This type is poorly represented on the map because its distribution is not extensive enough to be mapped in most areas. The type grades in and out of coastal forest types and estuarine and palustrine wetland types.

References. Crawford *et al.* 1999, Weideman 1974, Ripley 1984

WET MEADOW (114)

Geographic Distribution. Montane herbaceous meadows of grass-like plants, primarily members of the Carex tribe. Soil must be saturated to moist throughout the growing season for the Carex to dominate. Soil surface is seasonally flooded from May-June from snowmelt. Occurs throughout most mountain ranges in eastern Oregon. This type is poorly represented on the map because these meadows typically are smaller than the minimum map unit

Structure and Appearance. Carex dominant meadows with dense sedge turf the primary vegetation layer. If the area is not grazed there are a number of *Carex* species that will occupy these sites. Grazing reduces species complexity and shifts dominance to Nebraska sedge (*Carex nebraskensis*).

Composition. Sedge species form the majority of species diversity in this type. Commonly occurring sedges include beaked sedge (*Carex rostrata*), water sedge (*C. aquatilis*), wooly sedge (*C. lanuginosa*), thickheaded sedge (*C. pachystachya*), and lenticular sedge (*C. lenticularis*). Drier microsites will typically contain tufted hair grass (*Deschampsia caespitosa*). Forbs are not abundant in this type.

Landscape Setting. Montane meadows where sub-surface soil conditions, or shallow ground water table maintain moist soils through the growing season. The type exists as small, discrete entities through the mountains of eastern Oregon and the eastern Cascades.

References. Kovalchik 1986, Johnson and Simon 1987, Johnson and Clausnitzer 1992, Kagan and Caicco 1992.

GRASS-SHRUB-SAPLING or REGENERATING YOUNG FOREST (121)

Geographic Distribution. Common throughout the mountains of Oregon.

Structure and Appearance. Captures the range of successional conditions following timber harvest. Site preparation following timber harvest is a ground scarification and burning of slash and large woody debris, followed by seeding of a mix of annual grasses to retard soil erosion and planting conifer seedlings. As the stand matures there may be a phase where resprouting shrub vegetation, or dormant shrub seeds germinated by prescription fire, dominate the overstory canopy layer. Later in the successional phase the conifer saplings have emerged through the shrub canopy and formed continuous canopies

Composition. A variety of shrubs and forbs can be present in this cover type based on regional flora and site history.

Landscape Setting. Appears as a patchwork mosaic woven into surrounding local forest cover types. The several large, continuous polygons that appear on the map in south-central and northeastern Oregon are burned over lands from fires in the 1980's.

OTHER TYPES

ALKALI PLAYA (122)

Geographic Distribution. Found in Harney, Lake, and Malheur Counties of southeastern Oregon. These barren flats are commonly associated with the larger pluvial lake basins of Alvord, Summer, Malheur, Catlow, and Pueblo Lakes.

Structure and Appearance. Barren, alkali flats that are seasonally flooded.

Composition. Alkali playas are largely devoid of vegetation.

Landscape Setting. This cover type is surrounded by the salt desert scrub, big sagebrush, or sagebrush steppe cover types.

References. Kagan and Caicco 1992, Mozingo 1987

URBAN (124)

Geographic Distribution. Urban areas depicted on the map are those cities and municipalities identified in the Oregon state service center digital urban area coverage.

AGRICULTURE (125)

Geographic Distribution. Found throughout Oregon. Agriculture is identified as those lands that have been modified for growing crops and/or animal husbandry.

TIDAL FLATS (126)

Geographic Distribution. Tidal flats are features associated with bays and estuaries along the Oregon coast. There are also a number of tidal flats in the lower Columbia River extending east to about Clatskanie.

Structure and Appearance. These are the sand-soil-muck surfaces that becomes exposed during low tide.

Composition. Tidal flats are basically devoid of significant amounts of rooted vegetation.

Landscape Setting. Forms the boundary layer between estuarine, or palustrine wetlands and open water habitats in Oregon’s bays, estuaries, and the lower reaches of the Columbia and many coastal rivers.

References. Cowardin *et al.* 1978

LAVA FLOWS (127)

Geographic Distribution. This cover type is found mostly in southeastern Oregon and eastern Cascades Mountains.

Structure and Appearance. Surface lava flows that are largely unvegetated (less than 15% vegetation cover). In eastern Oregon, lava flows may be thinly vegetated with sagebrush, primarily big sagebrush (*Artemisia tridentata*) and annual grasses, especially cheatgrass (*Bromus tectorum*). The lava flows in the Cascades tend to be largely unvegetated with scattered pockets of soil that are deep enough to sustain vegetation. In these soil pockets, shrubs such as gooseberry (*Ribes cereum*), or snowbush (*Ceanothus velutinus*), or conifers, especially lodgepole pine (*Pinus contorta*) can survive.

COASTAL DUNES (128)

Geographic Distribution. The coastal dunes of Oregon attain their greatest development between Florence and Coos Bay where they form a continuous surface that extends several miles inland. Dunes can form through a variety of processes that are influenced by local topography, prevailing wind direction, and source supply of sand. While dunes can be found throughout the length of the Oregon coast they mostly are small, discrete features that do not show up in the vegetation map.

Structure and Appearance. Coastal dunes, as they relate to this vegetation description, are sparsely vegetated. Dunes are regions of actively moving sand and only a few types of plants do well in this environment, and typically are grasses or grass-like plants.

Composition. The most commonly encountered plants encountered on these dunes are European beach grass (*Ammophila arenaria*), seashore bluegrass (*Poa macrantha*), American dune grass (*Elymus mollis*) and large-headed sedge (*Carex macrocephala*). Other forbs are beach morning glory (*Convolvulus soldanella*), beach knotweed (*Polygonum paronychia*), yellow abronia (*Abronia latifolia*) and silver beach weed (*Franseria chamissonis*).

Landscape Setting. Coastal dunes can appear as a mosaic with coastal forest, estuarine and palustrine wetlands and coastal strand vegetation.

References. Weideman *et al.* 1974, Ripley 1984

ALPINE FELL and SNOWFIELDS (129)

Geographic Distribution. This cover type depicts the non-vegetated areas above upper treeline in the highest mountains throughout the state. Persistent snow cover and rock talus slopes dominate the local landscape. Found in above timberline environments on the higher peaks and ranges of the Cascades, Steens, and ranges in northeastern Oregon.

OPEN WATER (130)

Geographic Distribution. Lakes, ponds, and reservoirs larger than 10 acres that occur throughout Oregon.

NATIONAL WETLAND INVENTORY (135) & GAP PALUSTRINE FOREST (200)

Geographic Distribution. Palustrine forest wetlands are characterized by overstory canopy vegetation greater than 18 feet in height. All water regime influences: lacustrine, riverine, and tidal margin is included. Palustrine forests, indeed all riparian vegetation systems, occur along the interface between aquatic and terrestrial ecosystems. The distribution of this type is a function of surface hydrologic features.

Structure and Appearance. Dominant overstory vegetation is trees. Canopies range from open to closed and in well-developed stands are typically multi-storied. The tree layer can be dominated by deciduous, conifer, or mixed canopies. The shrub layer, both tall and low, generally forms dense thickets. Forb layer is abundant and diverse.

Composition. Common eastern Oregon deciduous canopy trees in this type are: black cottonwood (*Populus trichocarpa*), white alder (*Alnus rhombifolia*), quaking aspen (*Populus tremuloides*), and peachleaf willow (*Salix amygdaloides*). Conifer trees in eastern Oregon palustrine forests typically do not dominate the overstory. Ponderosa pine (*Pinus ponderosa*), lodgepole pine (*P. contorta*), and Douglas fir (*Pseudotsuga menziesii*) are the most commonly encountered overstory conifers.

Western Oregon palustrine forests common deciduous trees include: big leaf maple (*Acer macrophyllum*), red alder (*Alnus rubra*), western ash (*Fraxinus latifolia*), black cottonwood Oregon white oak (*Quercus garryana*), and pacific willow (*Salix lucida*). Conifers commonly dominate the overstory in many western Oregon palustrine forest conditions. Lodgepole pine is common in bogs and deflation plains in the coastal margin. Western red cedar (*Thuja plicata*), western hemlock (*Tsuga heterophylla*), Douglas fir, and grand fir (*Abies grandis*).

Landscape Setting. Palustrine forests tend to be narrow, linear features that closely follow the moving watercourse.

References. Chappell *et al.* 1999, Kagan and Caicco 1992, Kovalchik 1986

NATIONAL WETLAND INVENTORY (136) & GAP PALUSTRINE SHRUBLAND (201)

Geographic Distribution. Palustrine shrublands, like palustrine forests, are vegetation cover types closely associated with surface hydrologic features. These tall shrub riparian areas are most prominent along low gradient streams that meander through the broad valleys and pluvial basins of eastern Oregon. The type is very common in the Silvies and Woods River basins.

Structure and Appearance. Dense, tall shrubs dominate the canopy layer of this type.

Composition. Eastern Oregon palustrine shrublands tend to be dominated by willow species (*Salix* spp.). Other shrubs found in these settings include chokecherry (*Prunus virginiana*), bog birch (*Betula glandulosa*), bog blueberry (*Vaccinium occidentale*), snowberry (*Symphoricarpos albus*), wax currant (*Ribes cereum*), and Douglas spirea (*Spiraea douglasii*).

Western Oregon palustrine shrublands are also dominated by willow species, especially Sitka willow (*Salix sitchensis*) and Hooker's willow (*S. hookeriana*), Douglas spirea, red-osier dogwood (*Cornus sericea*), snowberry, and black hawthorn (*Crataegus douglasii*).

References. Cowardin *et al.* 1979, Kovalchik 1986, Franklin 1972.

NWI (137) & GAP ESTUARINE EMERGENT WETLAND (202)

Geographic Distribution. Common wetland vegetation that borders Oregon's coastal river mouths, bays, and estuaries. Estuarine emergent vegetation is occupied by plants that can withstand inundation by salt and brackish water.

Structure and Appearance. Herbaceous wetlands composed of grass, grass-like, and forbs. Vegetation composition and pattern is strongly influenced by tidal inundation and elevation within the salt marsh.

Composition. The lowest salt marsh plant community occupies exposed tidal flats during periods of low tides and is characterized by such halophytic plants as seashore saltgrass (*Distichlis spicata*), pickleweed (*Salicornia virginica*), jaumea (*Jaumea carnosa*), shore podgrass (*Triglochin maritimum*), and saltmarsh sedge (*Carex lyngbyei*).

The intermarsh community (higher elevation, less flooding) commonly associated plants include redtop bentgrass (*Agrostis alba*), rush (*Juncus articulatus*), Pacific potentilla (*Potentilla pacifica*), yarrow (*Achillea millefolium*), sea-watch angelica (*Angelica lucida*), giant vetch (*Vicia gigantea*), Pacific waterwort (*Oenanthe sarmentosa*), and Douglas aster (*Aster subspicatus*).

The transition zone (upper elevation saltmarsh to terrestrial upland) is characterized by salmonberry (*Rubus spectabilis*), bracken (*Pteridium aquilinum*), sword fern (*Polystichum munitum*), common velvetgrass (*Holcus lanatus*), Alaska fringecup (*Tellima grandiflora*), red alder (*Alnus rubra*), Sitka spruce (*Picea sitchensis*), and western hemlock (*Tsuga heterophylla*).

Landscape Setting. Borders the cover types of open water and adjacent upland types. Agriculture is a common bordering cover type as many of Oregon's estuaries are diked to permit dairy cattle grazing.

References. Weideman 1986, Frenkel and Eilers 1976, Mitchell 1981, Cowardin *et al.* 1982.

NWI (138) & GAP PALUSTRINE EMERGENT WETLAND (203)

Geographic Distribution. Freshwater herbaceous wetlands distributed throughout the state. Especially prevalent in the Klamath Basin, Malheur-Harney and Warner Lakes basins, the Grande Ronde Valley, Willamette Valley, and the coastal margin.

Structure and Appearance. Medium tall (2-4 feet) to tall (>4 feet) grass, or grass-like plants that occur in dense mosaics depending on substrate and water depth.

Composition. Commonly associated herbaceous plants in this type, cattail (*Typha latifolia*), several bulrush species (*Scirpus olneyi*, *S. acutus*, *S. validus*, and *S. americanus*), burreed (*Sparganium emersum* and *S. eurycarpum*), flourish in shallow standing water situations. In the drier reaches of this type where the surface may dry out but subsurface is persistently wet numerous sedge (*Carex* spp.) and rush (*Juncus* spp.) dominate. Spikerush, (*Eleocharis* spp.) also can be an important component in this seasonal flooded margin.

Grasses that are commonly associated with this type are blue wildrye (*Elymus glaucus*), tufted hair grass (*Deschampsia caespitosa*), bluejoint reedgrass (*Calamagrostis canadensis*), reed canary grass (*Phalaris arundinacea*), American sloughgrass (*Beckmannia syzigachne*) and northern mannagrass (*Glycera borealis*).

Landscape Setting. This type is restricted to perennially flooded regions, or where the ground water lies just below the soil surface. Some type of agriculture typically borders emergent wetlands. Their silty soils are very fertile and are drained and converted to agriculture wherever possible.

References. Chappell *et al.* 1998, Christy and Titus 1996, Kovalchik 1986.

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Appendix 2.2. Discussion of ODFW's Use of Aerial Videography for OR-GAP

Airborne Videography

ODFW had airborne videography recorded between August 25 and September 3, 1993. Approximately 4% of Oregon was sampled by flying north-south transects at approximately 30-km intervals (Figure 2.2). In areas of high vegetation diversity and variability, transects were flown at 15 km intervals. The video was shot from an airplane flying approximately 600m above the ground with a zoom camera activated every nine seconds for five seconds. Hence, the video has coverage at two scales: approximately 1:1,800 and 1:150 when displayed on a 25-inch diagonal television.

The video acquisition system integrated a digital color video camera, a laptop computer, a Super VHS (S-VHS) VCR, a Trimble Pathfinder GPS, and a Horita time code generator/recorder/encoder to record real-time location data as well as the video imagery. The Horita time code generator/recorder/encoder recorded the GPS time onto the audio track of the videocassette and dubbed the time in a window directly on the imagery as well. Simultaneously, GPS time and the corresponding location were recorded once per second in a digital file on the laptop computer. At the 1:150 scale, there are more than 18,000 reference points that are GPS linked to ground coordinates. These GPS points are not differentially corrected. Therefore, the GPS acquired geodetic measurement could be 0 to 140 meters from the true location of each reference point (Graham 1993).

Results

Results from our research evaluating airborne videography were not encouraging (Barrett, 1998). Our analysis indicates that airborne videography has limited usefulness as a tool for Landsat TM-based vegetation map validation. Despite the fact that collecting it can be substantially faster than field work and that it allows remote, inaccessible-by-ground areas to be sampled, we did not find airborne videography to be an efficient method for assessing the accuracy of our satellite derived vegetation maps.

There were a number of reasons airborne videography was not efficient. First, the cost of acquiring airborne videography, while cheaper than traditional aerial photography, is still quite expensive. For example, the ODFW video acquired in this study cost $30,000 in 1993. A more costly, increased-density of flight-lines in a more complex sampling scheme would be necessary to sufficiently assess the accuracy of the 1998 OR-GAP state vegetation map. Second, the accuracy of the video interpretation must be assessed before it can be used to assess the accuracy of the satellite-based map - thus, a certain amount of field work must still be performed. The collection of enough field points to perform this assessment will likely be difficult as it depends on having a sufficient number of video sample points for each vegetation class within observation distance of an accessible road. Additionally, this substitution of interpreted videography for "ground-truth" data will yield a more complex, if not questionable, statistical analysis in the final assessment. Finally, the inferior spectral resolution of our airborne video made successful interpretation of vegetation classes difficult.

In this study, a misleading overall interpretation accuracy of nearly 95 percent was obtained for the higher resolution ODFW video. However, this video was recorded in a relatively small area of low vegetation diversity, and interpretation accuracy was substantially lower for mixed species classes in this video as well as in supplemental video. These findings indicate that airborne videography will be less suitable for accuracy assessment as the vegetation classification and landscapes increase in complexity (southwestern Oregon for example).

Despite its limited value as an accuracy assessment tool, airborne videography would be a valuable classification aid in the development of a satellite-based vegetation map. GPS geo-referenced airborne video could be used to quickly generate training areas for supervised classifications or to help label classes resulting from unsupervised classifications of satellite imagery. Proper planning of video acquisition is the key to its successful use for these purposes.

Chris Kiilsgaard

Figure 2.1. OR-GAP Current Land Cover

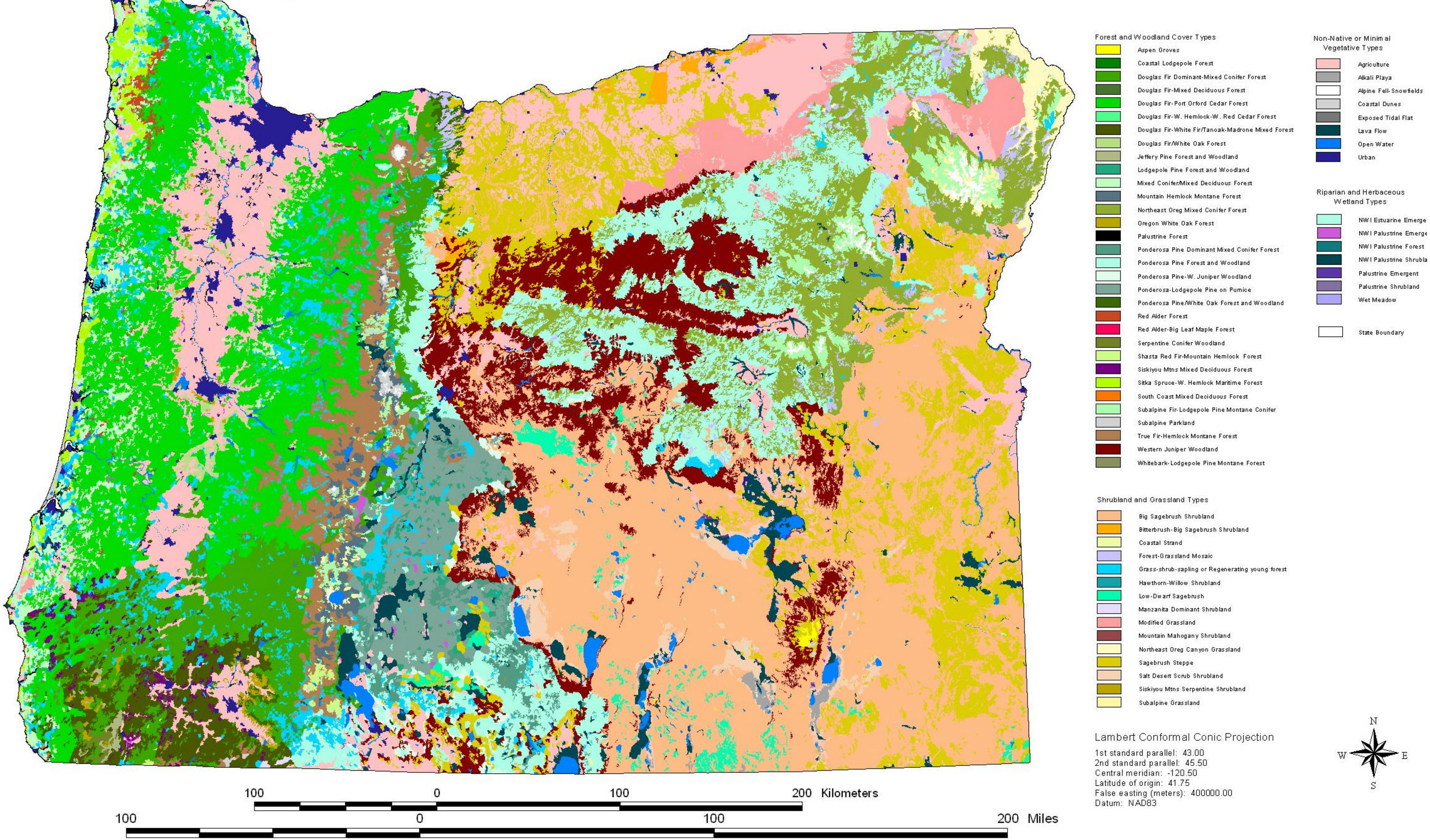


Figure 3.1. OR-GAP Historical Land Cover

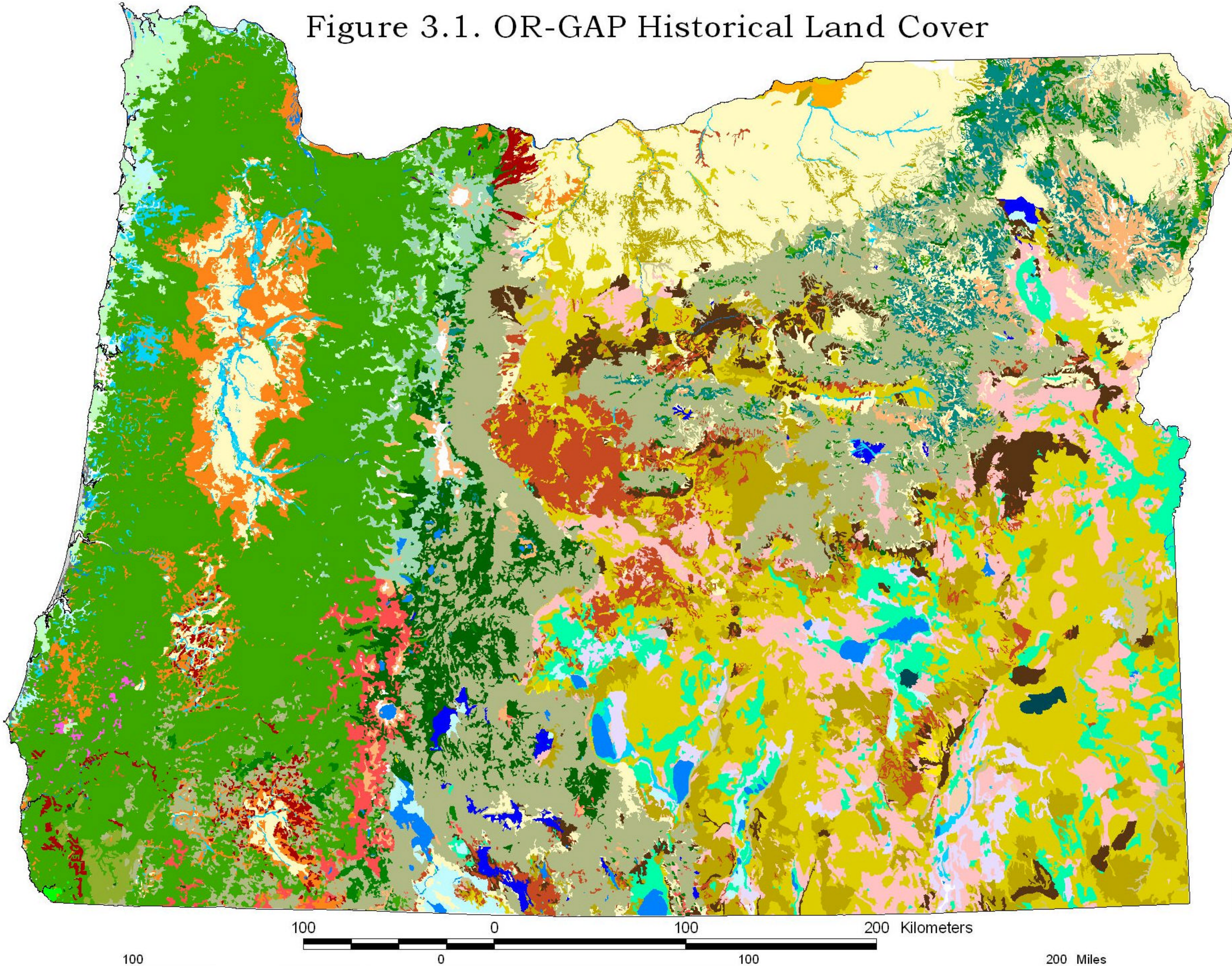


Figure 4.3. OR-GAP Current Wildlife Habitat

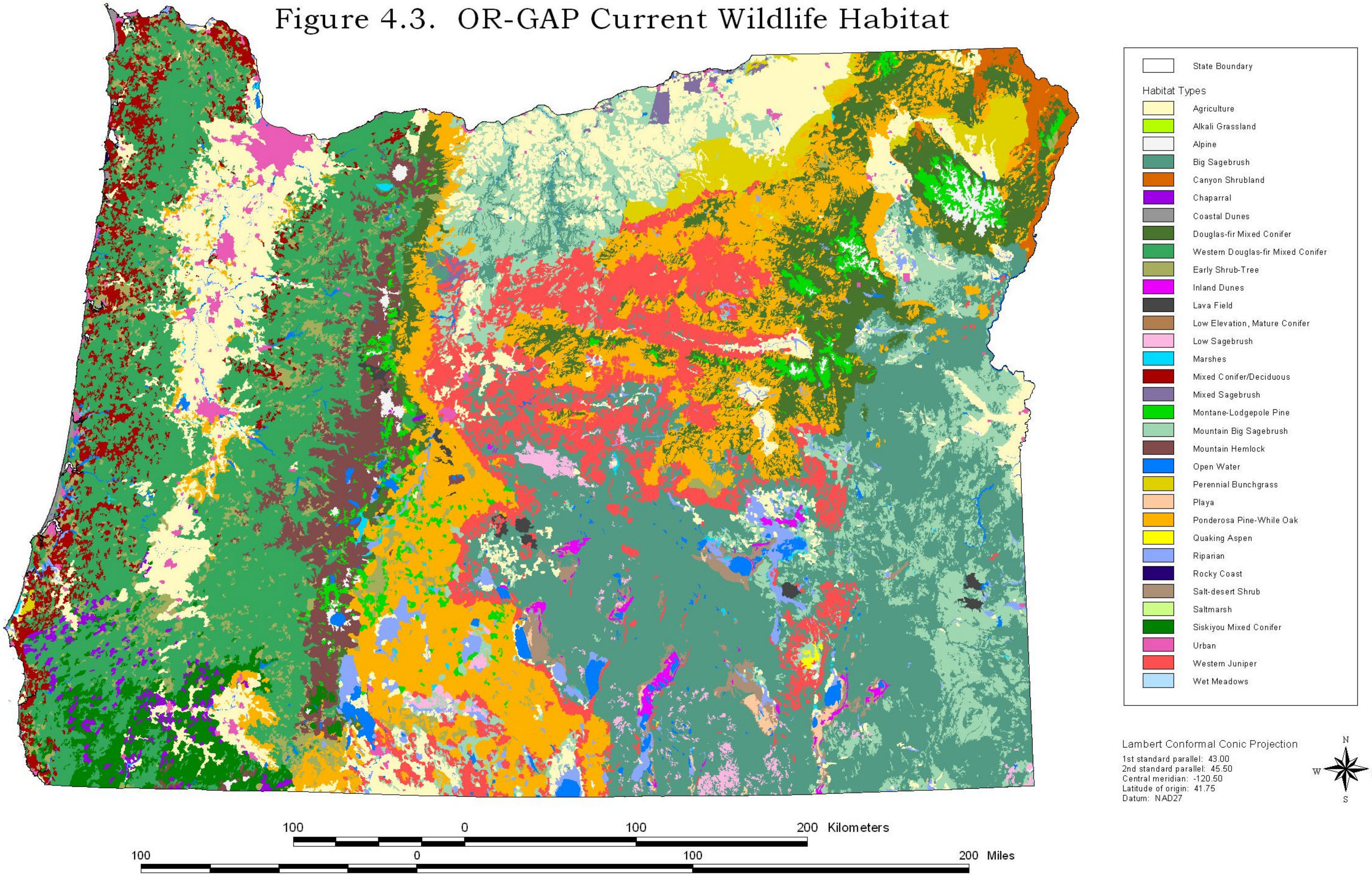
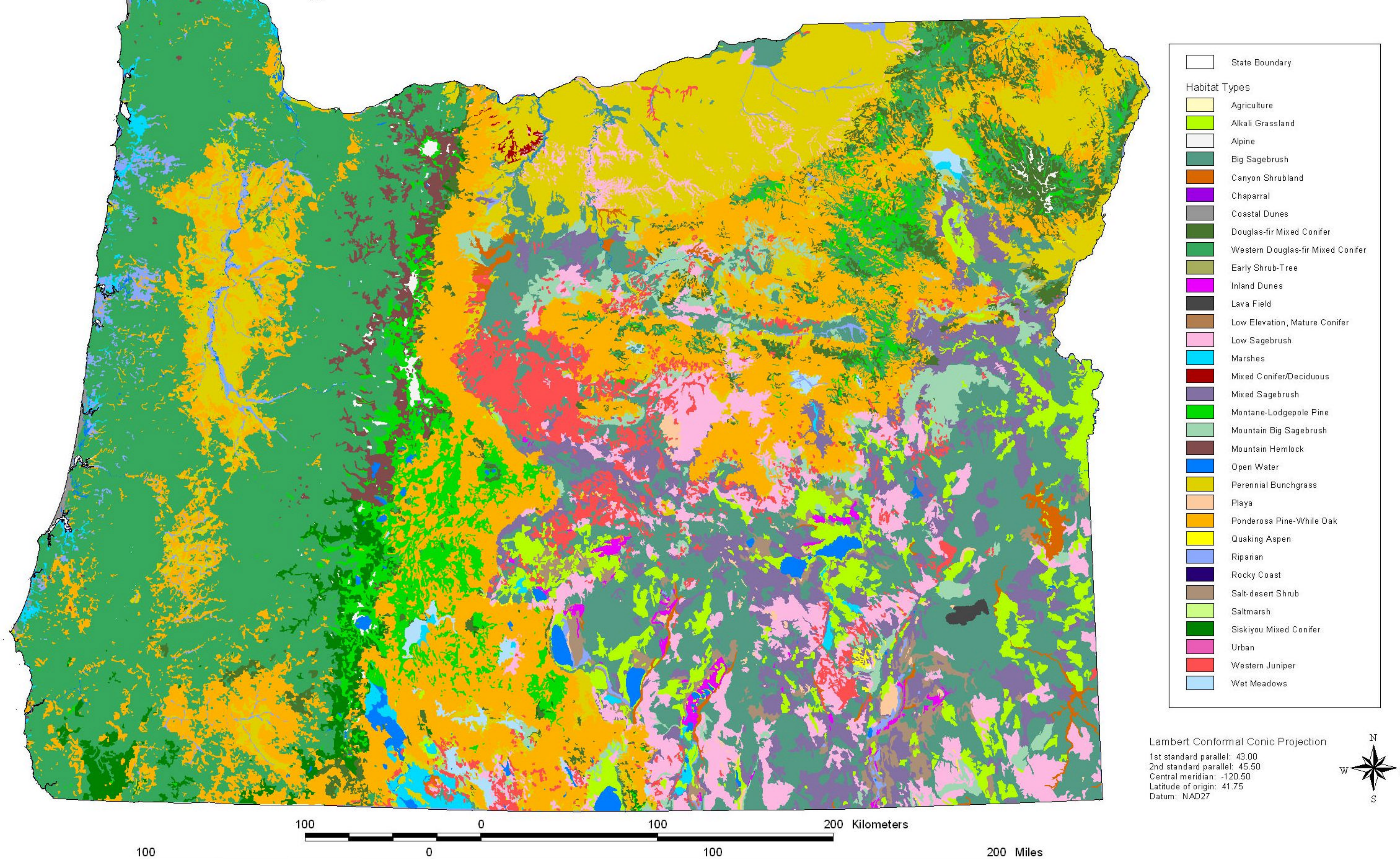
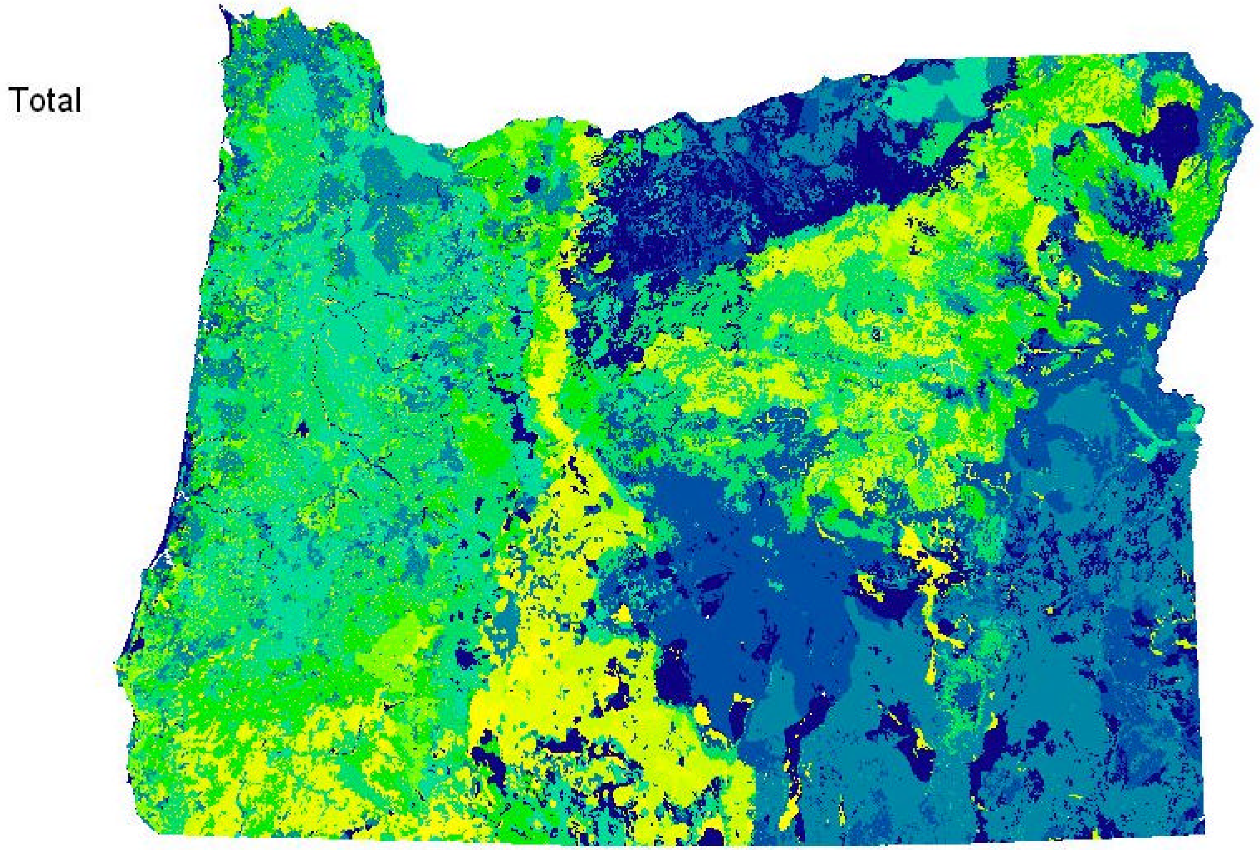
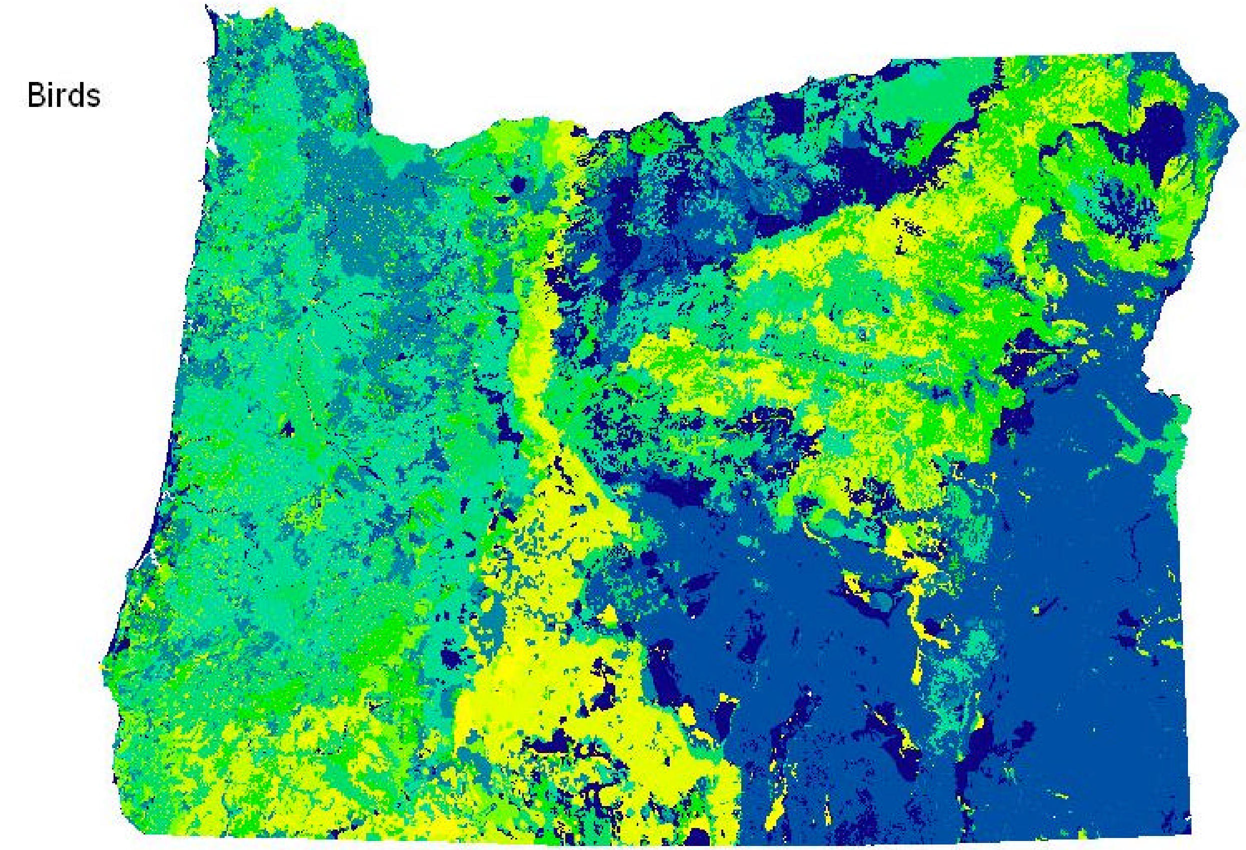


Figure 4.4. OR-GAP Historical Wildlife Habitat







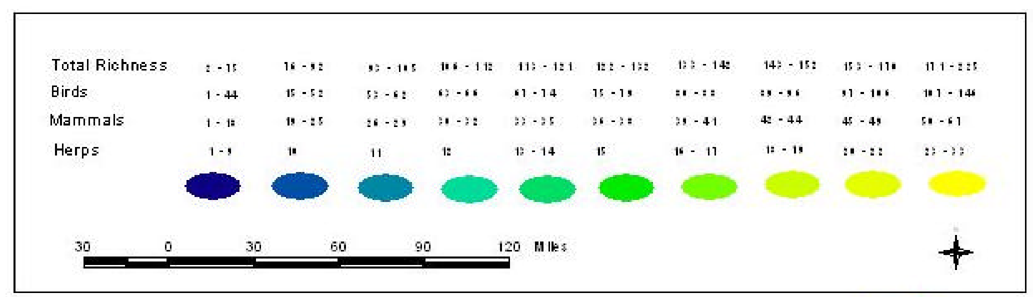
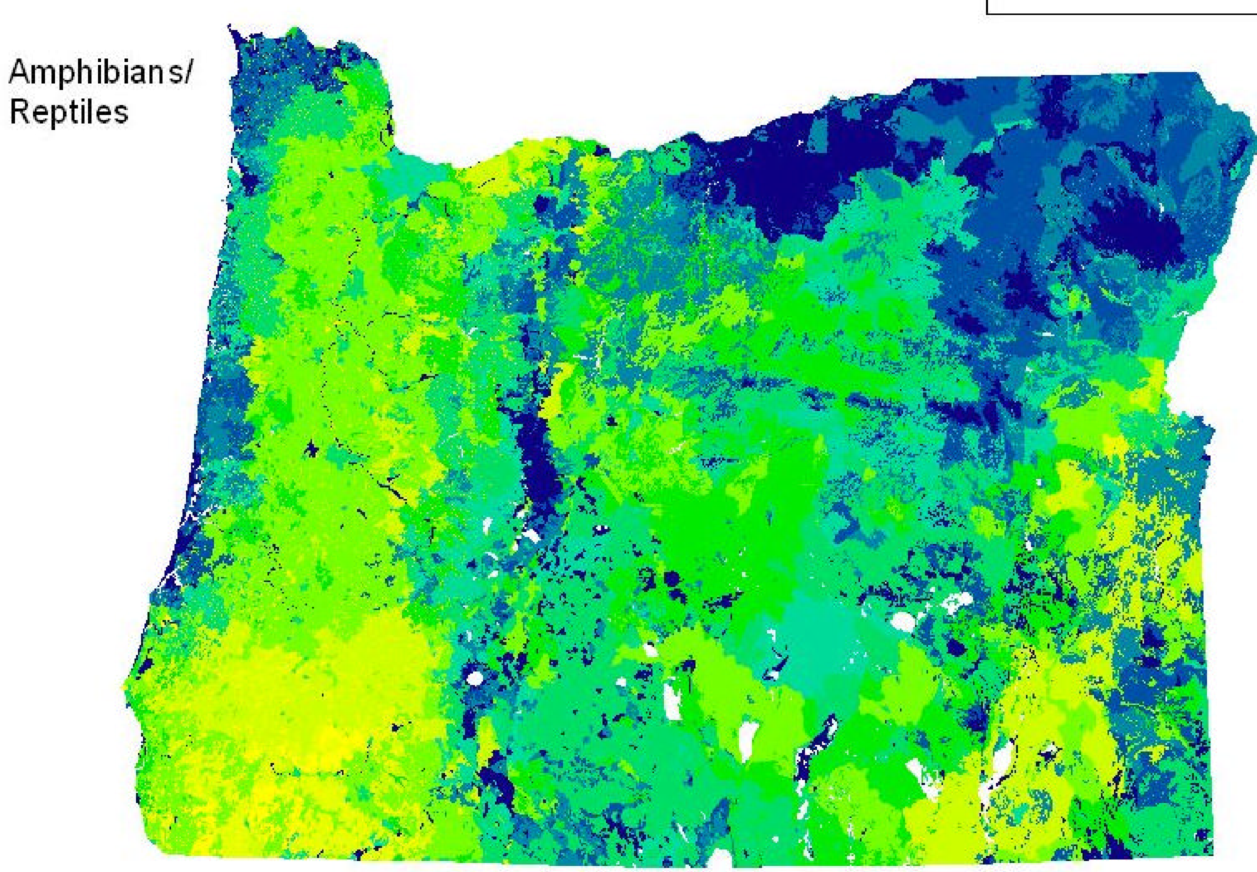
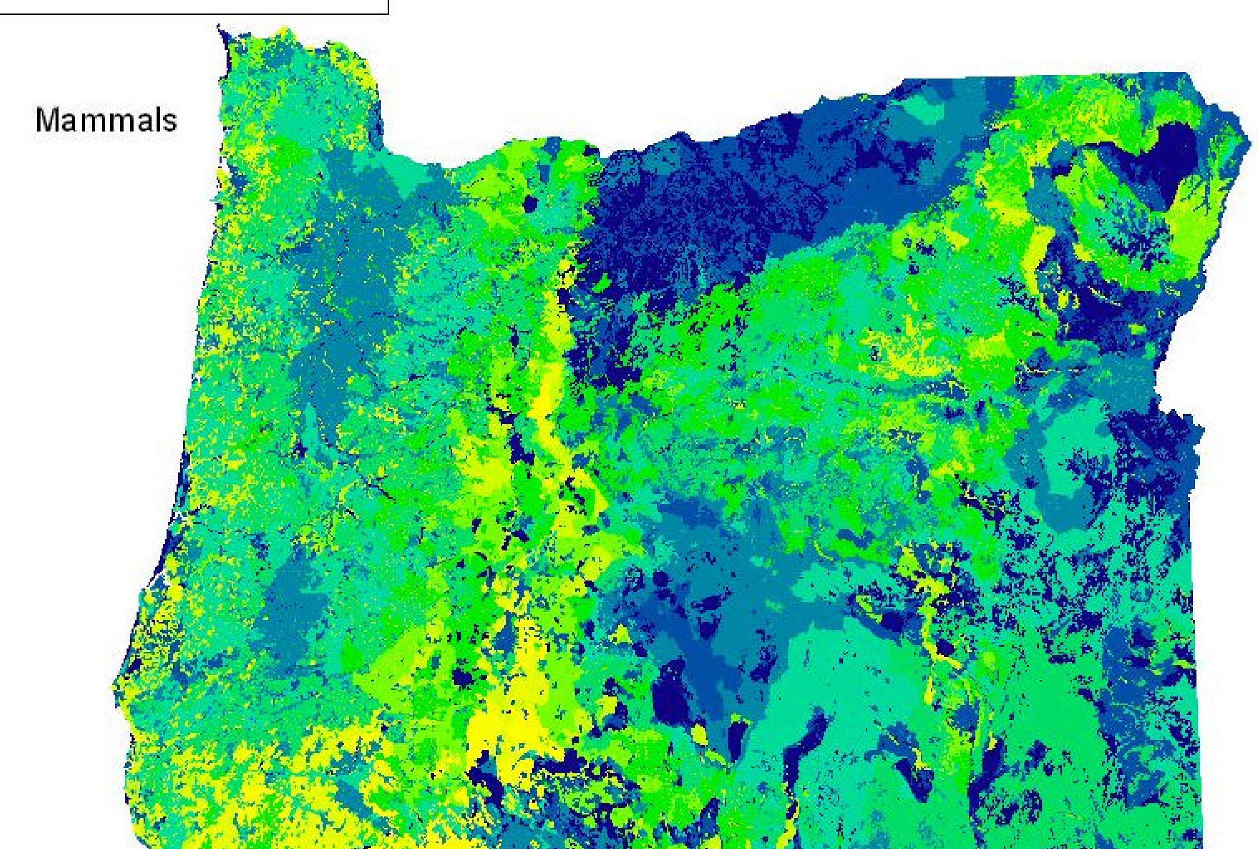


Figure 4.6. Current Species Richness for all species, herps, birds and mammals





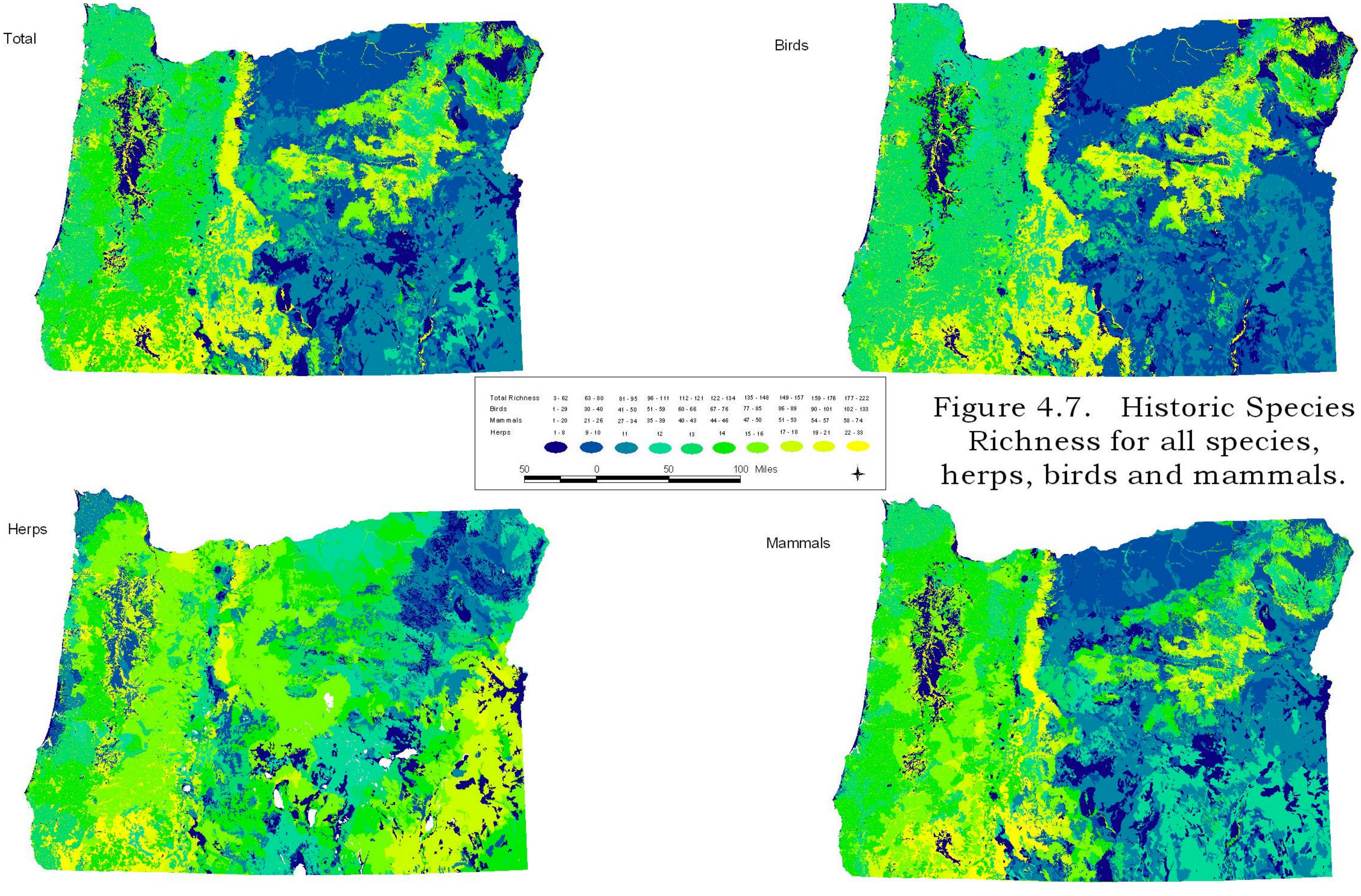


Figure 4.7. Historic Species Richness for all species, herps, birds and mammals.

Figure 5.1. OR-GAP Land Ownership

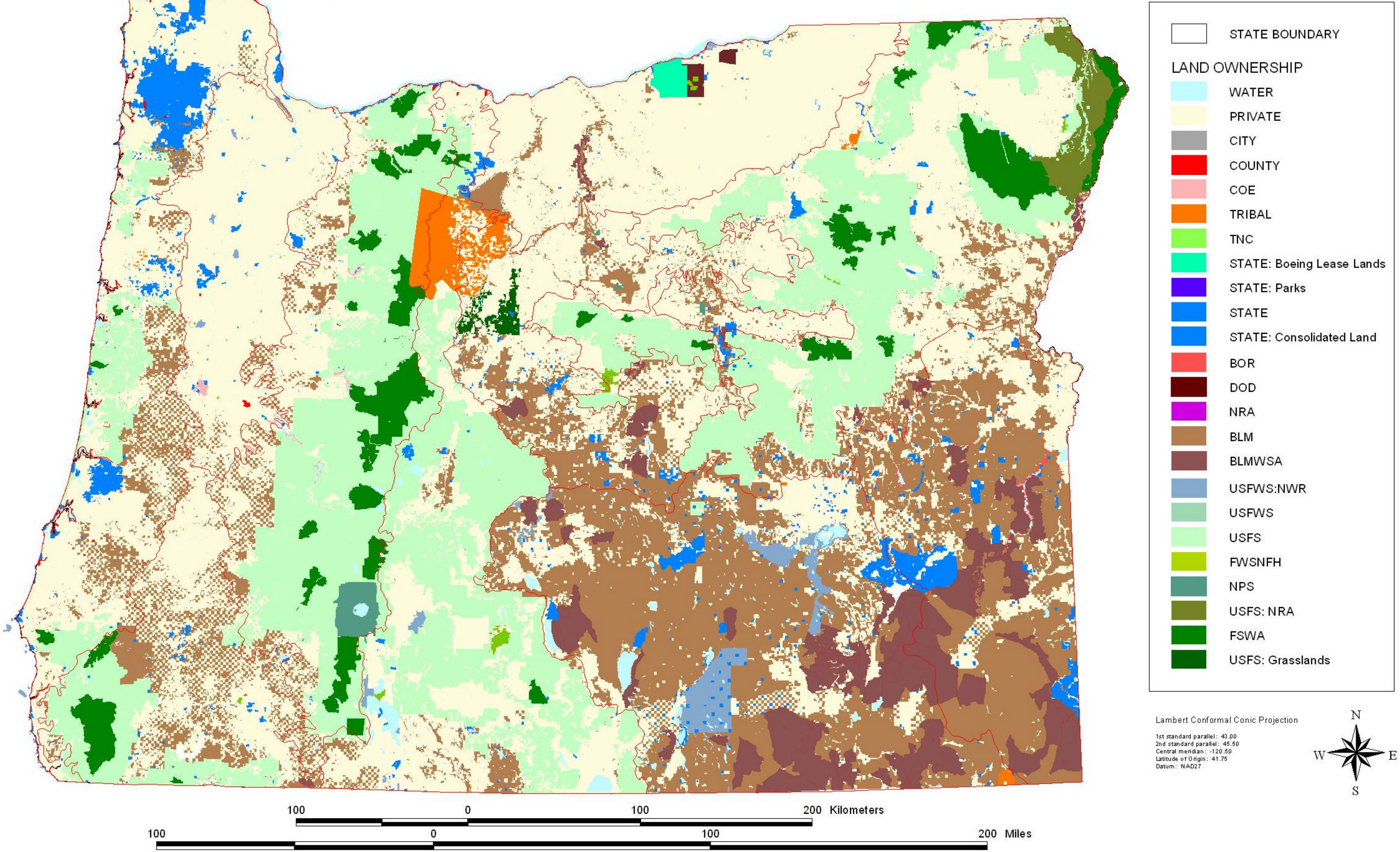


Figure 5.2. OR-GAP Land Management

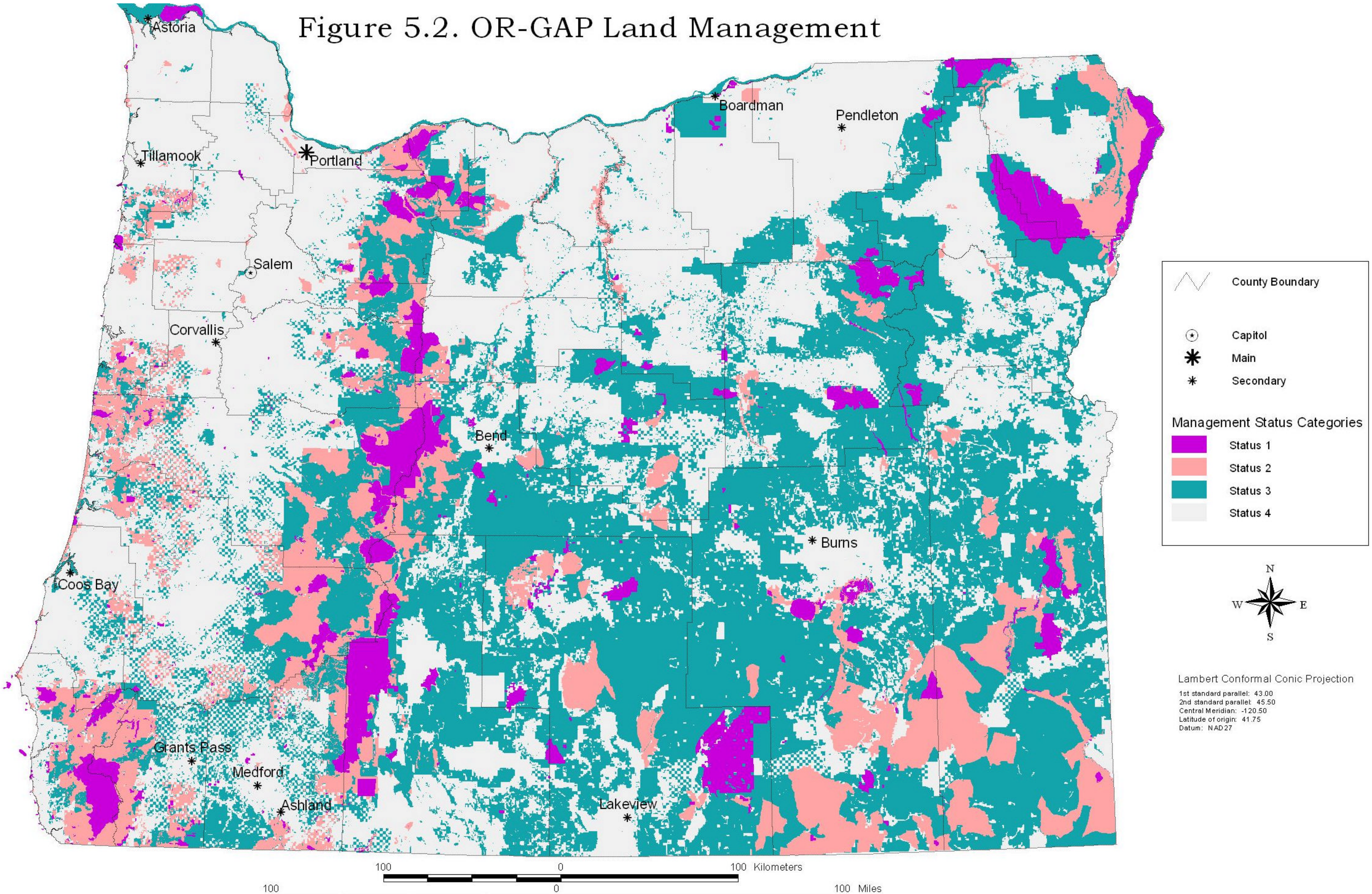
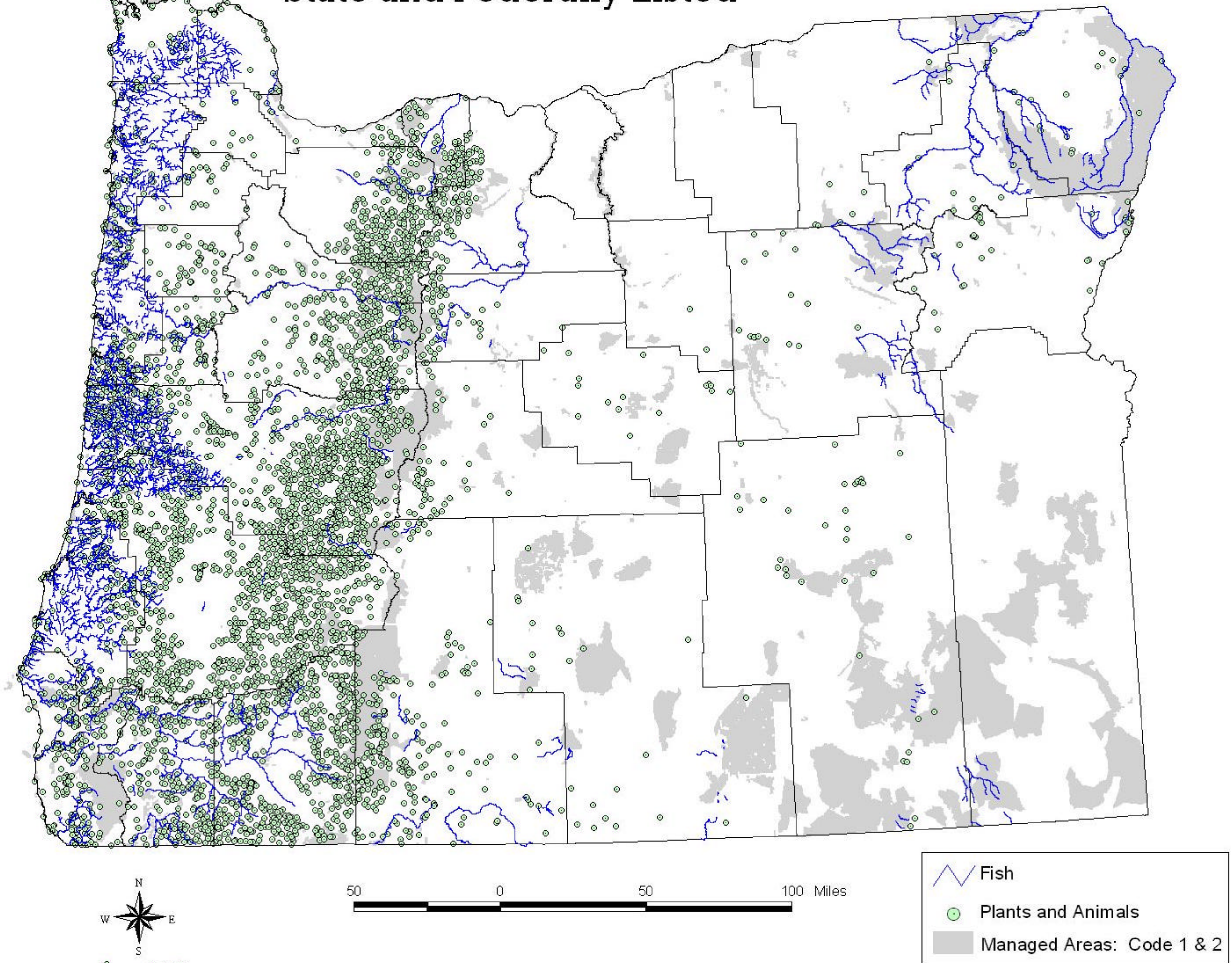
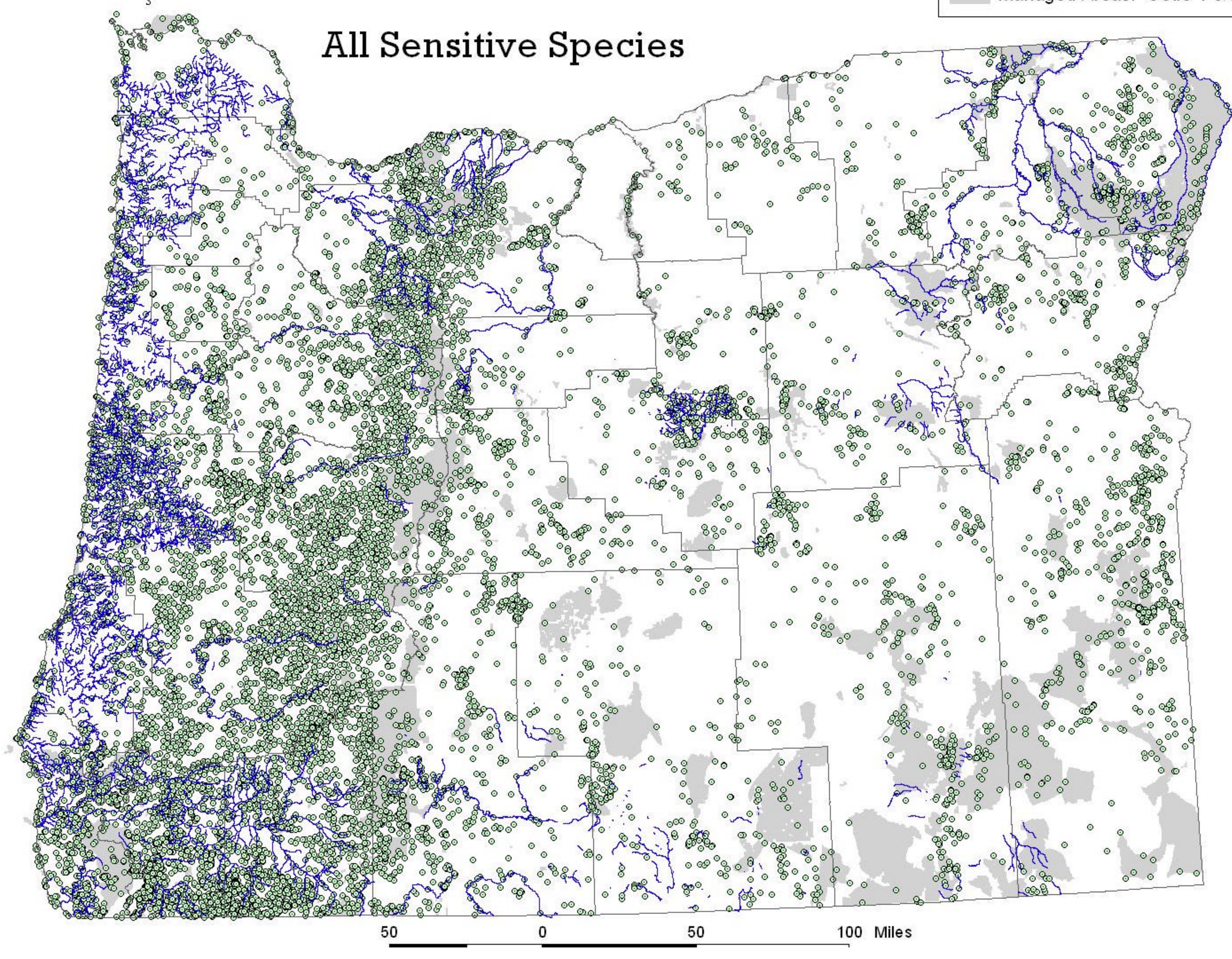
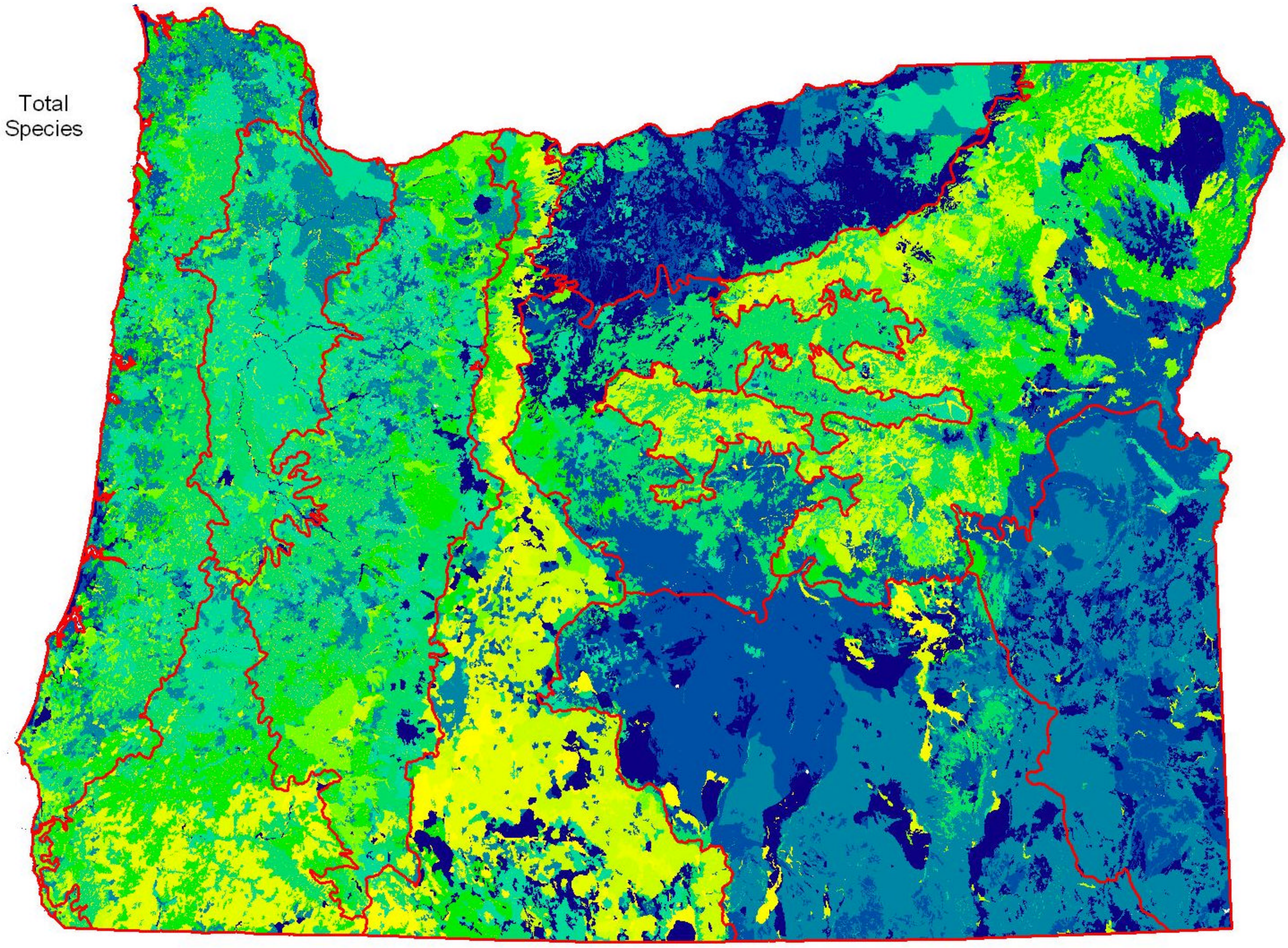


Figure 5.3. OR-GAP
State and Federally Listed







Priority Richness	2 - 40	41 - 46	47 - 51	52 - 55	56 - 59	60 - 62	63 - 66	67 - 71	72 - 77	78 - 116
Total Richness	2 - 75	76 - 92	93 - 105	106 - 112	113 - 121	122 - 132	133 - 142	143 - 152	153 - 170	171 - 225

Figure 6.8. Species Richness Map of all species and of priority species in Oregon.