Washington's Biodiversity

Status and Threats

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ABOUT THIS REPORT

This report is a summary assessment of the status of, and threats to, the biodiversity of Washington State. Its goal is to be brief yet comprehensive; it is not meant to be exhaustive. Detailed information is available in the cited sources.

John Gamon of the Washington Department of Natural Resources Natural Heritage Program prepared this report for the Washington Biodiversity Council. The report's primary purpose is to assist the Council in identifying priorities and recommendations for a 30-year statewide biodiversity conservation strategy.

While this report is meant to cover all of Washington's biodiversity, terrestrial environments are discussed more comprehensively than are marine environments

Some biological concepts used here are defined generally, rather than adhering to their strict academic origins. For clarification, see the Glossary.

This report does not cover the many conservation mechanisms and existing protections in Washington State, which are addressed in other materials prepared for the Council.

For more information about these materials, or the Council generally, please visit our website, or contact us directly:

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EXECUTIVE SUMMARY

Washington has an exceptional array of environments, which provide the foundation for our state's rich biodiversity. Yet we cannot take the continued existence of our biodiversity for granted. Tremendous population growth and development, increasing land-use conflicts, and increasing lists of species and ecosystems that are of concern suggest that we are losing ground.

Yellow sandverbena. *B. Legler photo*

In 2004, Governor Locke issued an executive order creating the Washington Biodiversity Council and giving the Council the task of developing a 30-year strategy for the conservation of Washington's biodiversity. As part of the preparation for developing a 30-year strategy, the Biodiversity Council commissioned this report on the current status of Washington's biodiversity.

Garter snake. *J. Jacobsen photo*

What do we mean by 'biodiversity'?

The Council defines biodiversity as follows:

> Biodiversity is the full range of life in all its forms. This includes the habitats in which life occurs, the ways that species and habitats interact with each other, and the physical environment and the processes necessary for those interactions.

For the purposes of this report, and to help the Council identify appropriate strategies, biodiversity is characterized at three principal levels: genetic, species, and ecosystems. Conservation must occur at each of these levels to successfully conserve "the full range of life in all its forms" in Washington.

Why is it important to conserve Washington's biodiversity?

Native species and ecosystems contribute billions of dollars annually to fisheries, timber harvest, outdoor recreation, and other sectors of Washington's economy. Native ecosystems provide clean water, clean air, natural flood control, habitats for fish, wildlife, and plant species, and numerous other services. Native ecosystems provide a laboratory for students at all levels (grade school to graduate school) to learn about the environment. Washington's species, ecosystems and natural landscapes provide a foundation for our cultural heritage and our spiritual values; they provide a sense of what it means to be a Washingtonian.

What does Washington's biodiversity include?

Genetic diversity

Although this is the most fundamental level of biodiversity, we generally have little direct knowledge of how genetic diversity is distributed within or between species. However, genetic variability is important for long-term survival of individual species.

Species diversity

Washington provides home to 3,100 vascular plant species, an estimate of thousands of mosses, lichens, liverworts and fungi, 140 mammals, 470 freshwater and marine fishes, 341 birds, 25 amphibians, 21 reptiles, an estimated 20,000 invertebrates, including more than 2,000 moths and butterflies, and a rich and largely unknown array of microorganisms. And we know that the cataloging of our biodiversity is not yet complete; new species are still being discovered and described within Washington. Of the better known groups of species, Washington ranks 13th among the 50 states, with 53 endemic species (NatureServe 2002).

EXECUTIVE SUMMARY

Ecosystems diversity

Washington is very rich in ecosystems diversity, with marine, freshwater, forest, shrubland, and grassland ecosystems. Ecologists have developed systematic classifications of ecosystems in Washington, and although the approaches have been different in terrestrial, freshwater, and marine environments, classification provides a common language and a framework for establishing conservation priorities. Ecosystems are also used as a 'coarse filter' to help ensure the conservation of common species.

Landscape Patterns

Scientists and planners recognize that the distribution of biodiversity does not conveniently follow political lines (international or state borders, county lines, etc.). Furthermore, the geographic extent of Washington makes it impractical to simply assess conservation needs statewide. Scientists have therefore developed different approaches to stratifying the state into units that make sense from a biological perspective.

Terrestrial ecologists in Washington have applied the concept of ecoregions. Portions of nine terrestrial ecoregions occur within Washington. Each of these ecoregions extends well beyond our borders into neighboring states and provinces

Fish biologists and others interested in the aquatic realm have delineated 'Ecological Drainage Units' and 'Salmon Recovery Regions.' Ten 'Ecological Drainage Units' and nine 'Salmon Recovery Regions' account for the distribution of freshwater aquatic biodiversity in Washington.

Puget Sound beach. *B. Legler photo*

How are we doing in terms of biodiversity conservation?

Species

A limited number of native species have increased in numbers. However, many species have experienced significant declines in Washington. Currently 40 animal species (including 15 fish) and 10 plant species that occur in Washington are listed under the federal Endangered Species Act. But the ESA provides only one measure of the status of our species. When one takes into account those species that are stable elsewhere, but declining or at-risk in Washington, the total number of species that are of conservation concern increases dramatically. There are more than 500 species of plants and animals that are of concern.

Sea stars. *N. Sefton, NOAA photo*

A number of specific factors have contributed to the declines. For terrestrial species, conversion of land to human-made environments and ecosystems degradation associated with land management practices are the most significant factors. For freshwater and marine species, pollution and contamination have contributed to declines.

What do we expect in the future? Additional species will need special management attention, particularly in those areas with the greatest amount of habitat loss—the Puget Trough and the Columbia Plateau.

EXECUTIVE SUMMARY

The combination of fragmented landscapes, compromised ecosystem functioning, and a changing climate will limit species' natural ability to migrate to suitable habitat. The probable result will be an increasing number of species facing significant declines.

Ecosystems

Many of Washington's ecosystems have also undergone significant declines. More than 60% of the recognized terrestrial plant associations occurring in Washington are considered vulnerable, imperiled, or critically imperiled. The declines have been primarily the result of conversion of land to human-made environments and/or degradation. The two ecoregions with the greatest amount of conversion of land have been the Puget Trough and the Columbia Plateau, each with 50% or greater conversion.

Ecosystems of particular concern include the following:

- Marine, estuarine, and nearshore ecosystems, particularly within Puget Sound, have been converted, modified, and contaminated.
- Riparian and freshwater aquatic ecosystems have been eliminated or degraded by construction of dams, dikes, and drainage ditches and by land use practices such as livestock grazing, timber harvest, and mining.
- Forested ecosystems have been converted and altered by management practices and fire suppression.
- Shrub-steppe and grassland ecosystems have been converted to agriculture.

Ecosystem processes, in particular natural disturbances, have also been disrupted or eliminated from the environment. The disruption of three natural disturbance processes in particular (fire, floods, and erosion along saltwater shorelines) has had a tremendous impact on the current status and condition of species and ecosystems in Washington.

Status of the Conservation Landscape

Significant protections exist, but given the current numbers of species and ecosystems of conservation concern, they are limited and inadequate.

Land ownership is one of the primary factors influencing protection of biodiversity, although ownership does not in and of itself determine the level of protection (or degree of threat). Public lands management typically includes at least some explicit policy directives regarding management for biodiversity values. On privately owned lands, voluntary landowner actions play an important role, particularly those at lower elevations. Protection of aquatic, particularly marine, environments is not as strongly correlated with ownership because of the fluid nature of the ecosystem and the mobility of many of the component species.

Thin-leaved peavine. *DNR photo*

What threatens our biodiversity?

Population growth has been a driving factor for landscape changes affecting biodiversity in Washington. Growth has been associated with:

- habitat loss and degradation,
- pollution and contamination of the environment,
- water quality and availability problems, and
- interruption of natural processes.

Mountain bog gentian.
B. Legler photo

West Cascades forest.
B. Legler photo

What threatens our biodiversity?

Population growth has been a driving factor for landscape changes affecting biodiversity in Washington. Growth has been associated with:

- habitat loss and degradation,
- pollution and contamination of the environment,
- water quality and availability problems, and
- interruption of natural processes.

Our population is currently more than 6 million, having doubled in the last 40 years. By 2030, Washington is expected to have more than 8 million residents. Future conversion of land to residential, business, and other purposes will further reduce availability of suitable habitat for species and ecosystems and increase the degree to which such lands are fragmented and isolated. As the land base for maintaining biodiversity decreases, appropriate management of the remaining land base takes on increasing significance. In particular, working landscapes (e.g., forests, grazing lands) will play an increasingly important role in maintaining biodiversity.

Pollution and contamination of Puget Sound pose huge challenges, particularly in light of the projected continued growth in western Washington.

Invasive species are also of great concern. In recognition of the tremendous economic and environmental impact caused by non-native plants and animals, the Legislature created the Washington Invasive Species Council in 2006.

Climate change is expected to have dramatic impacts on the status of our biodiversity, including the erosion and loss of nearshore habitats as sea level rises, altered flows and water temperatures in our rivers and streams affecting salmon, and changes in the frequency, severity, and duration of natural disturbances, such as fire and pest outbreaks. As our population grows, and as climate change results in a decreasing snow pack, there will likely be a trend toward insufficient water availability during the summer to meet the needs of people, farms, and our native biodiversity.

Conservation Assessments

Conservation needs assessments have been undertaken in Washington at various geographic scales. Many have been designed independently, and may not complement assessments at different scales or by neighboring jurisdictions. Improved communication and broader engagement of stakeholders is needed to strengthen coordination of state assessment efforts. Currently, ecoregional assessments are the only planning effort at this scale designed to capture the full range of biodiversity. Their comprehensive nature

provides a potential framework by which to organize state and local assessment efforts to better complement one another.

Assessments done to date generally have some important limitations. One is that natural processes, and the degree to which they have been interrupted, are not generally addressed in assessments, regardless of scale. Another limitation is that there has not yet been a comprehensive statewide threat analysis. A third limitation is that assessments represent a point in time, yet the status and conditions of our biodiversity are not static. Therefore a funded, systemic approach to update key assessments is needed.

Bird survey, Pierce County. *J. Jacobsen photo*

Information Needs

Sufficient information is available to support the development of biodiversity conservation strategies for Washington. While more information could always enhance our efforts, we have a pretty good sense of which species and ecosystems are most imperiled. However, some definite information gaps exist.

Chinook salmon. *IAC photo*

Species

Our knowledge of which species in the state are of conservation concern is well-developed for some taxonomic groups, less so for others, and clearly inadequate for yet others. Even within the groups of rare species that are reasonably well-known, additional inventory and mapping would make conservation efforts more effective. Information regarding threats to species of conservation concern is often inadequate for identifying specific positive actions. Broad-brush information is available for most of the state's common species, but declines in common species are not detected very well.

Ecosystems

To ensure conservation of our ecosystems diversity, we need to fully understand it. Additional ecosystems classification efforts can help us gain that understanding. Further inventory and mapping of ecosystems is necessary.

Although definite information needs exist, we do know enough to take meaningful conservation action. Furthermore, the information that we do have regarding threats (population growth, climate change, etc.) suggests that we need to take action sooner rather than later. Unless significant actions are taken, we risk losing much of our rich natural heritage in Washington State.

Mouth of Snow Creek. *IAC photo*

INTRODUCTION

Washington has an exceptional diversity of environments, including the marine waters of Puget Sound and the outer coast, temperate rainforests, the subalpine parklands and meadows and alpine slopes of the Olympics and Cascades, the dry, open forests of the eastern flanks of the Cascades, the expansive shrub-steppe, the grasslands of the Palouse, the mighty Columbia River, and more. The diversity of these environments provides the foundation for the richness of our state's biodiversity.

Temperate rain forest within Olympic National Park. *NPS photo*

Yet we cannot take the continued existence of our biodiversity for granted. The tremendous growth and development all around us, the increasing degree of conflict over land-use decisions among environmental, economic, and social values, and the growing list of species covered by the Endangered Species Act suggest that we are losing ground.

In 2004, Governor Locke issued an executive order creating the Washington Biodiversity Council and giving the Council the task of developing a 30-year strategy for the conservation of Washington's biodiversity.[1] As part of the preparation for developing a 30-year strategy, the Biodiversity Council has commissioned this report on the current status of Washington's biodiversity.

What is biodiversity?

Use of the term biodiversity has become increasingly common, yet it can mean different things to different people. The Washington Biodiversity Council has defined biodiversity as follows:

> Biodiversity is the full range of life in all its forms. This includes the habitats in which life occurs, the ways that species and habitats interact with each other, and the physical environment and the processes necessary for those interactions.

This definition includes all species that occur within the state, from the large and visible (most plants and many animals) to the microscopic (soil microbes, plankton, etc.). It includes migratory and/or wide-ranging animals that spend only a portion of their life here. And while this definition does not distinguish between native and non-native species, i.e., between those that occur here naturally and those that have either invaded or been purposefully imported, the Governor's Executive Order[1] refers to the risk of losing our "…rich natural diversity." This report, therefore, emphasizes the native components of our biodiversity.

Coastal estuary. *DNR photo*

The definition includes the interactions that help sustain each species. Some of these interactions are with other species (predator / prey relationships, symbiotic relationships, etc.). Other interactions are between the species and the physical environment. The definition includes natural processes, such as fire and flooding. These natural processes are critical in maintaining the full suite of species and ecosystems that constitute our biodiversity.

Scientists view biodiversity at three principal levels: genetic, species, and ecosystems. They are not independent levels, but rather intricately woven together. Conservation biologists and planners also recognize that interactions between ecosystems form landscape patterns that are important. The concept of ecoregions (see below) is intended to capture landscape level diversity.

Conservation must occur at genetic, species, ecosystems, and landscape levels to successfully conserve "the full range of life in all its forms in Washington.

Shrub-steppe landscape. *DNR photo*

Genetic diversity is the most fundamental level of biodiversity; it results in differences among individuals within a single species. Genes within individual organisms, and their frequencies in a population, are the basic level at which evolution occurs. Genetic variability is important to long-term survival of a species; it allows species to respond to environmental change.

Species diversity is probably the level of biodiversity with which people are most familiar. We recognize different plants in our yards. We distinguish between different birds and other wildlife that we see in our neighborhoods or out in the countryside. We recognize and distinguish different species, even though we may not think of them in terms of a biologist's definition of species. Biologists have several definitions of species; for this report, species will be defined using the 'biological species concept,' which defines a species as a group of organisms that can interbreed in the wild and produce fertile offspring. Organisms can look alike, yet be members of different species (e.g., Western and Eastern meadowlarks). Conversely, organisms may look different, yet be members of the same species (e.g., male and female differences in many bird species, or different color forms in many plant species).

Species diversity of species richness? Ecologists often distinguish between *species richness* – the number of species in a particular area – and *species diversity* – the number of different species in a particular area (i.e., species richness) weighted by some measure of abundance, such as the number of individuals. The distinction can be important when setting goals and/or prioritizing conservation actions. However, for this report, the term *species diversity* is used simply to refer to species richness.

Another concept important to the understanding of biological diversity is that of evolutionary lineages. As a result of their individual evolutionary lineages, some species have many close relatives (e.g., there are more than a dozen recognized native species of the wildflower paintbrush in Washington), while others have few or no close living relatives (e.g., water howellia, a diminutive aquatic plant that is the only member of its genus). The loss of a species with few or no living relatives represents a greater loss of distinct genetic diversity than would the loss of one species within a large genus.

Ecosystems diversity encompasses the full variety of environments and species assemblages in the state. Forests, grasslands, wetlands, and subalpine meadows all reflect the concept of ecosystems; they are assemblages of species occurring within particular physical environments. But not all forests are the same; they do not all include the same mix of species, or undergo the same natural processes, or occur within the same physical environments. This is true for grasslands, wetlands, etc.

It is assumed that conservation of the full array of ecosystem types will result in the conservation of common species. In other words, ecosystems are used as a *coarse filter* in conservation planning to help account for common species.

It is also important to note that the term 'ecosystem' does not have a fixed scale in its general usage. It has been used to characterize areas that vary in size from a small puddle of water to large landscapes. The appropriate scale depends on the question(s) being addressed. In part because of this, and in order to better understand the diversity of ecosystems, ecologists have developed various ecosystem classification systems. Conservation biologists and planners have increasingly looked to ecosystem classification systems as tools for their conservation efforts.

Ecologists distinguish between *communities* – all of the organisms that live in a particular area – and *ecosystems* – the communities of organisms plus the physical environment, including the interactions between the two components. Because community types are often used by biologists and conservation planners to represent ecosystem types, the term *ecosystem* is used in this report to include both concepts.

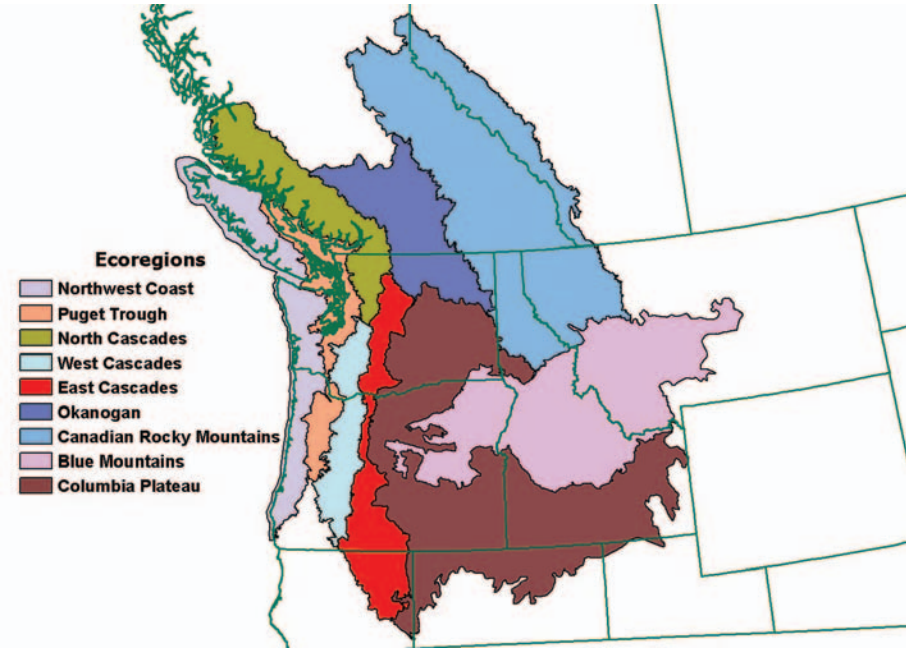


Figure 1.1. Washington's Terrestrial Ecoregions. Please note: Ecoregion names have been modified to increase name familiarity for Washingtonians (e.g., the full name for the Puget Trough ecoregion is the Willamette Valley-Puget Trough-Georgia Basin ecoregion). See footnote 2.

Ecoregions – As noted above, ecologists and conservation biologists recognize that ecosystems (and their component parts) interact with each other to form a higher level of diversity, i.e., the patterns of ecosystems distributed across the landscape. The concept of ecoregions was developed to reflect these broad ecological patterns. They have been delineated at a spatial scale at which ecological and evolutionary processes operate. As a result, each ecoregion has a distinctive composition and pattern of species distributions. Portions of nine terrestrial ecoregions have been delineated within Washington (Figure 1.1).[2]

Puget Sound and the marine waters of the Strait of Juan De Fuca and the outer coast add significant landscape diversity to the state of Washington that is not reflected in the delineation of the terrestrial ecoregions.

Conservation planning at the ecoregional scale can accommodate the needs of wide-ranging species and can consider natural disturbances that may be important for the maintenance of biodiversity.

Selected Biodiversity Contributions to Washington's Economy

Fisheries: $145,850,000 in 2004[3]

Timber products:

- $229 million in revenue generated in 2005 from DNR lands alone.[4]
- $9.23 billion in revenue for manufacturing wood and paper products and exporting logs and chips.[5]

Outdoor recreation: an estimated $2 billion/year.[6]

Why is it important to conserve Washington's biodiversity?

There are several compelling reasons to conserve biodiversity. Many are measurable in terms of providing a healthy environment or contributing to a robust economy, while others reflect personal value systems.

Native species and ecosystems contribute billions of dollars annually to Washington's economy. Natural resources play a vital role in Washington state's economy, from fisheries[3], to timber production[4,5], to the many ways that people enjoy the outdoors.[6] Investing in maintaining healthy ecosystems helps sustain natural resource based economies.

Native ecosystems provide life support for Washington. Healthy, functioning ecosystems provide us with clean water[7,8] and clean air, which would otherwise require the application of expensive technologies to produce. Ecosystems also provide natural flood control, pollination, natural pest controls, carbon storage to help buffer against climate change, and habitat for fish, wildlife, and plant species.

Natural ecosystems provide a laboratory to learn about the environment. In order to successfully manage natural resources, current and future generations of managers need healthy ecosystems to study. The knowledge gained can be applied to managed landscapes (e.g., forests, grasslands, or cultivated crops). Students of all ages can also benefit from natural laboratories.

Washington's species and natural landscapes provide a foundation for our cultural heritage and our spiritual values. Although we do not all share the same cultural and spiritual values, most of us identify with the many natural features that make Washington special. Many people rely on these natural values for their wellbeing and believe that they should be conserved for future generations.

The Cedar River Watershed supplies clean drinking water to 1.3 million people. It is one of only six major drinking water systems in the country that does not require any specially fabricated filtration.[7,8]

Students on a Watershed field trip.
DNR photo

Native species are critical in the development of medicines and food crops. Humans rely on naturally occurring species for food and medicines. A mere 20 species of plants provide about 90 percent of the world's food. Forty percent of all prescriptions dispensed in the United States are from substances derived from plants, animals, or microorganisms.[9] A prime example comes from the Pacific Northwest. The Pacific yew tree provided the original compound (taxol) upon which treatment for advanced ovarian cancer is based. Prior to the discovery of its anti-cancer properties, the Pacific yew tree was of little interest; it had little commercial value as a timber product.[10]

Pacific yew tree. Native species are critical in the development of medicines and food crops.
C. Antieau photo

Footnotes

[1] Governor Locke. 2004. Executive Order 04-02. http://www.biodiversity.wa.gov/documents/EO_0402.pdf

[2] Map reprinted from: Washington Department of Natural Resources. 2003. State of Washington Natural Heritage Plan. Olympia. 64 p. The delineation of these ecoregions was developed by The Nature Conservancy and many partners on the basis of work done by Robert G. Bailey (U.S. Forest Service), James Omernik (EPA), and other scholars.

[3] State of Washington Office of Financial Management. 2005 Data Book: http://www.ofm.wa.gov/databook/resources/nt15.asp

[4] Washington Department of Natural Resources. 2005. Annual Report. Olympia. 48p.

[5] U.S. Census Bureau Economic Report. 2004.

[6] Washington Department of Fish and Wildlife. 2005. Lands 20/20. A Clear Vision for the Future. 40p.

[7] Cedar River Watershed Education Center. 2006. http://www. cedarriver.org/watershed/supply.shtml

[8] Seattle Public Utilities. 2006. http://www.ci.seattle.wa.us/util/About_SPU/Water_System/Water_Sources_&_Treatment/Cedar_River_Watershed/index.asp

[9] NatureServe. 2006. http://www.natureserve.org/consIssues/ten Reasons.jsp

[10] U.S. Fish and Wildlife Service. 2005. Why Save Endangered Species? an online brochure http://www.fws.gov/endangered/Why_Save_End_Species_July_2005.pdf

As noted in the Introduction, biodiversity can be characterized at various levels, including genes, species, ecosystems, and landscapes (or ecoregions). This report presents information on Washington's ecoregions, ecosystems, and species. There is generally very little information available regarding the distribution of genetic diversity within species.

Landscape Diversity – The Concept of Ecoregions

Ecologists have devised different systems for characterizing the landscape-level diversity of terrestrial, freshwater, and marine environments. The various systems work well for their respective environments, although having multiple systems creates challenges for coordinating efforts that extend beyond or across the different environments.

Portions of nine terrestrial ecoregions have been delineated within Washington (Figure 2.1).[1] Ecoregions are delineated to reflect broad ecological patterns. As a result each ecoregion has a distinctive composition and pattern of species distributions. Note that each of these ecoregions extends beyond our borders. As a result, Washington shares many species and ecosystems with neighboring states and provinces; we have a mix of flora and fauna from the Great Basin, the Rocky Mountains, etc.

The terrestrial ecoregions do not adequately represent freshwater aquatic or marine ecosystems diversity. At a landscape level, freshwater ecosystems are better characterized in terms of their hydrologic relationships, i.e., whether or not they are part of the same watershed. The Nature Conservancy has developed a freshwater classification system for Washington, making use of the concept of Ecological Drainage Units (EDUs). There are portions of ten EDUs in Washington (Figure 2.2).[2] The agencies involved in salmon recovery have delineated separate Salmon Recovery Regions (Figure 2.3).[3] The interface between aquatic (including both freshwater and marine) and terrestrial landscapes is not particularly well accounted for in any of the approaches to terrestrial or aquatic landscape delineation.

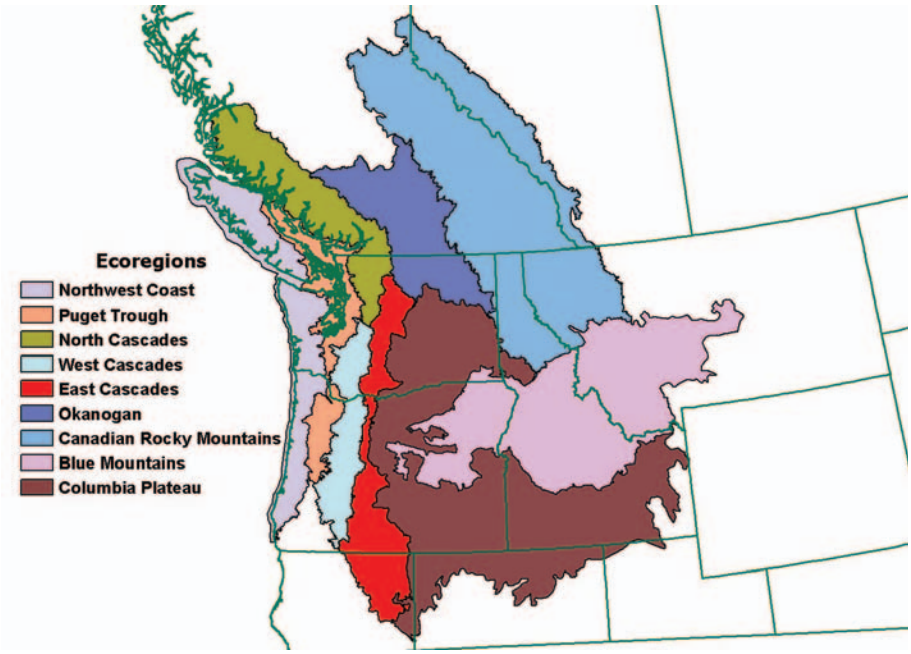


Figure 2.1. Washington's Terrestrial Ecoregions. See footnote 1.

The importance of Puget Sound is somewhat masked by the delineation of terrestrial ecoregions, ecological drainage units, and salmon recovery regions. None of these landscape delineation systems adequately highlights Puget Sound's unique biological characteristics as an inland fjordal system.

Ecosystems Diversity

Washington has a tremendous variety of ecosystems. The diversity of ecosystems is a reflection of the presence within Washington of nine ecoregions, each of which extends well beyond our state borders. As a result, we have a mixture of ecosystem types from the Rocky Mountains, the Great Basin, the southern Cascades, and the boreal forests to the north. We also have a variety of estuarine, nearshore and marine ecosystems that add to our diversity.

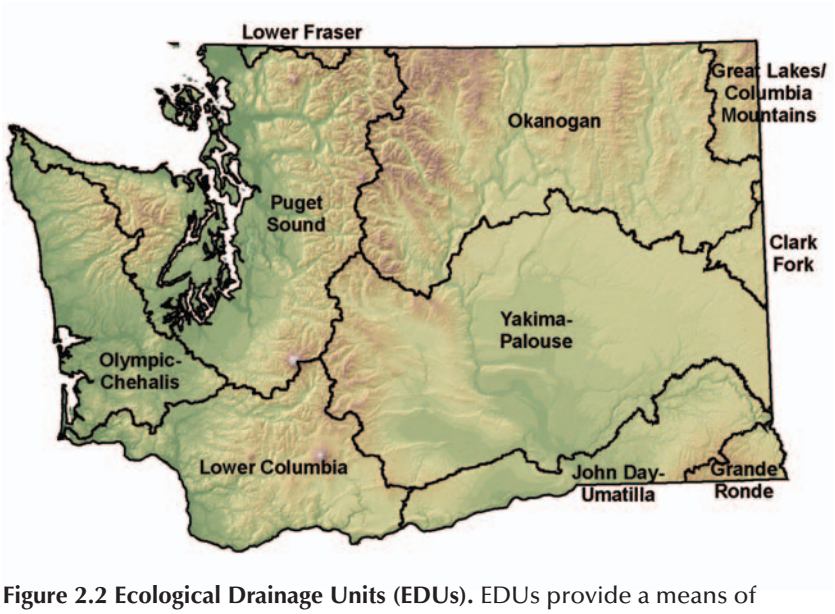


Figure 2.2 Ecological Drainage Units (EDUs). EDUs provide a means of characterizing and assessing ecological components within defined hydrologic systems. See footnote 2.

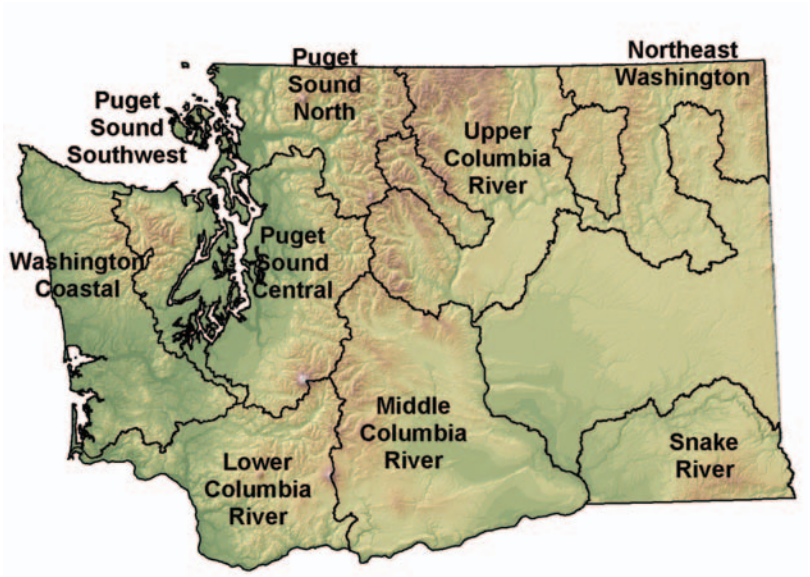


Figure 2.3 Salmon Recovery Regions. Recovery planning and implementation is organized by regions. See footnote 3.

Washington's Diversity of Ecosystems:

- Marine environments, from deep waters to nearshore habitats
- Estuaries
- Coastal beaches and dunes
- Forests (variously dominated by one of more than a dozen conifer tree species)
- Woodlands (e.g., oak woodlands of lowland western Washington)
- Grasslands dominated by bunchgrasses
- Shrub-steppe dominated by various species of sagebrush and bunch-grasses
- Freshwater environments, including lakes, rivers, streams, bogs, vernal ponds, etc.
- Subalpine and alpine environments
- Interior sand dunes, talus slopes, and other special habitats

Formal classification of ecosystems is a useful tool for conservation planning. As noted in the Introduction, the term 'ecosystem' does not have a fixed scale in its general usage. It has been used to characterize areas that vary in size from an individual stand of trees to large landscapes. In part because of this, and in order to better understand the diversity of ecosystems, ecologists have developed various ecosystem classification systems. Classification results in a reasonably definitive list of ecosystem types and a common language to refer to those types, which then allow the setting of priorities necessary for conservation planning. Ecosystems can be used as a coarse filter in conservation planning. By ensuring the conservation of ecosystem types, the conservation of the common species that make up those types can be achieved in a more efficient manner.

The approach to ecosystems classification has been different in terrestrial, freshwater aquatic, and marine environments. The relative diversity of ecosystems between these environments is therefore difficult to assess. This also means that conservation assessment and prioritization efforts have not been seamless across terrestrial and aquatic environments.

Terrestrial Ecosystems

- Classification based upon vegetation and/or utility as wildlife habitat.
- There are an estimated 100 ecological systems[4] in Washington, which have been reduced to 29 wildlife habitats.[5]

Freshwater Aquatic Ecosystems

- Classification relies primarily on physical parameter data (e.g., stream gradient, elevation). How well the classification represents distribution patterns of the biotic components needs to be tested.

Marine Ecosystems

- Classification uses physical and biotic parameter data, resulting in identification of 60 intertidal and subtidal ecosystem types.[6]
- Estuarine and marine shorelines in Washington State have also been mapped according to the ShoreZone Mapping System by the DNR Nearshore Habitat Program.[7]

Pygmy rabbits. *WDFW photo*

Death camas.
B. Legler photo

Species Diversity

Washington is home to a great number of species. We have grizzly bears and pygmy rabbits, sea anemones and sagebrush, diminutive lichens and giant Palouse earthworms, deer-ferns and death camas.

The species diversity is a reflection of our ecosystems diversity, from marine and freshwater aquatic to terrestrial. Our flora and fauna are a mix of species from the north, south, east, and west. Some of our species are at the center of their range in Washington, while others occur here at the very edge of their range.

Many of our species are migratory, spending part, but not all, of their lives in Washington. Salmon, gray whales, southern resident orcas, and many marine bird species utilize marine and inland waters outside of our borders. Migratory waterfowl and neotropical migratory birds are here only seasonally.

Washington's Species Diversity [8]

- 3,100 vascular plant species
- An estimate of thousands of mosses, lichens, liverworts, and fungi
- 140 mammals
- 470 freshwater and marine fishes
- 341 birds[9]
- 25 amphibians
- 21 reptiles
- An estimated 20,000 invertebrates, including more than 2,000 moths and butterflies

On the other hand, some of our species are endemic, i.e., unique to Washington, occurring nowhere else on Earth.[8,9] Endemism provides one measure of Washington's biodiversity. According to NatureServe (2002), Washington ranks 13th among the 50 states, with 53 endemic species.[10]

Of the 53 species endemic to Washington, 49 are plant species:

- 20 occur in the East Cascades Ecoregion, primarily within the Wenatchee Mountains.
- 18 occur within the Columbia Plateau Ecoregion.
- 9 occur within the NW Coast Ecoregion, primarily within the Olympic Mountains.

Basalt daisy is a narrow endemic. Its global range is limited to an area approximately 10 miles x 2 miles in Washington State. *DNR photo*

Exciting new discoveries in the millipede world. Recent work has resulted in the discovery of 69 new species of millipedes in the Pacific Northwest, including one new family. These discoveries represent a 64% increase in the recognized millipede diversity in the Pacific Northwest.[11]
W. Leonard photo

The four endemic animal species include two salamanders, one fish, and one mammal. All occur in western Washington; three occur on the Olympic Peninsula.

The cataloging of Washington's biodiversity is not yet complete. Species new to science are still being discovered in Washington.[11] Range extensions also continue to be documented, resulting in a growing list of species that are known to occur in Washington.

Genetic Diversity

Genetic diversity within most species is poorly known. There are exceptions, such as salmon, where detailed knowledge of genetic variability helps form the basis for conservation actions. For some

species, particularly those that are extremely rare, information regarding the genetic diversity within the species is critical to recovery planning. Such information has helped shape conservation strategies for both animal species (e.g., greater sage-grouse, pygmy rabbit, western gray squirrel, and streaked horned larks) and plant species (e.g., golden paintbrush) in Washington.

For most species, however, where such detailed information is lacking, an assumption is made that genetic diversity is best captured or represented by increasing the number of populations conserved and by maximizing the range of environments of those populations that are protected.

Footnotes

[1] Map reprinted from: Washington Department of Natural Resources. 2003. State of Washington Natural Heritage Plan. Olympia. 64 p. The delineation of these ecoregions was developed by The Nature Conservancy and many partners on the basis of work done by Robert G. Bailey (U.S. Forest Service), James Omernik (EPA), and other scholars.

[2] Map of Ecological Drainage Units obtained from The Nature Conservancy, Washington Field Office.

[3] Map from Washington State Governor's Salmon Recovery Office website: http://www.governor.wa.gov/gsro/regions/default.htm.

[4] The concept of ecological systems is described on the NatureServe Explorer website at: http://www.natureserveexplorer.org.

[5] Johnson, D.A. and T. O'Neil, managing directors. 2001. *Wildlife-habitat relationships in Oregon and Washington*. Oregon State University Press, Corvallis, Oregon. 736 p.

[6] Dethier, M.N. 1990. *A Marine and Estuarine Habitat Classification System for Washington State*. Natural Heritage Program, Washington Department of Natural Resources. 60 p.

[7] Berry, H.D., J.R. Harper, T.F. Mumford Jr., B.E. Bookheim, A.T. Sewell, L.J. Tamayo. 2001. The Washington State ShoreZone Inventory User's Manual. Report for Washington Department of Natural Resources, Aquatic Resources Division, Olympia, WA.

[8] This information was synthesized from a number of sources, including major herbaria and natural history museums, the Washington Natural Heritage Program, Washington Department of Fish and Wildlife, NatureServe, Audubon Washington, and many others.

[9] Species that either breed or stop in Washington on their annual migrations. Washington Department of Fish and Wildlife. 2005. *Comprehensive Wildlife Conservation Strategy*.

[10] NatureServe 2002. *States of the Union: Ranking America's Biodiversity. A NatureServe Report to The Nature Conservancy*. 25 p. NatureServe (2002) data do not include subspecies or varieties. A significant number of recognized subspecies and varieties are endemic to Washington. However, because the same is true for other states, including subspecies and varieties would not likely significantly change Washington's overall ranking of 13th among the 50 states.

[11] Shear, W.A. and Leonard, W.P. 2007. The millipede family Anthroleucosomatidae new to North America: *Leschius mcallisteri*, n. gen., n. sp. (Diplopoda: Chordeumatida: Antrholeucosomatoidea) *Zootaxa* 609:1-7. Also William Leonard, personal communication (2006).

Pick up a newspaper on any given day and you are likely to see a story featuring some important aspect of biodiversity conservation: designation of much of Puget Sound as critical habitat for killer whales, the death of the last male pygmy rabbit from Washington, importation of natural predators to combat invasive species, closure of Puget Sound beaches to shellfish harvest due to high toxin levels. The stories and the issues vary from day to day, but all signal changes occurring to our native species and ecosystems.

Last male purebred Columbia Basin pygmy rabbit dies

The Associated Press

Seattle Times headline – May 17, 2006

And although the biodiversity of any given place does not remain static—colonization and extinction are both natural processes—the pace and scope of species' declines and extinctions occurring today are cause for concern. Such concern for Washington's native species and ecosystems led to the creation of the Biodiversity Council and the development of this report.

Species Overview

A limited number of native species have increased in numbers. In general, those species that can take advantage of disturbances or colonize altered environments have increased. Species that have undergone population increases or that have expanded their range are generally not of conservation concern (e.g., western scrub jay). However, they often are the species with which many people have the most interactions (e.g., crows, robins), and thus they provide an important means for understanding biodiversity issues.

Federal Endangered Species Act listings in Washington[1]:

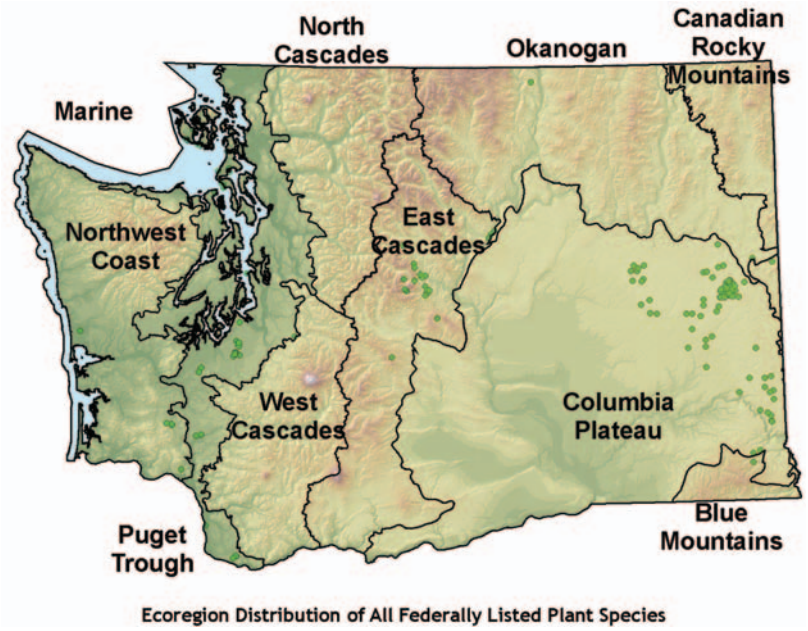
40 animal species
- 14 mammals
- 6 birds
- 4 reptiles
- 15 fish
- 1 invertebrate

10 plant species

Many species have experienced significant declines in Washington. The changes in the landscape over the last 200 years have resulted in significant declines for many of Washington's native species, both aquatic and terrestrial. Various state and federal agencies and some conservation organizations maintain lists of species that are of conservation concern; all of these lists continue to grow as landscape changes overshadow conservation efforts.

One measure of decline is the number of species listed as endangered or threatened under the federal Endangered Species Act (ESA). There are currently 40 animal species (including 15 fish) and 10 plant species that occur in Washington that are listed under the ESA.[1] Known occurences of the listed species are mapped in Figure 3.1.[2] More federally listed species occur within the Northwest Coast and Puget Trough than in other ecoregions in the state as a result of the number of listed marine species.

ESA listings are high profile and have legal implications. Many of the listed species are in immediate danger of extinction. However, the federal list of endangered and threatened species is not a true reflection of the number of species that warrant conservation attention. Many additional species are of conservation concern because their numbers have declined or because they are naturally rare and today find themselves within a landscape setting where they face human-related threats. Additionally, some species are of concern in Washington, but are more abundant and stable elsewhere. Lists maintained by the Washington Department of Fish and Wildlife (for animals) and by the Natural Heritage Program (for plants) provide a more comprehensive view of the status of Washington's species. Tables 3.1 and 3.2 identify the numbers of species of animals and plants, respectively, that have been identified as Endangered, Threatened, or Sensitive in Washington.



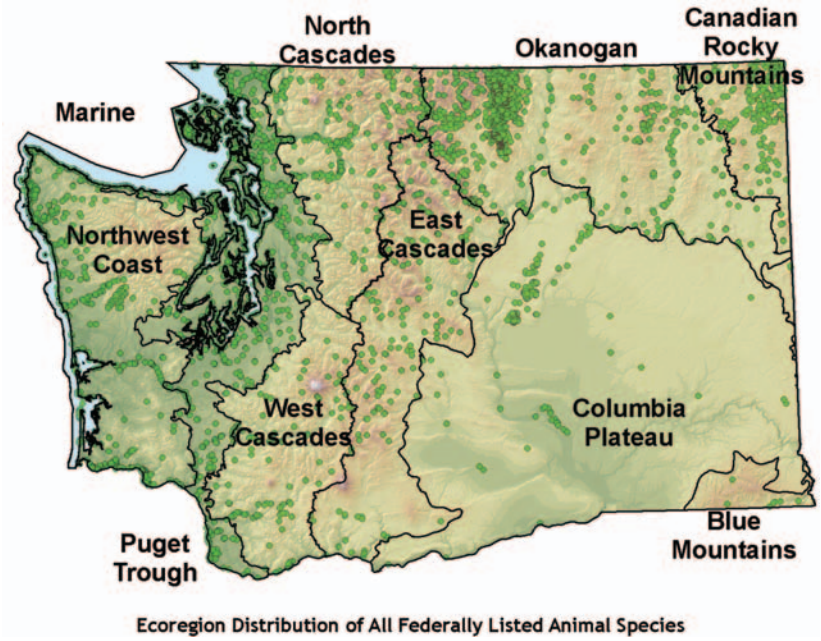


Figure 3.1. Known occurrences of plant and animal species listed under the federal Endangered Species Act. The top map depicts known occurrences of the ten listed plant species. The bottom map depicts the 40 listed animal species. Both maps include some occurrences that are historic only, i.e., not all dots represent existing occurrences. See footnote 2.

Note that for animal species there is a backlog of 109 candidate species being considered for state-listing as endangered, threatened or sensitive. There are many additional invertebrate species for which there is insufficient information, but which may ultimately warrant being considered for listing. Fifty-four plant species are also under review.

As noted above, some species are of concern in Washington, but may be more stable elsewhere. Table 3.3 shows the number of Washington plant and animal species that are of conservation concern both globally and within Washington. Many of the species in this category are either at the edge of their range in Washington or occur here in populations that are disjunct from the major part of their range. The distinction emphasized in Table 3.3—global vs. state status—may provide one approach to prioritizing conservation effort.

When one takes into account those species that are stable elsewhere, but declining or of concern in Washington, the total number of species that are of conservation concern increases dramatically. There are more than 500 species of plants and animals that are of concern.[6] These species face an uncertain future in Washington unless they are given special management consideration. Complete lists of species considered of conservation concern by the Washington Natural Heritage Program and the Washington Department of

Fish and Wildlife are available on the respective agency websites. The list of Washington's rare plant species with their respective ranks can be found at: http://www.dnr.wa.gov/nhp/refdesk/lists/plantrnk.html. Animal species identified in the *Comprehensive Wildlife Conservation Strategy* can be found at: http://wdfw.wa.gov/wlm/cwcs/.

Species that are of conservation concern are not distributed evenly across the state. Table 3.4 shows the number of plant and animal species of conservation concern by ecoregion. It should be noted that while marine species are included in the numbers, they are somewhat masked by the lack of a marine ecoregion in the table. Figure 3.2 depicts the distribution of the plant species that are of conservation concern in Washington.[9] Similar data are available for animal species of concern.

A number of specific factors have contributed to the declines. For terrestrial species, conversion of land to human-made environments and ecosystems degradation associated with land management practices are the most significant factors. The Puget Trough and Columbia Plateau ecoregions have had the highest level of conversion (see Figure 3.3), and not surprisingly have the greatest number of species of conservation concern. Marine species have also been impacted by land cover change and urban development

Table 3.1 WDFW-listed animal species by taxonomic group.[3]

Animal Group	Endangered	Threatened	Sensitive	Candidates
Mammals	14	4	1	11
Birds	7	5	2	23
Reptiles	2	2	0	4
Amphibians	2	0	1	6
Fish	0	0	3	37
Mollusks	0	0	0	10
Insects	3	0	0	18
Total	28	11	7	109

Table 3.2 DNR-Natural Heritage Program-listed plant species.[4]

Status Category	Number of Species
Endangered	39
Threatened	107
Sensitive	143
Possibly Extirpated	16
Under Review	54

Table 3.3 Number of Washington species of global and state conservation concern.[5]

Global Rank	Plants	Animals
Critically imperiled globally	13	38
Imperiled globally	53	68
Vulnerable globally	118	113
State Rank	**Plants**	**Animals**
Critically Imperiled w/in WA	172	93
Imperiled w/in WA	140	87
Vulnerable w/in WA	49	204

Please Note: There is significant overlap between the lists of species tallied under the global and state ranking categories. For example, all of the 'critically imperiled globally' species are also 'critically imperiled in WA.' See the NatureServe Explorer website for an explanation of global and state ranking (www.natureserveexplorer.org).

as stormwater and other surface water makes its way to Puget Sound, carrying contaminants, excess nutrients, and pathogens into the marine waters. Shoreline alteration has caused changes in near-shore habitat structure. Overharvest has contributed to the decline of many fish species.

Despite the long list of species that are of conservation concern, the fact that there are still extant populations of most of the species provides us with an opportunity for success. In fact, there are only two plants and two animals native to Washington that are currently thought to be globally extinct. The pale bugseed *(Corispermum pallidum)* and thistle milk-vetch *(Astragalus kentrophyta var. douglasii)* are both known only from old specimens collected from the Columbia Plateau.[10] The Tacoma pocket gopher *(Thomomys mazama tacomaensis)* and the Cathlamet pocket gopher *(Thomomys mazama louiei)* are known from limited historic records, but recent survey efforts have failed to find any extant individuals.[11] There are a number of other species that appear to be extirpated from Washington. Twenty-one plant species fall into this category as well as a number of animal species, including the fisher, Columbia River tiger beetle, and the yellow-billed cuckoo.[12] Opportunities to restore these species may exist since they are still extant elsewhere within their range, although there may be little or no suitable habitat remaining in Washington. However, the extirpation of local populations represents a loss of genetic diversity.

Table 3.4. Distribution of species of conservation concern by ecoregion

Ecoregion	Plants[7]	Animals[8]	Total
NW Coast	69	84	153
Puget Trough	56	101	157
North Cascades	36	29	65
West Cascades	36	50	86
East Cascades	87	41	128
Okanogan	68	54	122
Canadian Rockies	38	31	69
Blue Mountains	28	43	71
Columbia Plateau	104	70	174

Please Note: There is considerable overlap between ecoregions of individual species. The total numbers reflected in this table includes 359 plant species and 179 animal species (not including salmonids).

Figure 3.2. Distribution of plant species of conservation concern.
Similar information is available for animal species of conservation concern from the Washington Department of Fish and Wildlife. See footnote 9.

For extinct species, there are no options. For species extirpated from Washington, but still extant elsewhere, the possibility of reintroduction and recovery exists. However, the extirpation of Washington populations represents a permanent loss of genetic diversity.

What do we expect in the future? Additional species will need special management attention, particularly in those areas with the greatest amount of habitat loss—the Puget Trough and the Columbia Plateau. The combination of fragmented landscapes, compromised ecosystem functioning, and a changing climate will limit species' natural ability to migrate to suitable habitat. The probable result will be an increasing number of species facing significant declines.[13,14]

More than 500 species of plants and animals are of concern (face an uncertain future) in Washington unless they receive special management consideration.[13] Audubon Washington[14] reports that 93 species and 4 subspecies, or one-third of our birds, are vulnerable to drastic population declines.

Ecosystems Overview

Many of Washington's ecosystems have undergone significant declines. More than 60% of the recognized terrestrial plant associations (the finest, most-detailed level in the National Vegetation Classification[15]) occurring in Washington are considered vulnerable, imperiled, or critically imperiled.[16] To the extent that these ecosystems are in trouble, their usefulness as a coarse filter for conservation of common species is seriously compromised (see Introduction, page 2 for a brief explanation of the coarse filter concept). That is, as more ecosystems are degraded or reduced in their extent, more species will decline to the point of imperilment. Although similar rankings and numbers are not available for marine and freshwater ecosystems, they are in similar jeopardy, as evidenced by other datasets such as miles of shoreline that have been modified.

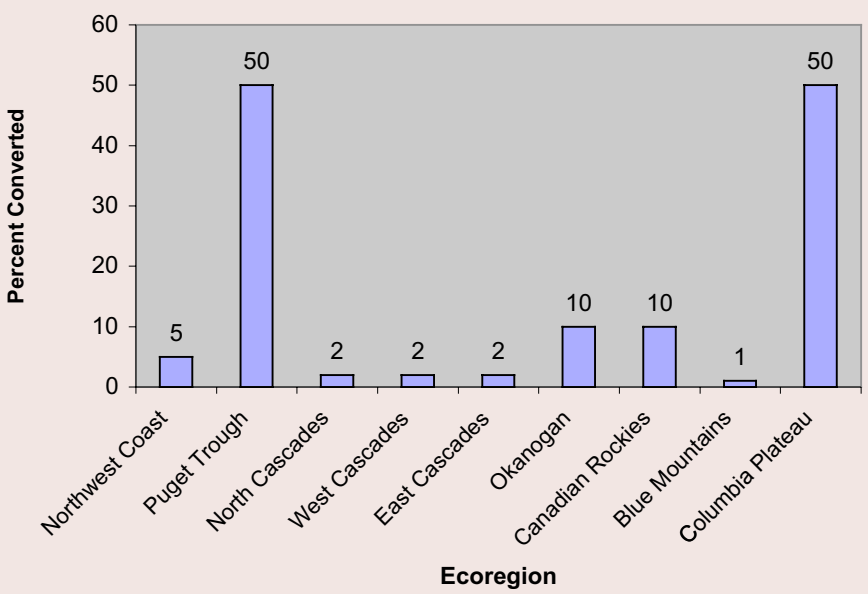


Figure 3.3 Land conversion by ecoregion. See footnote 17.

The declines have been primarily the result of conversion to other land uses and/or degradation. The two ecoregions with the greatest amount of conversion of land have been the Puget Trough and the Columbia Plateau, each with 50% or greater conversion (Figure 3.3).[17] In the Puget Trough, there has been significant loss of marine, estuarine, and terrestrial ecosystems. For aquatic environments, contamination has been one of the major factors responsible for ecosystem declines. The data upon which Figure 3.3 is based are now 10 or more years old, so the percentage of converted land within each ecoregion is higher than the figure indicates. The figure also only indicates land that has been virtually entirely converted; it does not include lands that have been significantly degraded through intensive land management practices.

Ecosystems of particular concern due to declines or degradation include the following:

Marine, estuarine, and nearshore ecosystems, particularly within Puget Sound, have been converted, modified, and contaminated. Up to 52 percent of the central Puget Sound shoreline has been modified by port development, armoring of beaches, etc.[18] The Duwamish River estuary in Seattle has been almost entirely converted to a human-managed waterway through filling the original mudflats and dredging a channel for shipping. The Puyallup River estuary has undergone similar changes, with 99 percent of its marsh ecosystem and 95 percent of the intertidal mud flats converted to port facilities.[19] There are 31 Superfund sites within the Puget Sound basin. Shellfish, fish, birds, and marine mammals in the Central and South Puget Sound regions have all been measured with high levels of toxic chemicals.[20] Killer whales have been identified as among the most contaminated marine mammals in the world, containing high levels of PCBs.[21] While these compounds continue to cycle through the food chain, new and emerging toxics, such as flame retardants and chemicals used in the manufacture of plastics, pose an array of new threats to biodiversity.

The Duwamish River. The estuary and tideflats were filled to make land more suitable for building upon and a channel was excavated for shipping. *DOE photo*

Although Puget Sound has been receiving considerable attention, and large-scale efforts are underway to help return it to a healthy condition, the growing human population will continue to present challenges to successful conservation of marine, estuarine, and nearshore ecosystems. Increases in impervious surfaces, altered hydrology, compromised water quality, and altered weather regimes associated with climate change will continue to put more of these marine, estuarine, and nearshore ecosystems at risk.

Riparian and freshwater aquatic ecosystems have been eliminated and/or degraded by construction of dams, dikes, and drainage ditches and by land use practices such as livestock grazing, timber harvest, and mining. There are more than 1,000 dams affecting the flow of Washington's waterways (Figure 3.4).[22, 23] The Hanford Reach is the only "free-flowing" portion of the Columbia River. But even through the Hanford Reach the river's flow is controlled by release of water at Priest Rapids dam. A natural flood regime has been entirely removed from both the Columbia and Snake rivers. Other rivers are similarly affected. In fact, three-fifths of Washington's rivers have been deemed to be in poor to fair health.[24]

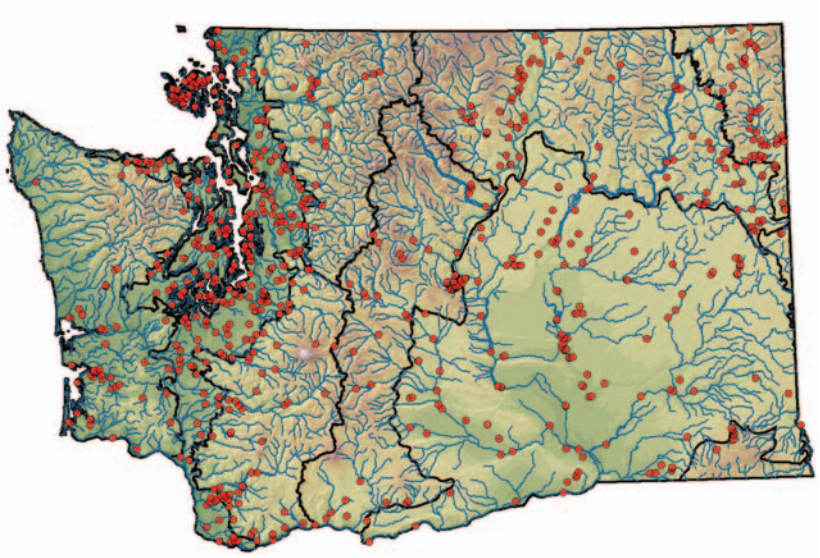


Figure 3.4. Dams in Washington. See footnote 23.

In addition to the major river systems, smaller riparian systems have been negatively impacted by land management practices. Past timber harvest practices resulted in increased stream temperatures, increased sediment loads, and they

often altered stream flows. In the Columbia Plateau ecoregion many natural riparian ecosystems have been replaced by ecosystems dominated by non-native species, little to no shrub or tree cover, and stream profiles altered by straightened channels and the effects of bank down-cutting by livestock.

Western red cedar stump.
B. Legler photo

Forested ecosystems have been converted and altered by management practices and fire suppression. Estimates of the percentage of Washington's historical old-growth that has been harvested vary from two-thirds to as high as 87%.[25,26] The change has been most evident in southwestern Washington and in the lowlands throughout the Puget Trough. Not only were these areas relatively easy to access for timber harvest, they were (and still are) primarily private land. Significant loss of old-growth occurred on public lands up through the 1970s and 1980s. We have also lost to development more than one million acres of Washington timberland in just the past two decades,[27] a majority of that in the Puget lowlands. Naturally-occurring stands with a mix of species and tree ages have generally been replaced by single species plantations. There has also been a significant reduction in the number of downed logs and standing snags, important components of habitat for wildlife species and for ecosystem processes.

Low elevation forests in eastern Washington (primarily ponderosa pine and oak woodland ecosystems) have been changed by timber harvest practices and fire suppression. For example, on the lower elevations of the eastern flank of the Cascades, forests historically were characterized by open stands of large ponderosa pine trees, which are relatively resistant to fire. Douglas-fir, on the other hand, is more susceptible to fire. This susceptibility was reduced or eliminated from many stands. However, with the advent of fire suppression, Douglas-fir is not eliminated from the stands. Over time, Douglas-fir gains ground, eventually overtopping ponderosa pine and out-competing its shade-intolerant seedlings. Harvest of the large ponderosa pine trees exacerbated the effects of fire suppression. The end result is that these ecosystems today have a significantly different structure and different species composition, including changes in pathogens, insects, and wildlife than they did historically.

As urban centers expand, forested ecosystems will continue to be subject to residential and urban development. At greater distances from urban centers, forests will be fragmented by suburban, exurban, and rural development. The movement of more people to rural landscapes will add complexity to fire suppression issues, particularly in eastern Washington where fire frequency, size, and severity are typically greater.

Shrub-steppe and grassland ecosystems have been converted to agriculture. More than 50% of the Columbia Plateau has been converted, primarily to agriculture (see Figure 3.3 above and Figure 3.5 below).[28,29] The remaining shrub-steppe is significantly fragmented, with many small, isolated remnants that will likely undergo further degradation and loss of function over time. Fragmented landscapes have more edge adjacent to converted and disturbed habitat, making them more vulnerable to encroachment by non-native species. Lack of continuous habitat also poses challenges for species that need to move around.

The Palouse portion of the ecoregion provides an extreme example of conversion. Since 1870, 94% of the original Palouse grasslands have been converted to crops, hay, or pasture.[30] The remaining Palouse grasslands are often in small north-facing slopes that were too steep to plow. These narrow strips are subject to gradual degradation from weed encroachment, loss of pollinators for native plants, etc.

ca. 1850

1995

Figure 3.5. Loss and fragmentation of shrub-steppe and grassland habitats from circa 1850 to 1995. Shrub-steppe and grassland is represented by the olive green color. Note the change from primarily olive to predominantly gray, representing the reduction in area dominated by native shrub-steppe vegetation. Johnson and O'Neil (2001). See footnote 29.

Within the shrub-steppe, inland sand dunes have recently become of conservation concern. Dunes have been converted to agriculture, used for recreational purposes, and stabilized to prevent the sand from moving around. Many of the historical dunes were inundated as dams along the Columbia River were built. We have also lost to development more than one million acres of Washington farmland in just the past two decades.[31] This represents an even greater impact on native species and ecosystems.

Ecosystem processes, in particular natural disturbances, have been disrupted or eliminated from the environment. Natural disturbances (e.g., fire, flooding, windstorms, outbreaks of disease, etc.) play an important role in the abundance, distribution, and species composition of ecosystems, creating the mosaic pattern of early, mid-, and late seral stages of individual ecosystem types. To the extent that our human activities have disrupted these processes, we have affected the current status and future trends of ecosystems and their component species.

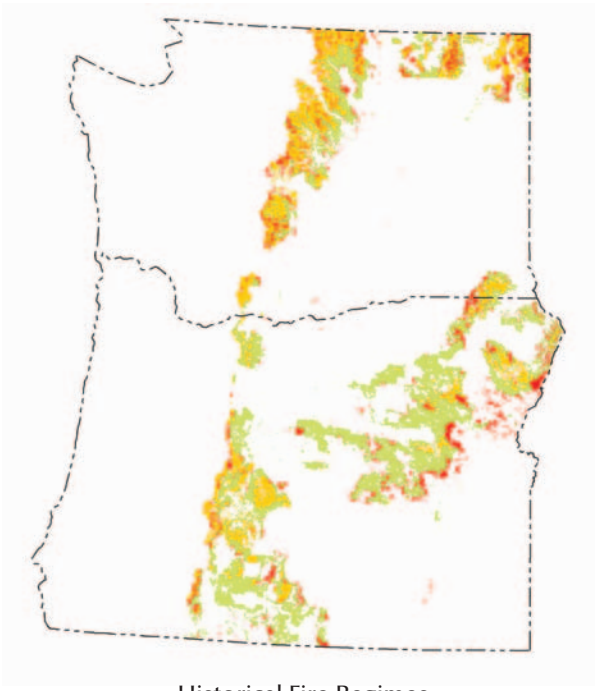
The disruption of three natural disturbance processes in particular has had a tremendous impact on the current status and condition of species and ecosystems in Washington: fire, floods, and erosion along saltwater shorelines. The disruption of these processes has had landscape level impacts.

Fire—We have aggressively put out fires in natural landscapes for many decades. This has shifted species composition away from fire resistant and fire dependent species. For forested ecosystems, this has resulted in stands that have more trees per acre, and the species composition gradually has shifted to increasing presence of fire-susceptible species. Figure 3.6 indicates the changes in fire regimes for eastern Washington (and eastern Oregon) federal lands.

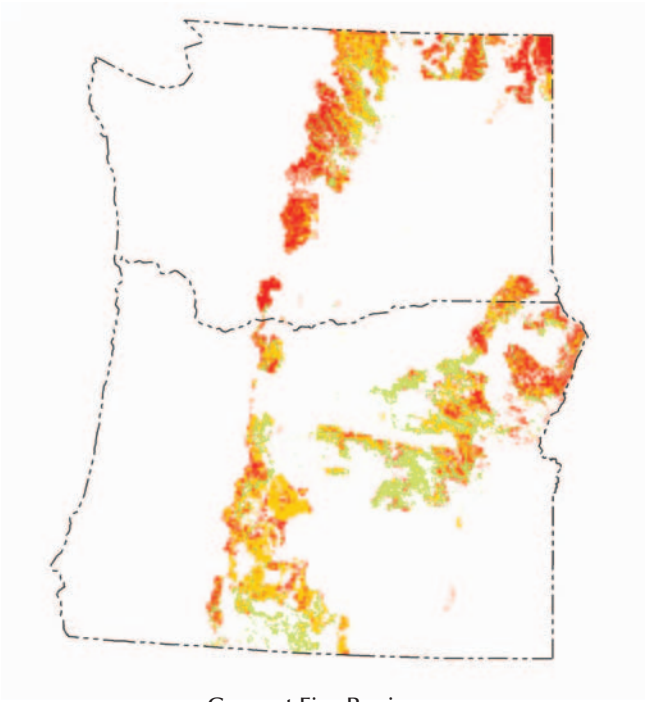
Impacts of Fire Suppression

- Fire-susceptible species increase.
- Fire dependent species decline.
- Dense, even-aged stands replace open and/or multi-layered canopies.
- Invasion of grasslands by woody vegetation.
- Homogeneity in landscape increases.
- Susceptibility to disease (at least in the case of forested ecosystems) increases.
- Fires, when they do eventually burn, are often very severe.

Floods—Our efforts to control the flow of water across and through the landscapes in which we work and live have had tremendous impacts on riparian and wetland ecosystems throughout the state. The impacts of dams on these ecosystems have already been mentioned (see Figure 3.2.). By controlling the flow of water, we have altered the delivery



Historical Fire Regimes



Current Fire Regimes

Figure 3.6 Historical and current fire regimes on east-side federal forest lands (reprinted by permission from U.S.D.A. Forest Service, Pacific Northwest Research Station, Science Update Issue 2, September 2002). Green indicates low severity and red indicates high severity fire regimes (orange indicates mixed effects). Note the significant increase in the severity of fires. See footnote 32.

Impacts of Altering Flow Regime

- Riparian systems upstream from dams inundated
- Sediments not carried downstream; no deposition of new materials in flood plains, estuaries, etc.
- Early seral riparian and floodplain ecosystems eliminated
- Seasonal flow patterns altered

of sediments and nutrients downstream, we have inundated many ecosystems, and we have virtually eliminated all early seral riparian and floodplain ecosystems. Impounding water has also dramatically impacted upland ecosystems; conversion of land for agriculture has been made feasible by the availability of water for irrigation.

Saltwater shoreline erosion—The development along the shorelines of Puget Sound has included construction of bulkheads intended to protect property from erosion. However, armoring the beaches has actually increased erosion and resulted in beaches that are steeper and rockier as a result of the sand being carried away. The end result is a loss of those animals and plants that require sand and small pebbles as their substrate.

Impacts of Armoring Beaches

- Erosion increases, leading to steeper, rockier beaches
- Animals and plants that require the gentler slope with sand and small pebbles eliminated from these beaches
- Sand lance—an important forage fish for other species—declines

Status of the Conservation Landscape

Significant protections exist, but they are limited and inadequate, given the current numbers of species and ecosystems of conservation concern. A number of conservation tools that contribute to the protection of our biodiversity are available and are being applied in Washington:

- Sustainable land management practices, including market-driven ecologically sound stewardship as well as voluntary landowner actions
- Public agency policies (e.g., U.S. Forest Service and Bureau of Land Management sensitive species policies)
- Designation of Marine Protected Areas
- Restoration of degraded ecosystems (e.g., Scot's broom control efforts on prairies in the South Puget Sound area)
- Laws and regulations (e.g., Endangered Species Act, Growth Management Act, Forest Practices Act, etc.)

Each tool has its strengths and its limitations, in part because individual species and ecosystems have different conservation needs. For example, a rare plant species occurring on a very limited number of acres within areas dominated by private ownership may benefit greatly from voluntary landowner actions. In contrast, wildlife species with larger ranges spanning a variety of ownerships, with potentially conflicting land management objectives, may require more than voluntary actions.

Land ownership is one of the primary factors influencing protection of biodiversity, although ownership does not in and of itself determine the level of protection (or degree of threat). Land ownership is a common thread for several of the conservation tools listed above: voluntary landowner actions, implementation of public agency policies, acquisition/designation of lands for conservation purposes, and restoration.

Public lands are often considered to provide a greater likelihood of successful conservation due to laws, policies, public expectations, etc. One reason that public lands are assumed to provide a greater likelihood of successful conservation is that state and federal land-managing agencies have policies in place to implement various laws, such as the Clean Water Act, Clean Air Act, Endangered Species Act, National Forest Management Act, the National Environmental Policy Act, and others. Private lands also often need to generate profits to support industry or family incomes. As a result, public lands have been less subject to outright conversion and the components of biodiversity have often been less subject to significant degradation.

In Washington, public ownership is greatest at higher elevations (see Figure 3.7).[33] Gap Analysis revealed that whereas more than 12% of Washington is in public ownership and receives a relatively high level of protection, "…the distribution of these lands is highly skewed toward high-elevation zones."[34] The national parks, federal wilderness areas, national forest lands, etc. are primarily at mid- to high elevations. The features on these lands—both the ecosystem types and the suite of common and rare species—are, by virtue of the land ownership and management objectives, at lesser risk from conversion and degradation.

Public lands are not, however, limited to mid- and higher elevations. Significant public ownership exists within the Columbia Plateau ecoregion, although much of it occurs in a checkerboard pattern with private ownership (see Figure 3.7). The checkerboard pattern of land ownership in the Columbia Plateau ecoregion has contributed to its severe fragmentation.

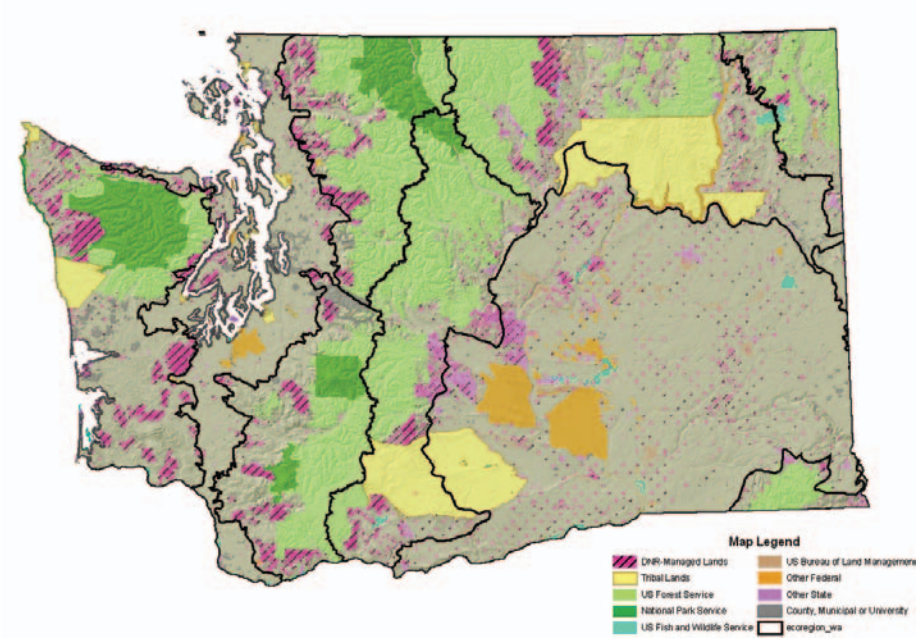


Figure 3.7. Public lands in Washington. See footnote 33.

Public lands specifically designated for conservation contribute to the protection of biodiversity. National parks and national wildlife refuges are perhaps the highest profile example of such lands. Federal and state agencies also identify lands for inclusion within the statewide system of natural areas in Washington. This system includes Natural Area Preserves, Natural Resources Conservation Areas, Research Natural Areas, and other federal or state land designations that provide conservation for significant ecological features. [35]

Non-profit organizations have also used ownership as one tool to achieve conservation. Land trusts have increased in Washington over the last ten years. Many land trusts emphasize conservation of natural ecosystems and protect lands through outright acquisition or the purchase of conservation easements.

Voluntary landowner actions play an important role on privately owned lands, particularly those at lower elevations. Lower elevation lands, in general, are more likely to be privately owned. Species and ecosystems occurring on these lands do not enjoy the same degree of legal and policy-level protection as species and ecosystems on public lands. As a result, the voluntary actions of even a limited number of land-owners can make a significant difference.

Puget Sound Action Team. ***2005-2007 Puget Sound Conservation and Recovery Plan Highlights:***

- Improve water quality in Hood Canal
- Clean up contaminated sites and sediments
- Conserve and recover orca, salmon, forage fish, and groundfish
- Prevent nutrient and pathogen pollution caused by human and animal wastes
- Protect shorelines and other critical areas that provide important ecological functions
- Restore degraded nearshore and freshwater habitats
- Reduce the harm from stormwater runoff
- Reduce toxic contamination and prevent future contamination

Ownership has different implications in aquatic, particularly marine, environments. The aquatic environment presents significant challenges to direct management of species and their habitats since much of the physical environment moves with the currents and tides. In essence, resource managers have less direct control over the environment.

Restoration of degraded ecosystems has been undertaken locally and is just beginning on larger scales. In a broad sense, restoration includes a wide range of projects, from simply making incremental improvement in a site's ecological condition, to reclamation of significantly degraded land with native species and at least some improvement in ecosystem functioning. In that broader sense, a number of impressive projects have been underway in Washington. For example, land management agencies and non-profit conservation organizations within the southern Puget Sound region have been cooperating for a number of years on the restoration of prairie and oak woodland ecosystems. The U.S. Forest Service and others have been using prescribed fire to restore ecosystems in the Cascades to a healthier condition. And most recently there has been considerable effort to identify and take action on the restoration needs for Puget Sound. Additional large-scale restoration efforts that take into account natural processes and ecosystem functioning will be needed for the successful conservation of Washington's biodiversity.

Footnotes

[1] U.S. Fish and Wildlife Service and U.S. Fish and Wildlife Service and National Oceanic and Atmospheric Administration – National Marine Fisheries Service have the authority and responsibility to list species under the federal Endangered Species Act. Data on federally listed species obtained from Washington Department of Fish and Wildlife and Washington Department of Natural Resources Natural Heritage Program websites.

[2] Plant occurrence data obtained from the Washington Department of Natural Resources Natural Program (2006). Animal occurrence data obtained from the Washington Department of Fish and Wildlife (2006).

[3] Washington Department of Fish and Wildlife. 2006. State Listed Species. Revised March, 2006.

[4] Washington Department of Natural Resources. 2006. Natural Heritage Program website: http://www.dnr.wa.gov/nhp/refdesk/lists/plantrnk.html

[5] NatureServe (www.natureserveexplorer.org) and Washington Natural Heritage Program (www.dnr.wa.gov) websites.

[6] Information sources: (1) Washington State Department of Natural Resources. 2005. *State of Washington Natural Heritage Plan. Update*. 52 p. Olympia. (2) Washington Department of Fish and

Wildlife's *Comprehensive Wildlife Conservation Strategy*.

[7] Washington State Department of Natural Resources. 2005. *State of Washington Natural Heritage Plan. Update*. 52 p. Olympia.

[8] Washington State Department of Fish and Wildlife. 2005. *Comprehensive Wildlife Conservation Strategy*.

[9] Plant occurrence data obtained from the Washington Department of Natural Resources Natural Heritage Program (2006).

[10] This statement does not include species that became extinct or extirpated from Washington prior to Euro-American settlement.

[11] Stinson, D. 2005. Status report for the Mazama pocket gopher, Streaked horned lark, and Taylor's checkerspot. Washington Department of Fish and Wildlife. Olympia.

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[13] Information sources: (1) Washington State Department of Natural Resources. 2005. *State of Washington Natural Heritage Plan. Update*. 52 p. Olympia. (2) Washington State Department of Fish and Wildlife. 2005. *Comprehensive Wildlife Conservation Strategy*.

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[16] Data sources: NatureServe's website (www.natureserveexplorer.org) and the Washington Natural Heritage Program's information system.

[17] Information based on: Cassidy, K.M., C.E. Grue, M.R. Smith, and K.M. Dvornich, eds. 1997. *Washington State Gap Analysis – Final Report*. Washington Cooperative Fish and Wildlife Research Unit, University of Washington, Seattle, Volumes 1-5.

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Washington State Office of Financial Management Environmental Chartbook: A Collection of Indicators on Washington's Environment, June 1999.

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[27] Timberland Acres in Washington State, Washington Department of Natural Resources, in *Washington State Office of Financial Management Environmental Chartbook: A Collection of Indicators on Washington's Environment*, June 1999.

[28] Information based on: Cassidy, K.M., C.E. Grue, M.R. Smith, and K.M. Dvornich, eds. 1997. *Washington State Gap Analysis – Final Report*. Washington Cooperative Fish and Wildlife Research Unit, University of Washington, Seattle, Volumes 1-5.

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[35] The statewide system of natural areas is authorized under RCW 79.70 – the Natural Area Preserves Act. The criteria for selection and the process for establishment of natural areas are described in the biennial *State of Washington Natural Heritage Plan*.

People have had a tremendous impact on Washington's landscapes and biodiversity. Changes were initiated when the first human arrived in the Pacific Northwest. Native Americans made use of the natural resources that were here, but two significant changes occurred following Euro-American contact and settlement: the human population grew rapidly and advancing technologies were applied to the management and extraction of natural resources. As a result, our native species and ecosystems have undergone declines and degradation. The threats to our biodiversity posed by population growth, conversion and degradation of ecosystems, invasions by non-native species, contamination of the environment, overexploitation for economic and recreational purposes, and climate change are also discussed briefly below.

Population Growth

Population growth has been a driving factor for landscape changes in Washington. This growth is positively correlated with habitat loss and degradation, pollution and contamination of the environment, water quality and availability problems, and the interruption of natural processes, such as species migrations and naturally occurring fires.

Our population is currently more than 6 million, having doubled in the last 40 years.[1] By 2030, Washington is expected to have more than 8 million residents (Figure 4.1).[2] Statewide, we currently have a density of almost 90 people per square mile (see Figure 4.2).[3] The 2030 projection is almost 130 people per square mile. Population growth is expected to be greatest in four Puget Sound counties (King, Snohomish, Pierce, and Kitsap), as well as in Clark and Spokane counties.[4] New buildings, roads, sewers, and water supply systems will be needed. All of these developments will add to the pressures on our species and ecosystems.

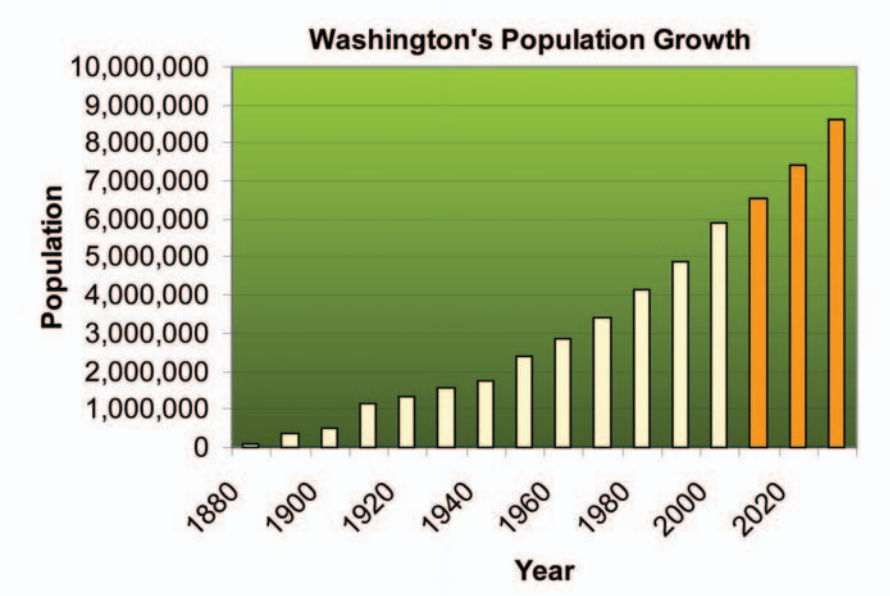


Figure 4.1 Population growth in Washington. Census data from 1890 to 2000, with projections to 2030. See footnotes 1, 2.

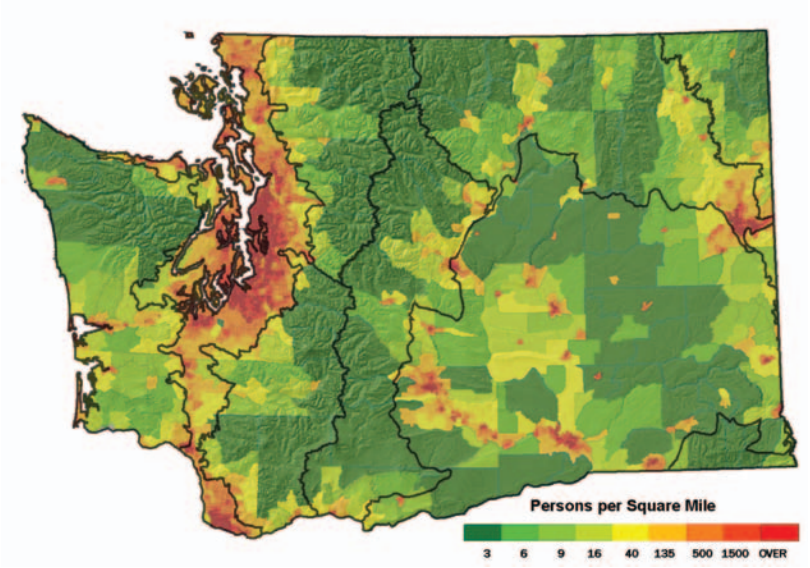


Figure 4.2. Population density in the year 2000. See footnote 3.

Conversion of land for agricultural, residential, and commercial uses

Humans have made significant changes in the land in terms of its suitability as habitat for individual species and in terms of the land's ability to sustain healthy, functioning ecosystems. In some places there has been total conversion to human-made environments. In other places, our activities have resulted in degraded ecosystems, i.e., ecosystems that are missing components and are not functioning as they would be naturally. This section addresses conversion to human-made environments.

Lots for sale in eastern Washington. New businesses, recreational opportunities, and relatively inexpensive land are contributing to growth and development. *DNR photo*

Land conversion resulting in the loss of suitability of habitat is arguably the single most significant factor responsible for the long lists of species and ecosystems of concern in Washington. Lands have been, and continue to be, converted for residential, commercial, and agricultural purposes, construction of roads and railroads, and construction of dams and other means of controlling the flow of water. Rates of conversion have been associated with both population growth and the development of technologies and transportation systems.

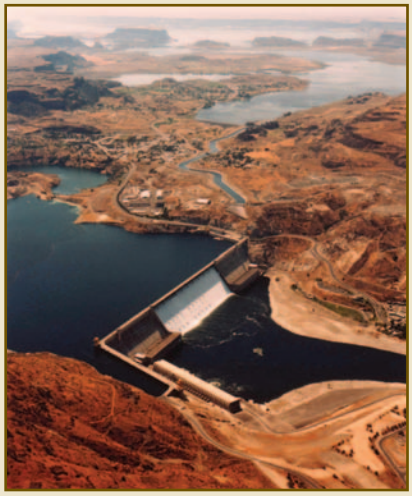
Future conversion will accompany the projected growth in our state's population. As noted above, population growth is expected to be greatest in King, Snohomish, Pierce, Kitsap, Clark, and Spokane counties. Growth in the western Washington counties will very likely result in continued reduction in the extent of lowland forested ecosystems. Since 1997, the conversion of forest to developed land has begun outpacing the conversion of agricultural lands. Washington and Oregon west of the Cascades are projected to see 1.9 million net acres of forest converted by 2030.[5]

Rapid population growth. Lowland ecosystems have been converted to a variety of land uses, including residential and commercial. *DNR photo*

And although the rate is lower, population growth is having a noticeable impact in eastern Washington as well. New businesses are becoming established, recreational opportunities are being marketed, and real estate is less expensive than in western Washington. With the rapid projected human population growth, how we manage conversion of land and degradation of our ecosystems will likely have a significant impact on how successful we are at maintaining our state's biodiversity.

Not all future conversion of land will be a direct result of population growth. Conversion for agricultural purposes continues today. Shrub-steppe continues to be converted to orchards, vineyards, organic farms, and center pivot irrigated cropland. In addition to the outright reduction in the total area covered by shrub-steppe, what remains is being increasingly fragmented, resulting in isolated remnants. Species dependent upon a healthy functioning shrub-steppe ecosystem within the Columbia Plateau ecoregion are at risk of significant declines and extirpation.

The continued loss of shrub-steppe is exacerbated by the increased fragmentation of that which remains, compromising the healthy functioning of these ecosystems.



Grand Coulee Dam. Riparian ecosystems behind dams have disappeared with inundation. *U.S. Army Corps photo*

"Water storage projects that reduce or eliminate natural flooding events in a river system will likely need to address the potential implications to natural functions in the watershed" (Water Storage Task Force 2001).[6]

Past impacts to riparian systems continue to threaten riparian dependent species and ecosystems today. Construction of dams inundated upstream riparian systems, while downstream systems were deprived of flooding, scouring, and sediment deposition. Sediments accumulate behind dams rather than being distributed to riparian areas, estuaries, and deltas on the way to the ocean. Dams have also created major problems for salmon and other migratory fish.

Meeting water storage needs for the state, particularly in light of climate change projections, may pose additional risks for species and ecosystems. Construction of additional water storage facilities is a distinct possibility to meet the duel demands of a growing population and declining winter snowpack, which accounts for much of our water storage capacity in Washington. During the 2000 session of the Legislature, a water storage task force was created to examine the need for increased storage capacity. In its report to the Legislature,[6] the task force acknowledged potential ecological risks to declining species, and the role of natural flooding events in maintaining healthy riparian ecosystems. A number of sites for water storage are being evaluated, including some that are very rich in biodiversity. Decisions regarding selection of water storage sites will likely need to weigh the social and economic benefits against the environmental and ecological costs.

Degradation of Ecosystems

In addition to the outright conversion of the land to human-made environments, continued degradation of ecosystems poses a serious threat to Washington's biodiversity. There have been many sources of degradation in Washington, including land use activities, invasive species, and pollution and contamination. The latter two (i.e., invasive species and pollution/contamination) are dealt with as categories distinct from degradation due to their severity and resultant significance. The discussion that follows under this heading is limited to land use and land management activities.

Timber harvest practices have changed patterns of forest age, structure, and species composition across the landscape. Overall our forests are younger and more homogeneous as a result. The mix of wildlife and plant species within the forests has changed along with the changes in overstory tree composition. Fire suppression has also resulted in changes in the species composition of some of our forests. In some instances, the forests are now more susceptible to damaging insects and various pathogens. Construction of roads to facilitate timber harvest has increased sedimentation in streams, affected movement of wildlife species, and provided an avenue for the invasion of non-native plant species (see next section).

Although timber harvest practices have improved in terms of their impacts on biodiversity, the improvement varies across the landscape. Localized impacts will likely continue to occur.

Off-road vehicle use. A number of outdoor recreational activities are expected to continue to increase as our population grows. *IAC photo*

Livestock grazing has changed the relative mix of native species on our grasslands and shrub-steppe. Ecosystems in eastern Washington did not evolve with large numbers of heavy grazers. The introduction of large herds of horses, cattle, and sheep led to damage to and/or destruction of the cryptobiotic crust and the elimination in many places of native bunchgrasses. Such places became ripe for invasion by non-native species, such as cheatgrass. Heavy grazing in eastern Washington forests reduced the shrub and forb understory, which has resulted in the development of dense, fire-prone, forests. Grazing has also had negative impacts on stream, riparian, and wetland systems, including increased sedimentation, altered stream flow patterns, and increased nutrient loads. Those ecosystems hardest hit by past grazing practices, where there has been nearly total replacement of native by non-native species, may never fully recover.

Increased outdoor recreation pressure on natural and semi-natural environments will contribute to degradation of habitat. The Washington Department of Fish and Wildlife reports that there are more than 2.5 million outdoor recreation days accumulated annually in Washington for hunting, fishing, and wildlife-related recreation.[7] The Interagency Committee for Outdoor Recreation projects increases over the next 20 years for many outdoor-related activities: hiking (20%), various nature activities (37%), visiting beaches (33%), and off-road vehicle riding (20%).[8] Although these activities contribute to the economy, there are environmental costs. Construction of recreation-related infrastructure has left a footprint on the environment: beach resorts, ski areas, roads, trails, campgrounds, etc. Furthermore, trampling of vegetation, compaction of soils, alteration of runoff and erosion patterns, an increased likelihood of non-native species invasions, and changes in animal behavior are all impacts that have been associated with recreational uses. As our growing population seeks places for outdoor recreation opportunities, these impacts are likely to increase.

Wind farm in eastern Washington. *DNR photo*

Development of wind energy facilities (and perhaps other alternative energy sources) has the potential to impact the quality and suitability of the environment for species and ecosystems. Recent construction of wind farms has included new roads and enhancement of existing roads. Along with the construction of the tower pads, these activities result in ground disturbances that degrade the ecosystems, at least within the immediate vicinity. Of particular concern is the impact on nesting areas for shrub-steppe and grassland birds.

The disturbed areas, and the road corridors, also become suitable habitat for invasive species. There is also concern regarding direct mortality of birds and bats.

Invasive Species

Invasive species will likely increase in number and in economic and environmental impact. Non-native invasive plant and animal species cause significant economic impact to property owners, farmers/ranchers, aquaculture, fisheries, etc. as a result of reduced yields and the cost of control and/or eradication.[9] Recognizing the severity of the impacts of non-native species, the Washington State Legislature created the Invasive Species Council during the 2006 legislative session (amending RCW 79A.25). The Council is to develop and implement a statewide invasive species strategic plan.

> "In the U.S., introduced weeds are spreading and invading approximately 1.7 million acres per year of wildlife habitat alone… Noxious weeds result in U.S. crop losses extimated at $26 billion a year." (Washington State Noxious Weed Control Board 2006)[9]

In addition to the economic impacts, there are tremendous environmental impacts. Non-native species often out-compete native species for resources (water, nutrients, pollinators, etc.), change nutrient cycling (in the case of nitrogen-fixing species such as Scot's broom), and alter disturbance patterns (e.g., cheatgrass is associated with increased fire frequency, severity, and size). Invasive species also have been identified as a threat to more than 25% of the state's plant species that are of conservation concern.[11]

Non-native plant species: Approximately 650 non-native plant species have already been documented in Washington.[12] Almost 100 of these are considered noxious weeds, with a legal requirement that the landowner undertake control measures.[13] Others, such as Scot's broom and cheatgrass, are already considered too common and widespread to control other than on a localized scale. Non-native plant species are invading both terrestrial and aquatic habitats. As of 2004, the Department of Ecology had surveyed 412 lakes and rivers; 250 (61 percent) contained invasive exotic plant species, including Eurasian water-milfoil, Brazilian elodea, and parrotfeather.[14] Several species of cordgrass (*Spartina* spp.) have become established in our estuaries and saltmarshes, raising tidal elevations, displacing native eelgrass and other plant species, significantly degrading intertidal feeding grounds of shorebirds, and possibly negatively impacting fish species.[15]

Non-native animal species: Many of Washington's animal species invaders are not recognized as such by the general public. Eastern gray squirrels, possums, and bullfrogs were not part of our fauna

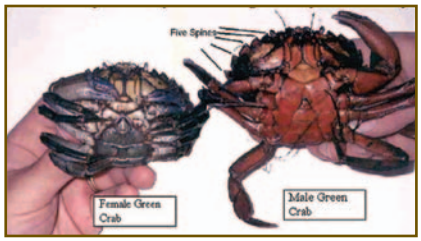
Scot's broom. This native of the Mediterranean is now widespread throughout lowland western Washington. *DNR photo*

In the U.S., non-native species are the second leading threat to imperiled and federally listed species, following only habitat degradation and loss (Stein et al. 2000). [10]

Dalmatian toadflax. A native of southeastern Europe, it was first recorded in Washington in 1911. It is now known from 23 counties. *DNR photo*

until fairly recently. Many other non-native animal species are basically unknown to the general public, but they have the potential to significantly and adversely affect both natural ecosystems and on natural resource-based economies. Gypsy moths provide one example. The European variety defoliates hardwood tree species and some shrubs, while the Asian variety also feeds on conifers. Due to their destructive potential, the Washington State Department of Agriculture invests significant effort each year to detect and eradicate any new infestations.[16]

Another example is the European green crab, which was not known from Washington's waters until 1998. It has the potential to significantly impact the state's clam, oyster, and mussel industries, and possibly even the commercially important Dungeness crab industry.[17] It may only be a matter of time until such notoriously destructive species as the zebra mussel arrive.



European Green Crab *WDFW photo*

While invasive species are a significant threat to biodiversity, their distribution is not uniform. Invasive plant species tend to be a greater threat where there is significant pre-existing disturbance to the ecosystem. There are notable exceptions, however, such as Dalmatian toadflax. Invasive animal species, due primarily to their mobility, are somewhat more likely to pose a threat to intact ecosystems.

According to an analysis of documented threats to biodiversity (primarily rare species) in Washington,[18] the threat to species of conservation concern posed by invasive species is greatest in the Columbia Plateau ecoregion (see Figure 4.3). These data, however, are heavily influenced by the total number of plant taxa that are of conservation concern.

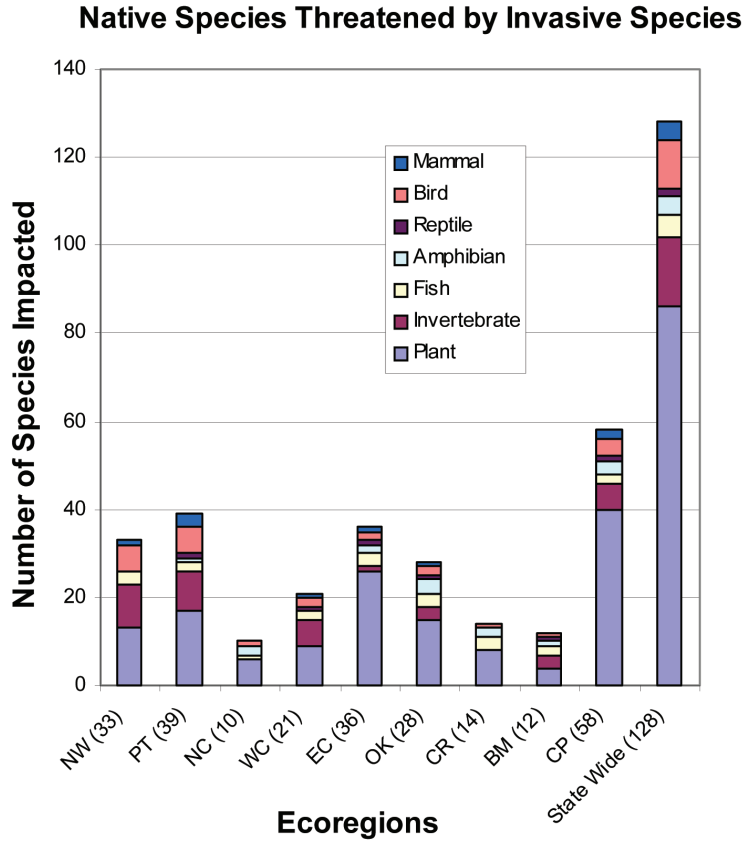


Figure 4.3. Invasive non-native species threat in Washington State. The number of rare native species impacted by invasive, non-native species, summarized by ecoregion and by general taxonomic groups. Total number of species impacted is listed in parentheses below ecoregion abbreviations. (see footnote 18)

Pollution / Contamination

Pollution and environmental contamination will likely accompany the projected growth in the population of the state. Increases in contamination of our environment, particularly via discharges of wastewater and stormwater runoff and atmospheric deposition of pollutants, such as those in automobile emissions, can be anticipated. As additional land in the Columbia Plateau ecoregion is converted to intensive agriculture, there is greater potential for contamination from the application of fertilizers and pesticides. With the on-going demand for petroleum, and with increased marine traffic of all kinds in Puget Sound waters, the danger of catastrophic oil spills increases. New chemicals and the inadequacy of assessing the impacts of chemicals' impacts on the environment are also risks.[19]

Our species and ecosystems will continue to be impacted by the legacy of past contamination: PCBs in the marine food chain have contributed to killer whales being one of the most contaminated marine mammals in the world and birds continue to get lead poisoning from shotgun pellets and from lead fishing sinkers.

Overexploitation

This section highlights overexploitation of individual species. Ecosystems that have been impacted by natural resource management, such as forests being impacted by timber harvest, or shrub-steppe by grazing practices, have been discussed in earlier sections.

The impacts of past overexploitation of species for economic or recreational purposes continues today. Overexploitation of species in Washington dates back to the 18th century arrival of fur trappers in the Pacific Northwest. International markets made it profitable for several companies to establish fur-trading forts within what would become the state of Washington. Beaver populations underwent dramatic declines that led to significant changes to riparian ecosystems throughout the Pacific Northwest.[20] Removal of beaver essentially eliminated a major natural disturbance from the landscape.

Predators such as wolves and fishers were also hunted and trapped to the point of near elimination from the state. The result is that predation as a major natural process has been significantly altered, and in some cases essentially removed from the state. Removal of predators has a ripple effect through the ecosystems of the individual predators, including increasing populations of prey species and resultant added pressure on their food resources.

More recently, the threat from overexploitation has been the greatest in the Puget Trough and Northwest Coast ecoregions, where fish and shellfish species have been heavily impacted. Overharvest has contributed to declines in salmon, several species of rockfish, Pacific herring and other forage fish, Olympia oyster, green sturgeon, bull trout, and other species. Several species of waterfowl are also vulnerable to overhunting.[21]

Hedgehog cactus *DNR photo*

Overexploitation is also a current concern for at least one of our rare native plants, the hedgehog cactus (*Pediocactus simpsonii* var. *robustior*). Individual plants have been dug from their native habitat and offered for sale. Although the harvest has not been quantified, it has the potential for significant negative effects.

Our growing population places many of our natural resources under increasing pressures. Many species of native plants

have become of interest within the floral greens industry in recent years, including salal, various ferns, and beargrass. Although these species do not appear to be currently threatened by overexploitation, there is little oversight regarding harvest levels.

As our population grows, and as climate change results in a decreasing snowpack, there will likely be a trend toward insufficient water being available during the summer to meet the needs of people, farms, and our native biodiversity.

Climate Change

Climate change will have dramatic impacts on the status of our biodiversity. According to the Climate Impacts Group at the University of Washington, we can expect significant changes to estuaries, nearshore habitats, the food web within Puget Sound, riparian habitats,[22] and our forested ecosystems. Salmon will face increasing pressures; their lifecycle makes them susceptible to climate change effects in freshwater, brackish estuaries, and the ocean.[23] Forests will change in their composition, structure, and distribution patterns as some species shift their geographic range while others simply decline. Rising temperatures could increase the frequency and intensity of fire and pest outbreaks, which could in turn reduce the diversity and extent of our forests.

Projected Impacts of Climate Change [22,23]

- Sea level rise will result in the erosion and loss of nearshore habitats
- Changes in temperature and nutrient availability may lead to declines in salt marsh and coastal wetland habitats
- Lower summer flows and warmer waters may negatively affect salmon
- Warmer water temperatures will impact plankton, which form the foundation of the marine food web
- Increased algal productivity in surface waters of Puget Sound would lead to a further depletion of oxygen at depth
- Frequency, severity, and duration of natural disturbances, such as fire and pest outbreaks, will likely change

Perhaps the most significant climate change impact on our biodiversity will be indirect: how will people respond to water storage and water usage challenges? Projections suggest that we will lose 63–87% of our winter snowpack by the end of this century, and that 50% will be lost by 2050. Washington relies heavily on this winter snowpack for our water storage system. Only 10% of our winter water storage is in man-made structures.[24] Constructing additional reservoirs to make up for what we lose in storage capacity provided by snowpack will further interrupt existing hydrologic regimes, adding additional stress to those systems.

How is future climate change and biodiversity's response to that change different from that of the past? Can species and ecosystems respond? What can we do to make a difference? Historically, climate change resulted in species migrations, altered dispersal patterns, and evolutionary processes, including extinction. For example, some species such as ponderosa pine and Garry oak, are likely of southern origin, having migrated northward during warmer times. Species' dispersal capabilities resulted in their colonizing appropriate habitat, even as it shifted spatially. Today, the suitable habitat base is limited due to conversion and degradation. Migration pathways are not continuous. Fragmentation of habitat isolates species into more localized populations, perhaps with compromised dispersal ability. This is likely to be the case particularly for those species that are rare and/or limited in their distribution to begin with.

Climate experts also project an increased frequency of extreme warm events and intense precipitation events.[24] Such an increase in extreme conditions may subject isolated, remnant patches of native species to greater risk of degradation and even extirpation.

Footnotes

[1] Washington State Office of Financial Management. 2005 Data Book.
[2] Washington State Office of Financial Management: http://www.ofm.wa.gov/pop/gma/projections.asp
[3] Washington State Office of Financial Management: http://www.ofm.wa.gov/popden/colormap.asp
[4] Washington State Office of Financial Management, *Washington State County Growth Management Population Projections: 2000 to 2025*.
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[10] Stein, B.A., L.S. Kutner and J.S. Adams. 2000. *Precious Heritage: The Status of Biodiversity in the United States*. A joint project of The Nature Conservancy and the Association for Biodiversity Information. Oxford University Press. 399 p.
[11] Bishop, A., A. Dotolo, M. Grady, A. Lillenthal, J. Panza, A. Varlamov and C. Wilson. 2005. Threats to Biodiversity in Washington: A Report Prepared for the Washington Biodiversity Council.
[12] Rice, P.M. INVADERS Database System (http://invader.dbs.umt.edu).
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[15] Washington Department of Natural Resources, Aquatic Resources Division website: http://www.dnr.wa.gov/htdocs/aqr/noxious_weeds/index.html
[16] Washington State Department of Agriculture website. Gypsy moth fact sheet. 2006. http://agr.wa.gov/PlantsInsects/InsectPests/GypsyMoth/FactSheet/docs/FactSheet2006.pdf
[17] Washington Department of Fish and Wildlife website: http://www.wdfw.wa.gov.
[18] Bishop, A., A. Dotolo, M. Grady, A. Lillenthal, J. Panza, A. Varlamov and C. Wilson. 2005. Threats to Biodiversity in Washington: A Report Prepared for the Washington Biodiversity Council.
[19] Redman, S., A. Criss, J. Dohrmann, and R. Shultz. 2006. *Toxics in Puget Sound. Review and analysis to support toxic controls*. Puget Sound Action Team. Office of the Governor. Olympia. 28 p.
[20] Robbins, W.G. and D.W. Wolf. 1994. *Landscape and the Intermontane Northwest: an environmental history*. Gen. Tech. Rep. PNW-GTR-319. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 32 p. (Everett, R.L., assessment team leader; Eastside forest eco system health assessment; Hessburg, P.F., science team leader and tech. Ed., Volume III: assessment).
[21] Washington Department of Fish and Wildlife. 2005. *Comprehensive Wildlife Conservation Strategy*.
[22] Snover, A.K., P.W. Mote, L. Whitely Binder, A.F. Hamlet and N.J. Mantua. 2005. *Uncertain Future: Climate Change and its Effects on Puget Sound*. A report for the Puget Sound Action Team by the Climate Impacts Group (Center for Science in the Earth System, Joint Institute for the Study of the Atmosphere and Oceans, University of Washington, Seattle).

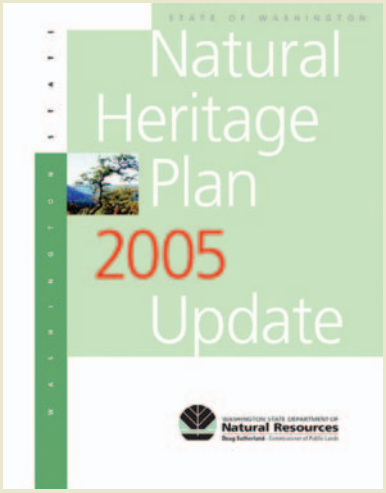
[23] Casola, J.H., J.E. Kay, A.K. Snover, R.A. Norheim, L.C. Whitely Binder and the Climate Impacts Group. 2005. *Climate Impacts on Washington's Hydropower, Water Supply, Forests, Fish and Agriculture*. A report prepared for King County (Washington) by the Climate Impacts Group (Center for Science in the Earth System, Joint Institute for the Study of the Atmosphere and Ocean, University of Washington, Seattle).

[24] Washington State Department of Ecology. 2004. *Washington's Environmental Health 2004*. Publication No. 04-01-011. Olympia, Washington. 61 p.

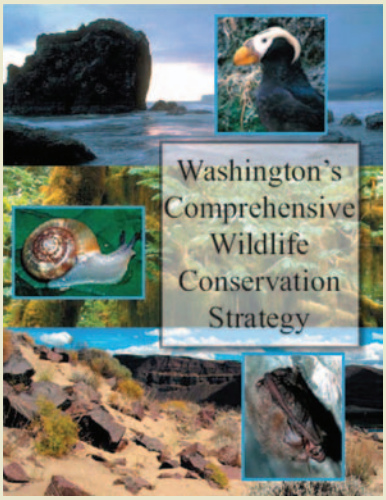
This section provides a brief overview of conservation assessments in Washington. It also identifies information gaps that, if filled, would improve our statewide conservation planning capability.

Conservation Assessments

Conservation needs assessments have been undertaken in Washington at various geographic scales. Some are based on political boundaries (e.g., the state or an individual county), while others are based on ecological boundaries (e.g., individual watersheds, Puget Sound, or individual ecoregions). Many assessments have included spatial components, identifying priority places for conservation action. Others have focused only on identifying priority species and ecosystems, or on identifying threats and/or conservation actions, without being spatially explicit. And some have been limited to individual species or groups of species. A brief discussion of a range of these assessments follows; the discussion is not intended to be comprehensive, but rather to provide examples of different approaches that have been used that might be useful in crafting a statewide biodiversity conservation strategy.



Statewide assessments. The *State of Washington Natural Heritage Plan* and the *Comprehensive Wildlife Conservation Strategy* are two examples of statewide assessments of conservation need. Both assessments identify priority features (species and ecosystems) rather than providing spatially explicit conservation priorities.



Statewide Assessments

Statewide assessments include *Gap Analysis of Washington State,*[1] Washington Department of Fish and Wildlife's *Comprehensive Wildlife Conservation Strategy,*[2] and the *State of Washington Natural Heritage Plan*.[3] Each of these assessments is fundamentally different.

Gap Analysis mapped the land cover of the state, modeled the distributions of select terrestrial vertebrates, and identified land cover types, vertebrate species, and areas of high vertebrate species richness that are inadequately represented in protected areas. It emphasized land cover types and vertebrate species richness. It also assessed various groups of at-risk species for the degree to which they occur on protected lands. It is rich in its use of geographical information systems (GIS) technology, and it is spatially explicit, but at a relatively coarse scale.

The *Comprehensive Wildlife Conservation Strategy* focuses on identifying the wildlife species and habitats of greatest conservation need by each ecoregion in the state. It also identifies threats and strategies to address the threats. It is a compilation of a tremendous amount of information from many sources. It does not, however, identify specific priority places for conservation action.

The *State of Washington Natural Heritage Plan* establishes the list of priority species and ecosystems for inclusion within the statewide system of natural areas, which includes various natural area categories employed by state and federal agencies and private, non-profit

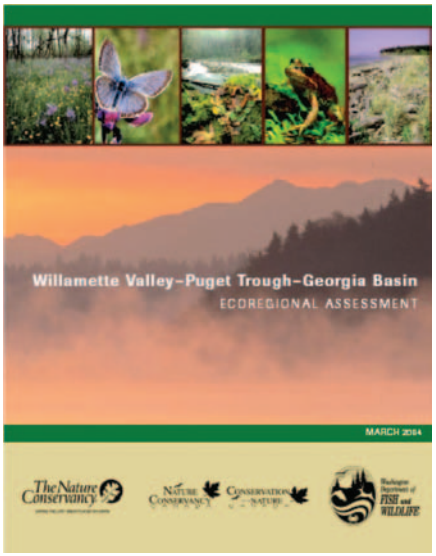
organizations. The *Natural Heritage Plan* does not directly identify priority places for conservation. Various local, state, and federal agencies use the priorities assigned in the *Natural Heritage Plan* to guide conservation actions and land-use decision-making.

Priorities for species and ecosystems established by both the Washington Department of Fish and Wildlife and the Department of Natural Resources (Natural Heritage Program) are also used in the process of evaluating land acquisition proposals under various federal and state grant programs.

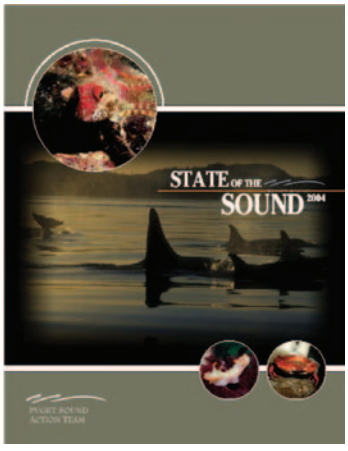
All three of the statewide assessments mentioned above use the concept of ecoregions to help characterize the distribution of species and ecosystems and as a means of assessing conservation priorities. However, none of these efforts comprehensively addresses the issue of conserving the full range of biodiversity over the long term.

Ecoregional Assessments

Conservation assessments at an ecoregional scale have been undertaken as a partnership between The Nature Conservancy, the Washington Department of Fish and Wildlife, the Department of Natural Resources, and many others. Because each of Washington's nine ecoregions extends beyond our state's borders, agencies and organizations from other states and the provinces of British Columbia and Alberta have participated in the process. The assessments are biodiversity-based; they are designed to account for the full range of biodiversity within each ecoregion. They identify the biological elements (generally species and ecosystem types) to be targeted for conservation. Through rigorous analysis and expert review, priority areas for conservation action are identified. As a result, the assessments are the most comprehensive and current efforts that support spatially explicit conservation priority setting at an ecoregional scale. They also provide a framework by which conservation actions at the local level can be measured. The current ecoregional assessments are limited, however, by gaps in availability of species occurrence data, the challenges of incorporating salmonid data, and different analytical approaches to marine, freshwater, and terrestrial environments.

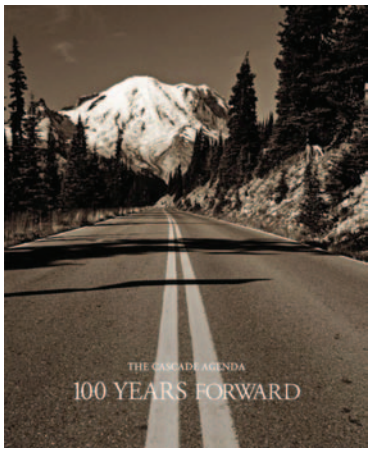


Ecoregional assessments. Assessments, such as the one completed for the Williamette Valley – Puget Trough-Georgia Basin, have been completed for Washington's nine ecoregions.



Mid-Scale Assessments

Significant coordinated effort has gone into assessing conservation needs within the Puget Sound region. These efforts are large in their geographic scope, they involve participation by many agencies, organizations, and governments, and they deal with complex, broad-scale issues. The Puget Sound Action Team has developed a conservation and recovery plan that is based on an assessment of needs within the Puget Sound basin.[4] The efforts undertaken to-date for Puget Sound focus more on threat abatement and recovery actions than identification of priority places to conserve as depicted in the ecoregional assessments. This may in part be due to the aquatic nature of the environment and the difficulties in conserving



habitats in such an environment. It also reflects a different approach to conservation action.

Another recent assessment at a relatively large scale is the Cascade Land Conservancy's project to create a vision for a sustainable future for King, Pierce, Snohomish and Kittitas counties. This project, called the Cascade Agenda, emphasizes maintenance of healthy economies and ecosystems.[5]

The Cascade Agenda starts with the premise that conservation and economic development need each other; you cannot have one without the other and maintain the quality of life that we expect in the Pacific Northwest. The report and the process attempt to look 100 years into the future. Through numerous community forums and meetings they identified the important features, including landscapes and natural areas, that participants wanted to see retained in the region. The vision that was developed from that process supports large-scale conservation of working landscapes, natural habitats, and recreational opportunities.

Local Assessments

Many assessments of conservation needs have been undertaken at more local scales, including county, watershed, and community levels. Such assessments appear to do a more comprehensive job of incorporating local values into the assessments. However, there is greater variability in the definition of the conservation values, often defined more generally in terms of open space or green space, or in terms of forest or wetlands, rather than as biodiversity conservation, which purposefully targets specific ecosystem types and species. To the extent that these local assessments do not purposefully target specific biological elements for conservation that potential contributions to regional or statewide conservation efforts are more difficult to assess.

There are, however, some local assessment efforts that have used an approach that is more readily incorporated into larger scale assessments. One example is the Pierce County Biodiversity Network. Developed as part of the county open space plan, the biodiversity network used GAP habitat maps to select a set of places that could potentially provide habitat for all native terrestrial vertebrate species in the county. It has also incorporated Priority Habitats and Species data from the Washington Department of Fish and Wildlife, rare plant and plant community data from the Natural Heritage Program, as well as data from many other sources. As a result, the contribution of Pierce County's plan to ecoregional and statewide efforts can be more readily measured.

Conservation Assessment Needs

As indicated above, many conservation assessments have been done in Washington using different approaches and covering different geographic scales. But taken as a whole, are they adequate? The following observations suggest ways in which the various assessments could lead collectively to more efficient and effective conservation.

Individual assessments generally have different purposes. Many have been designed independently and may not complement assessments at different scales or by neighboring jurisdictions. In particular, the biological elements that are the objects of conservation effort are often defined differently from one assessment to the next. The result is that it is difficult, if not impossible, to assess the collective

conservation need and/or the collective contribution of conservation actions. A land trust or a county may provide protection for green space or open space without knowledge of whether that space contributes to ecoregional or other mid-scale assessment goals. Conversely, mid-scale assessments may not adequately account for the contribution of open space to specific conservation targets, such as individual ecosystem types.

Adult cougar and cub. *WDFW photo*

For assessment efforts to complement each other, better communication and broader, proactive engagement of stakeholders is needed. Although each assessment has typically been designed for its own purposes, there are often overlapping areas of interest between different assessments. Groups working at any particular geographic scale could benefit from the knowledge and expertise available at other scales. Unfortunately, there is no framework to provide for such communication and coordination of efforts.

Natural processes, and the degree to which they have been interrupted, are not generally addressed in assessments, regardless of scale. Assessments done to date for terrestrial environments have generally focused on species and ecosystems that are of conservation concern. Some, such as ecoregional assessments, have identified priority places for conservation based on the presence of species and ecosystems. Few assessments have included examination of the interruption of natural processes, such as fire or flooding regimes, or of the impacts of fragmentation, isolation, and the loss of corridors. Such issues are acknowledged, but generally not analyzed to identify conservation actions that could be taken to abate or reverse the interruption. This is in part due to a lack of basic understanding regarding the processes and the impacts of interrupting them. The assessment efforts relating to Puget Sound have placed greater emphasis on threats and the impact of natural processes being interrupted than have terrestrial assessments.

Threats are typically identified and addressed in terms of their impacts on individual species and ecosystems or how they impact individual sites. Many threats, such as invasive species and environmental contamination, will require a comprehensive, statewide approach to complement efforts at individual sites or within individual ecosystem types.

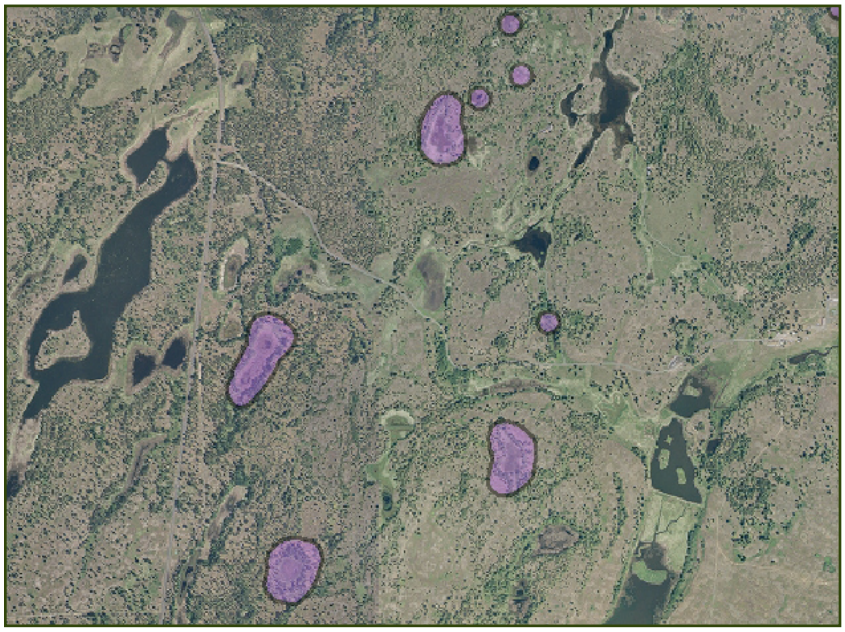
Assessments represent a point in time, yet the status and condition of our biodiversity is not static. In order to improve the useful lifetime of conservation assessments, we need to improve our ability to update them quickly and easily. This may require the development of new tools to manage and analyze information. It will also require the identification of appropriate components of biodiversity to monitor over time.

Information Gaps

Species Information

Our knowledge of which species in the state are of conservation concern is well-developed for some taxonomic groups, less so for others, and clearly inadequate for yet others. Taxonomic groups with generally well-developed information and understanding of rarity and priorities include vascular plants, vertebrates, and select groups of invertebrates (e.g., butterflies). There are, of course, exceptions within

these groups. Taxonomic groups with only moderately developed information include mosses, lichens, some groups of fungi, some fishes, some invertebrates (e.g., dragonflies, beetles, and mollusks), and marine species in general. Taxonomic groups that are largely unknown include most terrestrial and aquatic invertebrate species, including many rare endemics, as well as many underground species, such as soil microbes and many fungi. Without better information regarding which species to target for conservation action, we may inadvertently lose some components of our native biodiversity.



Rare species mapping. Precise locations for many high priority rare species are known and managed in GIS. Known locations of water howellia, a federally listed plant species that occupies seasonal wetlands, are shown in the map above. *DNR photo*

Even within the groups of rare species that are reasonably well-known, additional inventory and mapping are needed. The needs fall into three basic categories. First, there are geographic areas of the state that have not been adequately inventoried. In particular, those areas of the state that are largely in private ownership are underrepresented in existing databases. Second, individual species and entire taxonomic groups have not been adequately inventoried. Third, although the Washington Department of Fish and Wildlife and the Washington Natural Heritage Program have extensive databases with information about the locations of species of conservation concern, the data for many species are old and insufficient to determine with confidence the species' current status. Inventory effort has not kept pace with the landscape changes that are occurring in Washington.

An on-going frustration shared by biologists and planners alike is a lack of negative survey data for rare species and quality ecosystems. As noted above, for many of the highest priority species, there is reasonably good knowledge (and resultant mapping) of where the species has been found. Unfortunately, not as much effort has gone into capturing spatial information regarding areas that have been surveyed for individual species when the species is not found. This is not as simple as it might sound. Negative survey results for a species do not always mean that the species is not present or that the habitat is not suitable. Surveys need to be conducted using appropriate techniques, at the appropriate time of year, and by trained observers.

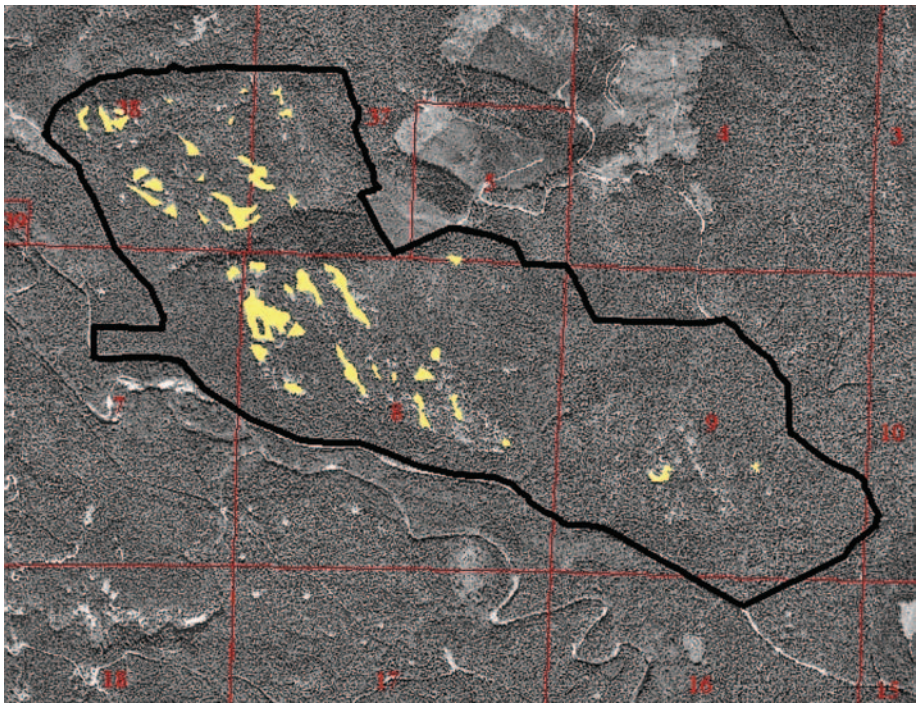
There is increasing interest in predictive habitat mapping for individual species, particularly those that are of conservation concern. The GAP analysis efforts in Washington in the 1990s modeled the distribution of animal species, resulting in maps that predicted the range of each species. Given that the number of conflicts between biodiversity conservation and legitimate land use practices appears to be increasing, there is a need for the development of new tools to more accurately predict where species of interest might occur. If nothing else, doing so would likely result in more efficiently getting the much-needed inventories started. An effort is underway to update the earlier GAP efforts for vertebrate species. There are also efforts, associated with forest sustainability certification, to create predictive range maps for plant communities and plant species that are of conservation concern.

Information regarding threats to species of conservation concern is often inadequate for identifying specific positive actions. Most of the information available regarding threats to individual rare species is observational rather than experimental. Furthermore, the information that is available has generally not undergone analyses that provide statistical validity. Conclusions regarding threat assessments are, therefore, often based upon best professional judgment. Fortunately, consensus often exists about such assessments, and conservation actions can be identified and undertaken with reasonable certainty regarding their appropriateness. In many cases, however, a more comprehensive understanding of threats would improve our ability to take positive restoration and recovery actions.

Broad-brush information is available for most of the state's common species, but declines in common species are not detected very well. Most effort currently is directed toward species that are already identified as being of conservation concern. Common species, with the exception of species that are hunted or fished, receive little attention; there are no systems to detect trends. Yet the pace of growth and development is likely to result in more and more species experiencing downward trends. This will likely become increasingly important if projections regarding population growth and accompanying development are realized. It would clearly be advantageous to identify species susceptible to changing trends as early as possible.

Ecosystems Information

To ensure conservation of our ecosystems diversity, we need to fully understand it. Additional ecosystems classification efforts can help us gain that understanding. Classification provides a consistent basis for characterizing different components of ecosystems across the landscape. Classification results in more precisely defined ecosystem units, which then provide a common language for different agencies, organizations, and land management jurisdictions as they jointly set priorities and identify ecosystem-specific conservation needs. Ecosystem classification needs are perhaps the greatest in marine (deep waters), freshwater aquatic (including riparian, vernal pools, etc.), and special at-risk terrestrial ecosystems (e.g., sand dunes). Essentially, we have not yet documented the full diversity of ecosystems within these environments. The better we understand our ecosystems diversity, the greater use we can make of ecosystems as a coarse filter to prioritize conservation of common species.



Detailed map of herbaceous bald ecosystems. Site-specific conservation actions for priority ecosystems require accurate and precise mapping, such as that shown here for herbaceous bald ecosystems on a portion of the Olympic Peninsula. *DNR photo*

To identify a desired future condition for ecosystems, an understanding of historical baseline conditions is necessary. However, many of our ecosystems have been altered to a point that we currently have little

understanding of what they looked like and how they functioned 100 or 200 years ago. Without additional information, a desired future condition for such ecosystems cannot be specifically identified.

Additional inventory and mapping of ecosystems is necessary. Many existing efforts are based on satellite imagery interpretation and computer modeling. Modeling efforts use physical parameter data (climate, topography, geology, soils, hydrology) along with available vegetation data to essentially predict the distribution of coarse ecosystem types (wildlife habitats, ecological systems). Map products at this scale are useful for gaining an overall understanding of how ecosystem types are distributed spatially and for initial prioritization for conservation effort. The statewide map of wildlife habitats produced by Johnson and O'Neill (2001)[6] is a good example of such a map. Ecological systems maps have also been produced for some of the ecoregions as part of the ecoregional assessment process being undertaken by The Nature Conservancy and its partners.[7]

However, more detailed inventory and mapping are needed as conservation actions begin to take place on the ground. That is, more ground truthing is needed to validate the mapping generated by imagery interpretation and modeling. Detailed mapping has been completed for a number of areas in the state, but these areas are generally relatively small and under a particular ownership or land management designation (e.g., many state parks and some natural areas have been mapped at a detailed scale). A major exception is that all estuarine and marine shorelines in Washington State were classified and mapped according to the ShoreZone Mapping System by the DNR Nearshore Habitat Program.[8]

Summary of Status of Conservation Assessments and Information Gaps

There is certainly sufficient information available to support the development of biodiversity conservation strategies for Washington. While more information could in some cases enhance our efforts, we have a pretty good sense of which species and ecosystems are most imperiled. There have also been numerous conservation assessments at a variety of geographic scales. The various assessments are not necessarily incompatible, but with greater coordination, they could be more complementary. That is, greater effectiveness and efficiency could be achieved.

The ecoregional assessments conducted by The Nature Conservancy, Washington Department of Fish and Wildlife, Washington Department of Natural Resources, and other partners are the most comprehensive and current assessments available. They identify species and ecosystems to target for conservation effort, and include information regarding where those species and ecosystems occur on the landscape. The assessments will be completed for all nine ecoregions within Washington soon. Currently, ecoregional assessments are the only planning effort covering the entire state designed to capture the full range of biodiversity.

Although the ecoregional assessments result in the mapping of high priority areas for conservation, they do not identify specific conservation actions that need to occur, or who should have responsibility for undertaking those actions. On-the-ground site conservation planning and implementation require more spatially precise information than is often currently available. Maximizing the usefulness of the ecoregional assessments will require active participation by various governmental entities (including land managing agencies, county planning departments, and others), and the private sector (including non-profit organizations and both industrial and individual landowners).

Improvements in our knowledge base regarding how ecosystems function, including how threats operate, would increase the likelihood of long-term successful conservation. Being able to detect

early declines in common species would also result in greater efficiency in the long run (i.e., an ounce of prevention is worth a pound of cure).

Finally, we do not currently have an adequate system in place to monitor the effectiveness of the overall biodiversity conservation effort in Washington. A system is needed (1) to provide the scientific basis for on-going adaptations to our overall effort and (2) that can be used to communicate to decision-makers and the public regarding biodiversity conservation needs.

Footnotes

[1] Cassidy, K.M., C.E. Grue, M.R. Smith, and K.M. Dvornich, eds. 1997. *Washington State Gap Analysis—Final Report*. Washington Cooperative Fish and Wildlife Research Unit, University of Washington, Seattle, Volumes 1-5.

[2] Washington Department of Fish and Wildlife. 2005. *Comprehensive Wildlife Conservation Strategy.*

[3] Washington Department of Natural Resources. 2005. *State of Washington Natural Heritage Plan 2005 Update.* Olympia. 52 p.

[4] Information obtained from the Puget Sound Action Team's website: http://www.psat.wa.gov.

[5] Information obtained from Cascade Land Conservancy's website: http://www.cascadeland.org.

[6] Johnson, D.A. and T. O'Neil, managing directors. 2001. *Wildlife-habitat relationships in Oregon and Washington*. Oregon State University Press, Corvallis, Oregon. 736 p.

[7] The Nature Conservancy has led an effort to undertake assessments in each of the ecoregions throughout the country. In Washington, the Department of Fish and Wildlife and the Department of Natural Resources have been major partners in this effort. Because each ecoregion in Washington extends beyond the state's boundaries, the process has included partners from neighboring states and provinces.

[8] Berry, H.D., J.R. Harper, T.F. Mumford Jr., B.E. Bookheim, A.T. Sewell, L.J. Tamayo. 2001. *The Washington State ShoreZone Inventory User's Manual*. Report for Washington Department of Natural Resources, Aquatic Resources Division, Olympia, WA.

GLOSSARY

Abatement. Reduction in degree or intensity.

Algal. Of or relating to algae.

Alpine. The general area in mountains that is above timberline.

Altered hydrology. Any condition in which the natural hydrologic regime has been changed. This includes spatial, temporal, and rate of flow of water through a given area.

Aquatic landscape. Basic ecological unit composed of living and non-living elements interacting within an aquatic environment.

Biodiversity. The full range of life in all its forms. This includes the habitats in which life occurs, the ways that species and habitats interact with each other, and the physical environment and the processes necessary for those interactions.

Boreal forests. Forests at northerly latitudes, characterized by conifers and long winters.

Brackish. Water that is saltier than fresh water but not as salty as sea water.

Carbon storage. The concept of counteracting the build-up of carbon dioxide in the atmosphere by either retaining carbon in a non-gaseous state or by capturing carbon dioxide and storing it underground or in the sea.

Center pivot irrigation. Type of irrigation system that consists of a wheel-driven frame supporting a series of sprinkler nozzles. The frame rotates around a central point to distribute water over a large circular area.

Coarse filter. An approach to conservation that uses some feature(s) of the landscape to represent several to many other features. For example, representative occurrences of a particular plant community, if adequately conserved, would provide protection for the suite of common species that make up that community.

Conservation. The protection, restoration, or sustainability of natural resources.

Conservation easement. A voluntary agreement between a private landowner and a municipal agency or qualified not-for-profit corporation to restrict the development, management, or use of land.

Conversion. The act of changing from one use, function, or purpose to another. In the context of this report, conversion refers to land being converted from a natural (or reasonably natural) state, to a non-natural state, such as an agricultural field or a housing development.

Corridors. Avenues or pathways by which individuals and populations can continue patterns of movement, which are sometimes necessary for the individual's or the population's survival.

Critically imperiled. As used in this document, the term constitutes a conservation status category defined by NatureServe. Critically imperiled means being at very high risk of extinction.

Cryptobiotic crust. A highly specialized community of cyanobacteria, mosses, lichens, and their by-products, which create a crust of soil particles bound together by organic materials.

Defoliate. To strip a plant of its leaves.

Degradation. Transition from a higher to a lower level or quality. In the context of this report, degradation refers to a lowering of overall ecological condition or to a state of being less natural than under pristine conditions. Degradation can be manifested in changes in composition, structure, or function.

Delta. A low, nearly flat accumulation of sediment deposited at the mouth of a river or stream, commonly triangular or fan-shaped.

Dispersal patterns. Refers to the spatial distribution of individuals within a species.

Ecological drainage units. Aggregates of watersheds that share ecological characteristics.

Ecoregion. A relatively large area characterized by fairly uniform climate and geology and a distinct assemblage of species and natural communities.

Ecosystem. All of the organisms that live in a particular area, the physical environment of that area, and the interactions between the species and the physical environment.

Ecosystem diversity. The variety of unique biological communities.

Endangered. In danger of becoming extinct or extirpated.

Endemic. Native to or limited to a certain region. Species endemic to Washington occur nowhere else.

Estuarine. Of, relating to, or occurring in an estuary.

Estuary. A semi-enclosed coastal body of water with one or more rivers or streams flowing into it, where salt and fresh water mix. Estuaries are typically the tidal mouth of a river.

Extant populations. Populations that still exist.

Extinct. No longer existing. Exterminated everywhere.

Extirpated. Destroyed or exterminated, generally from a specific area. In contrast to extinct, which is to be exterminated everywhere.

Fire dependent species. Species for which fire is essential to their long term survival. For example, the seeds of many plant species will not germinate unless they are exposed to fire.

Fire resistant species. Species with characteristics that give them a lower probability of being injured or killed by fire. For example, the bark of ponderosa pine trees conveys some fire resistance to large, mature trees.

Forage fish. Small fish that often breed prolifically and serve as food for predatory fish.

Forb. A broad-leaved herb or forage plant other than a grass.

Fragmentation. Refers to conversion or degradation of the natural landscape, resulting in isolated (or semi-isolated) remnant patches.

Genetic diversity. Variation within a species that is attributable to differences in hereditary material.

Genetic variability. The state of being genetically variable, of having more than one genetic state.

Ground fish. A bottom dwelling fish such as flounder or cod.

Homogeneity. The state or quality of being the same or similar in nature or kind.

Hydrologic relationship. Relationship that deals with the occurrence, circulation, distribution, and properties of the waters of the earth and its atmosphere.

Impervious surfaces. Hard, non-porous surfaces such as roads, parking lots, and rooftops that prevent precipitation from soaking into the ground, thus increasing surface runoff.

Invasive species. Non-native species that threaten ecosystems, habitats, or species.

Invertebrates. Animals without backbones, including slugs, snails, earthworms, insects, spiders.

Lichen. A fungus that harbors algae within its body; the fungus and algae function as if they were a single organism, being indistinguishable without a microscope.

Liverworts. A group of small, photosynthetic, non-vascular plants that occur in diverse habitats. Some species have lobe-shaped leaves that resemble a liver.

Microorganism. An organism that can be seen only through a microscope. Microorganisms include bacteria, protozoa, algae, and fungi.

Migratory. Tending to change location periodically, especially to move seasonally from one region to another.

Mollusks. A large group of invertebrates, found primarily in salt water. For example, clams, oysters, and snails.

NatureServe. A network of Natural Heritage Programs and Conservation Data Centers, which are

located throughout the western hemisphere; a non-profit, conservation organization with its main office in Arlington, Virginia. http://www.natureserve.org/

Nearshore. An indefinite zone extending seaward from the marine shoreline to below the low tide line.

Pathogen. Any disease-producing microorganism or material.

Plankton. Small to microscopic organisms that live in fresh or salt water and are carried along by the currents.

Predator/prey relationship. The interaction between a predator, a species that eats another species, which is its prey.

Puget Trough. The lowlands surrounding Puget Sound. Also, a defined ecoregion that embraces the lowlands and marine waters lying between the Cascades to the east and the coastal ranges and Olympics to the west, from sea level to an elevation of about 1,000 feet. Washington-centric shorthand for the Willamette Valley-Puget Trough-Georgia Basin ecoregion.

Riparian. Belonging or relating to the bank of a stream or river.

Salmonid. A member of the family Salmonidae, which includes salmon, trout, and whitefish.

Scouring. Removal of soil or sediment material by the flow of a river or stream, or by waves and currents.

Seral. A transitional stage of succession in a plant or animal community.

Shrub-steppe. Grassland with a shrub component. In Washington the shrubs are often, but not exclusively, species of sagebrush.

Soil microbes. Microscopic organisms that live in the soil and feed on organic matter.

Species. A group of organisms with the same ancestry that can reproduce only with each other.

Species diversity. The number of different species in a particular area (i.e., the species richness) weighted by a measure of abundance, such as the number of individuals. In this report, the term species diversity is used simply to refer to species richness.

Species richness. The number of different species in a particular area.

Subalpine. The zone that lies just below timberline in mountain areas.

Substrate. The surface on which a plant or animal grows or is attached.

Superfund sites. The United States federal government established the Superfund Program in 1980 to clean up the worst hazardous-waste sites nationwide.

Symbiotic relationship. A relationship between two entities that is mutually beneficial.

Talus slope. A slope formed by an accumulation of rock debris at the base of a cliff.

Taxonomic group. An animal or plant group with an evolutionary relationship.

Temperate rainforest. A coniferous or broadleaf forest that occurs in mid-latitudes areas of high rainfall.

Terrestrial. Growing on the ground and supported by soil.

Threatened. Likely in the near future to become endangered.

Understory. An underlying layer of vegetation, especially the plants that grow beneath a forest's canopy. May include trees, shrubs, and forbs.

Vascular plant. A plant that has an internal water and food transport system of specially modified cells (xylem and phloem) that form tube- or pipe-like structures.

Vernal pool. A pool of water forming in the spring, which usually dries up for part of the year.

Vertebrates. Animals with backbones, including fish, amphibians, reptiles, birds, and mammals.

Abbreviations

DOE. Department of Ecology.

DNR. Department of Natural Resources.

EPA. Environmental Protection Agency.

GAP. Gap analysis.

GIS. Geographical Information System.

IAC. Interagency Committee for Outdoor Recreation.

NPS. National Park Service.

WDFW. Washington Department of Fish and Wildlife.

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