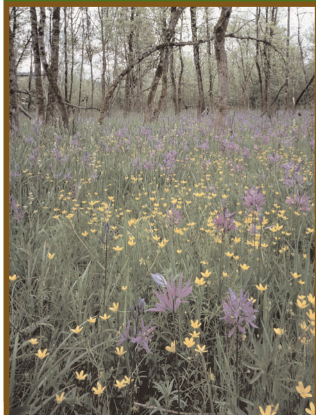




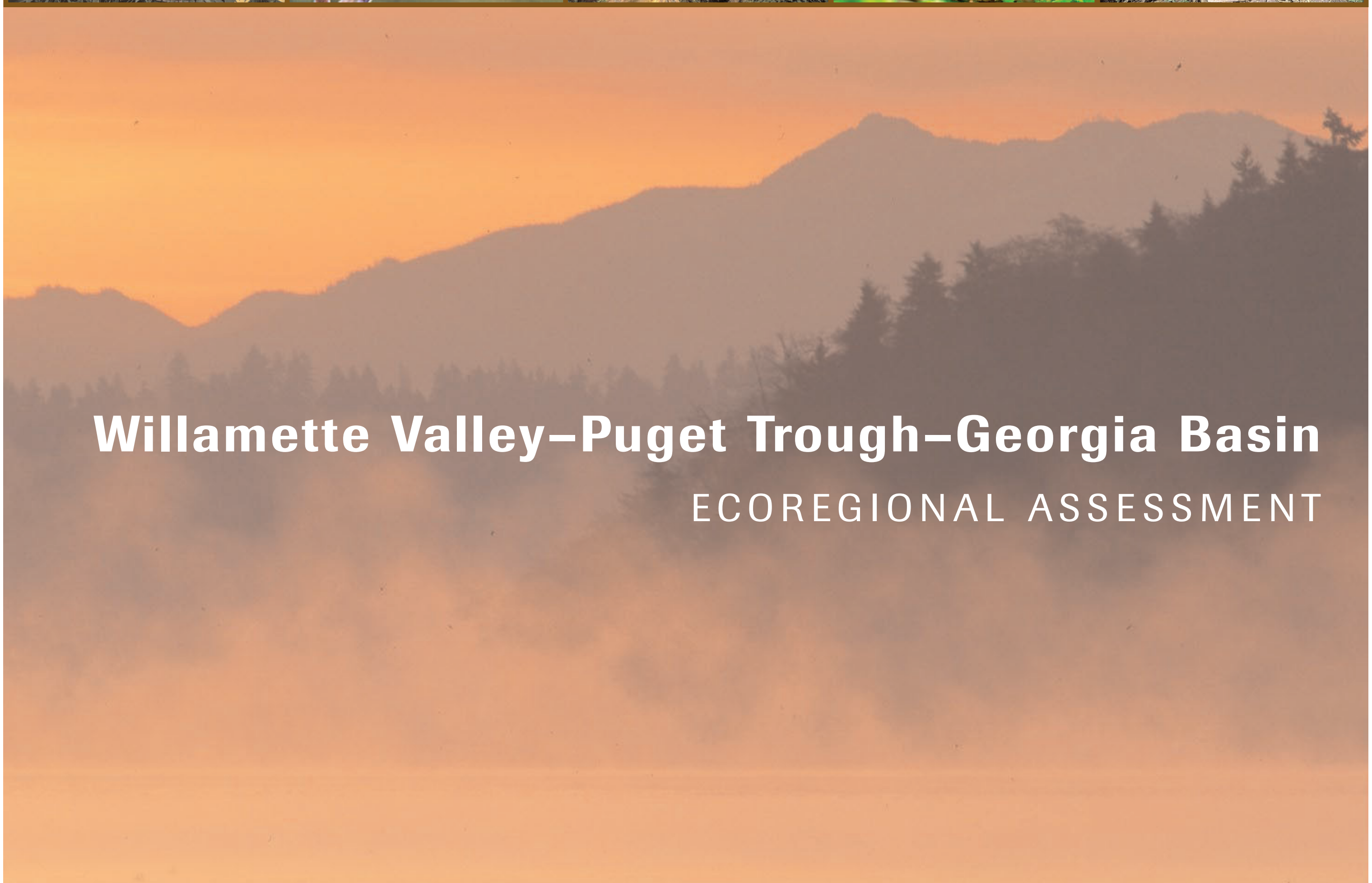

Willamette Valley–Puget Trough–Georgia Basin

ECOREGIONAL ASSESSMENT

MARCH 2004

The Nature Conservancy
SAVING THE LAST GREAT PLACES ON EARTH

Nature Conservancy Canada

Conservation de la Nature Canada

Washington Department of Fish and Wildlife

Willamette Valley–Puget Trough–Georgia Basin

ECOREGIONAL ASSESSMENT

Citation:

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It is four and one-half years since the Charter Agreement of the Willamette Valley-Puget Trough-Georgia Basin ecoregion was completed, initiating a process to produce a biodiversity conservation assessment for the ecoregion. During that time, literally hundreds of individuals have helped, with many working long and hard, to develop a document and set of tools to assist in the conservation of this remarkable ecoregion's species, natural communities, and systems. This assessment is the result of those efforts.

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Executive Summary

The report in your hands addresses a pressing need. It is a first approximation of the most important places for conserving native species and ecosystems in the most highly developed region of the Pacific Northwest: the fertile lowlands of Oregon's Willamette Valley, Washington's Puget Trough, British Columbia's Georgia Basin, and the nearshore marine waters of Puget Sound and the Strait of Georgia. These extraordinary places are all part of a common ecoregion and share similar climate, geology, history, landforms, and native species.

Resources for conservation in this ecoregion are limited, urban areas are expanding, and an extraordinary heritage of native species and ecosystems is at risk. This assessment is intended to help conservation agencies, planners and organizations direct their resources to the most important places for supporting the ecoregion's biodiversity. It describes a portfolio of priority conservation areas that are of exceptional biological value and are the most likely places for conservation to succeed based on their current condition, land use and other factors.

Assessment Methods

The Nature Conservancy, the Nature Conservancy of Canada, and the Washington Department of Fish and Wildlife are the primary partners in this assessment. The Oregon State Natural Heritage Information Center, the Natural Heritage and Nearshore Habitat programs of the Washington Department of Natural Resources, and the British Columbia Conservation Data Centre are major contributors of technical expertise and data. We also benefited from the participation of many other scientists and conservation experts as team members and expert reviewers.

Five expert technical teams collaborated on a series of analyses based on methods developed by The Nature Conservancy and other scientists. Three teams covered the terrestrial environment's plants, animals and ecological systems. A fourth assessed the nearshore marine environment within the Puget Sound and Georgia Strait. A fifth team studied the ecoregion's freshwater systems.

Salmon were not addressed in this assessment. Government and other organizations are developing salmon conservation strategies based on analyses which this assessment cannot replace. However, this report should provide a helpful context for those planning for the conservation of salmon or any other focal group.

Each team began by selecting the species, communities and ecological systems that would serve as the conservation targets, i.e., the elements biodiversity that should be included in priority conservation areas. This resulted in the selection of 833 targets, including 422 terrestrial species targets, 68 nearshore marine species targets, 36 freshwater species targets, 90 rare plant community types and 217 coarse filter system targets. These system targets are the major habitat types that make up the terrestrial, freshwater and nearshore marine environments. They are used as targets based on the hypothesis that by ensuring their full representation in the portfolio, the majority of species in the ecoregion—including the vast number of poorly studied or unknown species—will also be included. In this way the coarse filter system targets serve as a substitute or surrogate in the face of inadequate data for many species.

For each of these 833 targets, all available records of location and status in the ecoregion were gathered and reviewed. Goals were then set for each target to serve as instructions or benchmarks for the identification of the portfolio of priority conservation areas. These goals described how many populations (for species targets) or how much area (for system targets) the portfolio should include to represent each target, and how those target occurrences should be distributed across the ecoregion to ensure good representation of genetic diversity and hedge against local extirpations.

A computer program, SITES, was used to select the optimal portfolio of sites, i.e., that set of sites which met the goals for the most targets at the lowest cost. Cost was minimized by selecting the most compact set of sites in areas rated as most suitable for long-term conservation. Suitability was described by an index, that was developed by the team, of existing land use and impacts. The SITES program then compared each part of the ecoregion against all others and analyzed millions of possible portfolios to select the most efficient alternative.

The technical teams then worked with the SITES program results to refine the portfolio. The work of the terrestrial, nearshore marine and freshwater teams was combined. The terrestrial portfolio became the foundation of the combined portfolio. Marine sites were added, with an emphasis on capturing those places where high-priority terrestrial and marine areas are ecologically connected. Because the freshwater analysis completed to date is in a preliminary state, freshwater results were used only where they clearly added to a defined terrestrial or marine site, again seeking to capture those places where these systems are ecologically connected.

Results

The final portfolio includes 372 priority conservation areas with a combined area of 1,264,000 hectares (ha) (3,122,080 acres [ac]), representing 23 percent of the ecoregion's total area. Thirty-nine shoreline segments totaling 89 kilometers (km) (55 miles [mi]) are also included. The portfolio includes the last places where many of the ecoregion's most imperiled species occur and the last, large expanses of relatively intact natural habitat. The sites included here are those regarded as having the highest likelihood of successful conservation according to the suitability factors utilized in the assessment.

Eighty percent of the land in this portfolio is privately owned. A wide range of federal, tribal, state, provincial and local government lands make up the remainder. The state of Washington is the largest landowner among these, with 92,000 ha (227,240 ac). Less than 1% is owned by non-profit conservation groups such as The Nature Conservancy. Approximately 6% of this portfolio lies within areas already designated for biodiversity conservation. A large proportion of the portfolio is currently managed for timber production. Ownership was not summarized for nearshore marine sites.

While conservation of these priority areas is vitally important for the biodiversity of this ecoregion, the portfolio is not sufficient to sustain all the native species that survive in the ecoregion today. First, it does not include full treatment of freshwater species and ecosystems, and its marine analysis does not include deepwater environments. Second, over half the targets selected for this assessment have been reduced to such small remnants that their long term survival in this ecoregion may be in question. In some cases, this reflects an incomplete survey of the ecoregion, but for the vast majority, it reflects the widespread loss of historic habitat and the highly altered nature of that which remains.

Using the Assessment

The Willamette Valley-Puget Trough-Georgia Basin Ecoregional Assessment is a resource for planners and others interested in the status or conservation of the biological diversity of this ecoregion. This assessment has no regulatory authority; it is simply a guide for prioritizing work on the conservation of habitats that support the ecoregion's extraordinary biological diversity.

We encourage users of this assessment to treat it as a first approximation, and to share any suggestions for improvement of future editions with the authors. The authors will review the use of the assessment and feedback received from users to determine the timing and focus of future editions.

Users are advised to be aware of the large scale at which this assessment was prepared. The portfolio does not include some sites that are locally significant for biodiversity conservation, such as small wetlands and small, high-quality patches of common habitat types. Mapped site boundaries are approximate and may include areas that are unsuitable for conservation mixed in with highly suitable areas. We expect that local planners equipped with more complete information and higher resolution data will develop refined boundaries for these sites.

There are large gaps in our knowledge of nature and these are reflected in this assessment. In particular, the marine and freshwater elements of this assessment do not provide a full picture of conservation priorities in these environments.

The assessment report and the final product data behind it are available to all interested parties. The assessment provides information for decision-makers who wish to ensure a future for the natural systems and species that have attracted us here and that will be treasured by those who follow. The Nature Conservancy, the Nature Conservancy of Canada, and the Washington Department of Fish and Wildlife will use its results and those of similar assessments for other northwest ecoregions to guide their prioritization of projects and funding. Governments, land trusts, and others are encouraged to use the assessment as a supplementary resource to other planning information.

As home to nearly three-quarters of the people of British Columbia, Washington, and Oregon, the Willamette Valley-Puget Trough-Georgia Basin ecoregion has given so much to our history and is especially critical to our future. Its natural richness is the foundation for our growth.

Chapter 1 – Introduction

Throughout the world, the ever-increasing demands on natural resources require conservation programs to set priorities. Society faces the critical challenge of choosing priority conservation areas that will conserve our natural heritage while creating the fewest conflicts with the legitimate use of natural resources.

The purpose of this ecoregional assessment is to identify priority areas for conserving the biodiversity of the Willamette Valley-Puget Trough-Georgia Basin ecoregion. This assessment is a guide for planners and decision-makers, and has no regulatory authority. It should be treated as a first approximation, and the gaps and limitations described herein must be taken into consideration by its users. We have attempted to conduct this work in a manner that is transparent and accessible to a wide range of users. This work was conducted with the expectation that it will be improved upon as the state of scientific knowledge improves, methods are further refined, and other conditions change.

The Willamette Valley-Puget Trough-Georgia Basin Ecoregional Assessment is the product of a partnership initiated in 1998 to identify priority conservation areas in this ecoregion. The Nature Conservancy (the Conservancy or TNC), the Nature Conservancy of Canada (NCC), and the Washington Department of Fish and Wildlife (WDFW) are the primary partners in this project. The Oregon Natural Heritage Information Center (ONHIC), the Natural Heritage Program (WNHP) and Nearshore Habitat Program of the Washington Department of Natural Resources (WDNR), and the British Columbia Conservation Data Centre (CDC) were major contributors of technical expertise and data. The project has also benefited from the participation of many other scientists and conservation experts as team members and reviewers.

This assessment uses an approach developed by the Conservancy (Groves et al. 2000, Groves et al. 2002) and other scientists to establish conservation priorities within the natural boundaries of ecoregions, or regional landscapes defined by their distinct climate, geology, landforms, and native species (Bailey 1994). Similar first iteration or first edition assessments have been completed for over 45 of the 81 ecoregions in the U.S., and for several others outside the U.S, with the objective of completing assessments throughout the U.S. (and in many parts of Canada and other countries) by 2008. The Nature Conservancy is leading a number of these assessments, while others are led by partner organizations or agencies using the same basic methodology.

The following topics are discussed in this chapter:

1.1 Description of the Ecoregion

The Willamette Valley-Puget Trough-Georgia Basin ecoregion is a long ribbon of broad valley lowlands and inland sea flanked by the rugged Cascade and coastal mountain ranges of British Columbia, Washington, and Oregon (See Map 1.2). It encompasses some 5,550,000 ha (13, 715,581 ac or 21,431 square miles (sq. mi.)) of Pacific inlet, coastal lowlands, islands, and intermontane lowland, and extends from the Sunshine Coast and eastern lowland of Vancouver Island along Georgia Strait, south through Puget Sound and the extensive plains and river floodplains in the Willamette Valley. Although the ecoregion's elevation (land portion) averages 445 feet (maximum 4,203 feet), the effect of the adjacent mountains, ocean intrusions, and glaciation in the region's northern two-thirds have caused dramatic localized differences in climate, soils, and geology. From distinctive combinations of these factors spring an array of ecological communities ranging from coniferous forests to open prairies, rocky balds, and oak savannas. The marine and estuarine environments of British Columbia and Washington add even greater diversity of communities and species. The ecoregion contains over 10,000 miles of streams and rivers, including the middle reaches of a number of major (third order or larger) rivers whose headwaters lie in the mountains of adjacent ecoregions.

Ninety percent of the terrestrial portion of the ecoregion is either private or tribal land. Nearly three-quarters of the populations of British Columbia, Washington, and Oregon live within this ecoregion. Human development of the ecoregion has been rapid since the 1850s and continues today, with a 62% growth in population from 1950-2000 and a 16% growth in the past 10 years (U.S. Census Bureau 2000; StatCan 2002; Risser et al. 2000). Habitat conversion for human uses has been widespread, reflecting the accessibility, rich natural resources, and economic potential of virtually the entire ecoregion. Today, over 40% of the ecoregion has been converted to urban or tilled agricultural uses, and most of the remainder is in production forestry, making this the most highly developed of the Pacific Northwest ecoregions

For purposes of this assessment, the ecoregion was divided into four sections, from north to south: the Georgia Basin, Puget Trough, Lower Columbia, and Willamette Valley. For further details describing this ecoregion, see Appendix 3.

1.2 Overview of the Ecoregional Assessment Process

Five technical teams of scientists and conservation specialists followed a planning framework called ecoregional conservation planning or ecoregional assessment (Groves et al. 2000, Groves et al. 2002). The teams included a terrestrial communities team, a plant species team, an animal species team, a freshwater team, and a marine team. All the technical teams were coordinated and directed by an oversight group called the core team, made up of technical team leads and other scientists and conservation professionals from British Columbia, Washington, and Oregon. Staff from The Nature Conservancy in Washington led data compilation, analysis, and portfolio development for terrestrial, marine, and freshwater conservation targets. (See the Acknowledgements section at the beginning of this report for the list of team members and their affiliations.)

Each technical team contributed to each of the following steps described below, and adopted innovations where necessary to address specific data limitations and other challenges. Chapters 2-5 describe in detail the methods used by each team.

1. **Identify conservation targets**- Conservation targets are those elements of biodiversity—plants, animals, plant communities, habitat types, etc.,—that are included in the analysis. Targets were selected to represent the full range of biodiversity in the ecoregion and to include any elements of special concern.

   Robert Jenkins, working for The Nature Conservancy in the 1970s, developed the concept of coarse filter and fine filter conservation targets for use in conservation planning (Jenkins 1996, Noss 1987). This approach hypothesizes that conservation of multiple, viable examples of all communities and ecological systems (coarse filter targets) will also conserve the majority of species that occupy them. This coarse filter strategy is a way to compensate for the lack of detailed information on the vast number of poorly studied invertebrates and other species.

   Fine filter targets are those species or imperiled natural communities which cannot be assumed to be captured by coarse filter targets. Fine filter targets warrant a special effort to ensure they are represented in the conservation assessment. These are typically rare or imperiled species or natural community types, but can include wide-ranging species that require special analysis, or species that occur in other ecoregions but have genetically important disjunct populations in the subject ecoregion of importance from a conservation standpoint.

   As we describe in this report, identifying targets is not always a simple matter. In the marine and freshwater realms especially, the lack of information on species and ecosystems forced our team to develop new habitat or coarse filter classification systems in order to define targets, and to do this assessment with very few fine filter or species targets.

2. **Assemble information on the locations or "occurrences" of targets**- Data are assembled on target occurrences (e.g. the location, and in some cases, aerial extent of a separate population or example of a species or community) from a variety of sources. Although existing agency databases make up the bulk of this data set, the teams often filled in data gaps by gathering information and consulting specialists for specific target groups.

3. **Determine how to represent and rank target occurrences**- Decisions are made regarding the best way to describe and map occurrences of each target. Targets may be represented as points for specific locations, such as rare plant population locations, or polygons to show the areal extent of fine or coarse filter targets. In addition, the ecological health or quality of each occurrence is ranked where possible using the NatureServe element occurrence ranking system (NatureServe and The Nature Conservancy 2000). The data are stored in a Geographical Information System (GIS).

4. **Set goals for each target-** The analytical tool used for ecoregional assessments requires goals for how many occurrences or how much habitat area must be conserved to sustain each target over time. These goals are used to drive the next step of the process: selection of a portfolio of conservation areas. In reality, very few targets are sufficiently understood to allow scientists to estimate with a high degree of confidence the number and distribution of occurrences that will be sufficient to ensure survival.

   It is essential that users of this assessment recognize this limitation. The goals cannot be treated as defined conditions that ensure long-term survival of species. However, they are important and useful tools for assembling a portfolio of conservation areas that captures multiple examples of the ecoregion's biodiversity. These goals also provide a metric for gauging the contribution of different portions of the ecoregion to the conservation of its biodiversity, and the progress of conservation in the ecoregion over time. The details of each team's work to set goals are laid out in chapters 2-4.

5. **Rate the suitability of each part of the ecoregion for conservation-** The ecoregion was divided into standard hexagonal, 750-ha assessment units (described in 2.4.1 of Chapter 2 and shown in Map 1.1). Each of these units was compared to the others using a set of factors the team selected to determine that unit's suitability for conservation or the likelihood of conservation success. These include factors likely to impact the quality of the habitat for native species, such as the extent of roads or developed areas, or the presence of dams in rivers, as well as factors likely to impact the cost of managing the area for conservation, such as proximity to urban areas, the percent of public versus private lands, or the existence of established conservation areas. In this way, a suitability index was developed.

   It is important to note that the factors chosen for this suitability index strongly influence the final selection of conservation areas, i.e., a different set of factors can result in a different portfolio. Also, some factors in the suitability index require consideration of what are traditionally policy questions. For example, setting the index to favor the selection of public over private land presumes a policy of using existing public lands to meet goals wherever possible, thereby minimizing the involvement of private or tribal lands. The suitability index factors chosen for this assessment are clearly documented in this report. Chapter 6 includes a Sensitivity

Analysis for the terrestrial portfolio that illustrates how changes in goals or the suitability index shape the final portfolio.

6. **Assemble the draft portfolio-** An ecoregional assessment entails hundreds of different targets existing at thousands of locations. The relative biodiversity value and relative conservation suitability of thousands of potential conservation areas must be evaluated. This complexity precludes simple inspection by experts to arrive at the most efficient and complimentary set of conservation areas. We chose to use an optimal site selection algorithm known as SITES (Andelman et al. 1999). Developed for The Nature Conservancy by the National Center for Ecological Analysis and Synthesis, SITES is computer software that aids scientists in identifying an efficient set of conservation areas. It uses a computational algorithm developed at the University of Adelaide, Australia (Possingham et al. 2000).

   To use SITES, we input data describing the biodiversity value and the conservation suitability for each of the thousands of hexagonal assessment units in the ecoregion. The type of targets, total number of targets, condition of targets, and conservation status of targets present at a particular place determines the biodiversity value of that assessment unit. Conservation suitability is input as a suitability index (described above) representing a set of weighted factors the team has chosen to represent the relative likelihood of successful conservation at a unit. The relative weighting of each of these factors is determined by the scientists conducting the assessment.

   SITES strives to minimize an objective function (Appendix 4). It begins by selecting a random set of hexagons, i.e., a random conservation portfolio. SITES then iteratively explores improvements to this random portfolio by randomly adding or removing hexagons. At each iteration, the new portfolio is compared with the previous portfolio and the better one is accepted. The algorithm uses a method called simulated annealing (Kirkpatrick et al. 1983) to reject sub-optimal portfolios, thus greatly increasing the chances of converging on the most efficient portfolio. Typically, the algorithm is run for 1 to 2 million iterations.

   SITES is a decision support tool. It cannot generate the ultimate conservation portfolio. Expert review and revision are necessary to compensate for gaps in the input data or other limitations of this automated part of the portfolio development process.

7. **Refine the portfolio through expert review-** The assessment teams and additional outside experts review the draft portfolio to correct errors of omission or inclusion by the computer-driven site selection process. These experts also assist the teams with refining individual site boundaries. The terrestrial, freshwater, and marine portfolios are then integrated into a single, final portfolio. This integrated portfolio is in turn subjected to additional expert refinement to produce the final portfolio.

1.2.1 The Challenge of Integrating Terrestrial, Freshwater, and Marine Analyses

The Willamette Valley-Puget Trough-Georgia Basin team set out to conduct an integrated assessment of the ecoregion's terrestrial, freshwater, and marine environments so far as the existing data would allow. This is one of the first ecoregional assessments that attempted such an integration. The results described here show great progress toward this goal. Full, balanced integration was not achieved however, and users of this assessment should understand how the team addressed the challenges inherent in the integration task.

The chief challenge is the imbalance of biodiversity data between environments. Terrestrial species and habitats are more fully documented than either marine or freshwater biodiversity in terms of their identification, location and relative condition. A major limitation on the marine assessment, for example, was the lack of comprehensive data for benthic habitats and other physical parameters in the offshore environment. This limited the marine analyses to the nearshore and a few shoal areas away from the coast for which data were available. Within the nearshore, data on fine filter (e.g., species) target occurrences and on habitat condition is lacking when compared to the terrestrial analysis. The resulting marine portfolio should be regarded as a representative sample of nearshore and shoreline habitats that provide a good starting point for field verification of habitat condition and other attributes that will determine which sites are higher priorities for conservation. The full marine portfolio was included in the integrated portfolio, but many of these sites require more field verification than the portfolio's terrestrial sites.

The freshwater analysis, meanwhile, faced similar limitations on species-level data outside of salmonids. In addition, the freshwater analysis could not be conducted within the boundaries of the terrestrially derived Willamette Valley-Puget Trough-Georgia Basin ecoregion; freshwater biodiversity is better represented within watersheds. It required analysis of the six watershed-based ecological drainage units that intersect the terrestrial ecoregion, as described in Chapter 3. The analysis was based primarily on comprehensive mapping of coarse filter freshwater systems and macrohabitats. We regard this work as a vital foundation for more refined freshwater conservation assessment across these six ecological drainage units.

Chapters 2-4 describe in detail the methods used in the independent terrestrial, freshwater, and marine biodiversity analyses. Chapter 5 describes the process of integrating these assessments into a single portfolio. That portfolio was built primarily around the terrestrial analysis because of its more comprehensive and data-rich treatment. The full representative portfolio of nearshore and shoreline sites developed by the marine team was also included. Only a portion of the freshwater analysis, however, was incorporated in the integrated portfolio. Specifically, where priority terrestrial sites overlapped with freshwater targets, these sites were configured to incorporate the associated freshwater attributes. No sites were included solely on the basis of freshwater biodiversity because further work is needed to refine the draft freshwater portfolios produced in this project. Users should be aware that the resulting, integrated portfolio does not serve as a comprehensive set of priority conservation areas for freshwater biodiversity.

Another challenge is salmon. Salmon are considered critical components (i.e., keystone species) in the freshwater ecological systems of this ecoregion. Salmon have a complex life history that requires connectivity between marine waters and upper stream reaches. Even though many stocks are judged to be in poor health, the species remain widespread in the ecoregion. All salmon species in the ecoregion are economically and culturally important, and a number of them are considered imperiled by state, provincial, tribal, and federal governments. These governments, non-governmental organizations and academic institutions are spending vast resources to address the issue of salmonid conservation in the ecoregion. Furthermore, government agencies within the U.S. with legal jurisdiction for salmonids are currently developing recovery plans. A similar process is underway in British Columbia. Recognizing the complexities, both ecologically and politically, of identifying priorities for salmonids, we chose not to address them as explicit conservation targets in this assessment. We are currently coordinating with our partners to determine how best to apply our ecoregional methodology to the issue of salmonid conservation in future assessments. In the meantime, this assessment should provide helpful information for those planning for salmon conservation, as well as other focal groups. For example, salmon planners can use this assessment to determine how any area identified as a priority site for salmon contributes to the larger biodiversity of the ecoregion.

1.2.2 Strengths and Limitations of This Assessment

The Willamette Valley-Puget Trough-Georgia Basin Ecoregional Assessment is a resource for planners and others interested in the status or conservation of the biological diversity of this area. This assessment improves on the informational resources previously available in several ways:

- The assessment was conducted at an ecoregional scale. It provides information for decisions and activities that occur at an ecoregional scale, such as establishing regional priorities for conservation action, coordinating programs for species or habitats that cross state, county, or other political boundaries, judging the regional importance of any particular site in the ecoregion, and measuring progress in protecting the full biodiversity of the ecoregion.

- This assessment has been designed to form the baseline for an ongoing, steadily improving ecoregional conservation effort. This first iteration or first edition assessment of the Willamette Valley-Puget Trough-Georgia Basin provides an estimate of what long-term success might look like for conserving this ecoregion's biodiversity. It quantifies the biodiversity of the ecoregion, tells us which areas contribute the most towards conservation of existing biodiversity, and which gaps in our knowledge must be filled in order to strengthen the assessment in its next edition. It provides a system to measure conservation progress over time as we continue to improve our understanding of the ecosystems and species we hope to conserve.

At the same time, it is important to recognize what this assessment is not intended to provide, and identify several important limitations on this work. In addition to those already described, users should be mindful of the following:

- This assessment has no regulatory authority. It is simply a guide to help inform conservation decision-making across the ecoregion. The portfolio is intrinsically flexible. The sites described are approximate, and often large and complex enough to require a wide range of resource management approaches. Ultimately, the exact siting and management of any priority conservation area will be based on the policies, values, and decisions of the affected landowners, governments, and other community members.

- This assessment should be treated as a first approximation. It is more complete for some species or ecological systems than for others, reflecting the variable state of knowledge of the natural world. Generally speaking, terrestrial biodiversity is more adequately represented than that of freshwater and marine systems. The boundaries ascribed to portfolio sites are approximate (developed at the 1:100,000 scale), and should be used only as a rough starting point for the detailed site-level planning necessary to support local land-use decisions.

- The priority conservation areas described in this assessment are not all intended to become parks or nature reserves set aside from economic activity. While some areas may warrant such protection, many will accommodate multiple uses as determined by landowners, local communities, and appropriate agencies.

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

- This assessment does not describe all the important natural places in the ecoregion. Many places outside of the ecoregional conservation portfolio described here are important for natural beauty, environmental education, general ecosystem function and conservation of local biodiversity. These include many small wetlands, small patches of natural habitat, and other important parts of our natural landscape. They should be managed to support their own special values.

- The portfolio of sites presented here should not be used as the sole guide for siting restoration projects. These priority sites include high-quality habitat that must be maintained as well as lower-quality habitat that will require restoration. These form a 'core' of important habitats where restoration is needed. Additional sites may also be needed to rebuild habitat for species, improve water quality, and meet other community objectives.

By completing this first edition, we have learned how to make subsequent editions stronger. These and other issues of strengths and limitations are described in further detail in subsequent chapters.

Chapter 2 – Terrestrial Systems and Species

This chapter describes the ecoregional assessment results for the plant communities, plant species, and animal species in the terrestrial environment and the processes used by the assessment teams for producing them. The chapter also describes the process of combining and refining these results to create a terrestrial portfolio.

Topics described in this chapter include the following:

Technical Teams

Three teams were involved in developing the terrestrial portfolio:

- A plant community team (section 2.1)
- A plant species team (section 2.2)
- An animals team (section 2.3)

The reports of each team are presented separately.

2.1 Identifying Plant Community and Ecological System Conservation Targets

2.1.1 Technical Team

The terrestrial plant communities and ecological systems team was composed of experts from The Nature Conservancy (TNC), the Washington Natural Heritage Program (WNHP), the

British Columbia Conservation Data Centre (CDC), and the Oregon Natural Heritage Information Center (ONHIC). The team consisted of the following people:

Chris Chappell, team leader	WNHP, DNR, Olympia, WA
Ed Alverson	TNC, Eugene, OR
Adolf Ceska	British Columbia CDC, Ministry of Environment, Lands & Parks, Victoria, BC
John Christy	ONHIC, Oregon State University, Portland, OR
Pat Comer	TNC (now with NatureServe), Boulder, CO

2.1.2 Selecting Coarse Filter Targets

Plant communities can be defined using a variety of scales. For this assessment, we used plant associations which are generally the finest scale defined in a classification system, and a more generalized categorization of communities we refer to as ecological systems. These associations and systems are referred to as terrestrial coarse filter conservation targets. A plant association is "a recurring plant community with a characteristic range in species composition, specific diagnostic species, and a defined range in habitat conditions and physiognomy or structure" (Jennings et al. 2002). The National Vegetation Classification (Anderson et al. 1998, Grossman et al. 1998, and as updated at www.natureserve.org/explorer) provides a relatively comprehensive classification of plant associations for the ecoregion. We used these plant associations to help define a set of ecological systems for the ecoregion.

Plant Association Targets

The technical team compared and resolved differences i.e., crosswalked in published plant association classifications across Oregon and Washington and in previously undescribed associations to the National Vegetation Classification. A group of British Columbia ecologists developed a plant association list for the British Columbia portion of the ecoregion.

A total of 204 terrestrial and wetland plant associations were identified within the ecoregion and assigned updated global heritage status ranks (G Ranks; see Table 2.1 for definitions). The sectional distribution, landscape pattern, and distribution pattern of plant associations in relation to the ecoregion were also determined (Appendix 5).

Out of the 204 total plant associations in the ecoregion, we selected all 75 globally imperiled or critically imperiled associations (26 G1, 5 G1G2, 36 G2, 8 G2G3) as conservation targets. Globally imperiled plant associations tend to occur either in extremely specific geographical or ecological settings (i.e., they are naturally rare due to restricted habitat), or, in the existing landscape, they consist of relatively few or small occurrences because of habitat loss. Therefore, they need specific attention to ensure inclusion in the portfolio. Fifteen locally vulnerable associations endemic to the ecoregion were also included as conservation targets.

TABLE 2.1 Global Heritage Status Ranks

RANK	DEFINITION
G1	Critically Imperiled: Critically imperiled globally because of extreme rarity or because of some factor(s) making it especially vulnerable to extinction. Typically 5 or fewer occurrences or very few remaining individuals (<1,000) or acres (<2,000) or linear miles (<10).
G2	Imperiled: Imperiled globally because of rarity or because of some factor(s) making it very vulnerable to extinction or elimination. Typically 6 to 20 occurrences or few remaining individuals (1,000 to 3,000) or acres (2,000 to 10,000) or linear miles (10 to 50).
G3	Vulnerable: Vulnerable globally either because very rare and local throughout its range, found only in a restricted range, or because of other facets making it vulnerable to extinction or elimination. Typically 21-100 occurrences or between 3,000 and 10,000 individuals.
G4	Apparently Secure: Uncommon but not rare (although it may be rare in parts of its range) but possibly cause for long-term concern. Typically more than 100 occurrences and more than 10,000 individuals.
G5	Secure: Common, widespread, and abundant (although it may be rare in parts of its range, particularly on the periphery). Not vulnerable in most of its range. Typically with considerably more than 100 occurrences and more than 10,000 individuals.
GX	Presumed Extinct (species): Believed to be extinct throughout its range. Not located despite intensive searches of historical sites and other appropriate habitat, and virtually no likelihood that it will be rediscovered (ecological communities). Eliminated throughout its range, with no restoration potential due to extinction of dominant or characteristic species.

Ecological Systems

The team grouped the 204 plant associations for this ecoregion into 19 terrestrial ecological systems based on existing knowledge of characteristic spatial patterns, the environmental setting, and driving ecological processes for the plant associations. There was not a one-to-one correspondence between plant associations and ecological systems. For example, while the majority of upland plant associations occur in only one ecological system, many of the riparian and wetland plant associations belong to more than one system.

The ecological systems were identified as conservation targets to serve as surrogates for the more common plant associations. Appendix 7 describes each of the ecological systems. Table 2.2 lists these terrestrial ecological systems, their characteristic spatial patterns, number of plant associations occurring within each, and their distribution by section within the Willamette Valley-Puget Trough-Georgia Basin ecoregion. Spatial patterns are defined in Table 2.3. Map 2.1 shows the major terrestrial systems that cover large areas in the ecoregion.

TABLE 2.2 WPG Ecoregion Terrestrial Ecological Systems

ECOLOGICAL SYSTEM	SPATIAL PATTERN*	NUMBER OF PLANT ASSOCIATIONS	DISTRIBUTION			
			WILLAMETTE VALLEY	LOWER COLUMBIA	PUGET TROUGH	GEORGIA BASIN
Intertidal Salt Marshes	Small Patch	16			X	X
Coastal Spits, Dunes, and Strand	Linear	4			X	X
Depressional Wetland Shrublands	Small Patch	9	X	X	X	X
Depressional Wetland Broadleaf Forests	Small Patch	11	X	X	X	X
Coniferous Forested Wetlands	Small Patch	3	H	X	X	X
Tidally Influenced Freshwater Wetlands	Small Patch/Linear	10		X	X	X
Riparian Forests and Shrublands	Linear	44	X	X	X	X
Freshwater Marshes	Small Patch	22	X	X	X	X
Freshwater Aquatic Beds	Small Patch	16	X	X	X	X
Autumnal Freshwater Mudflats	Small Patch	7	X	X	?	?
Sphagnum Bogs and Fens	Small Patch	22	X	X	X	X
Wet Prairies	Large Patch	11	X	X	H	

TABLE 2.2 (Cont'd.) WPG Ecoregion Terrestrial Ecological Systems

ECOLOGICAL SYSTEM	SPATIAL PATTERN*	NUMBER OF PLANT ASSOCIATIONS	DISTRIBUTION WILLAMETTE VALLEY	LOWER COLUMBIA	PUGET TROUGH	GEORGIA BASIN
Vernal Pools	Small Patch	5	X	?		X
Upland Prairies and Savannas	Large Patch	6	X	X	X	H
Herbaceous Balds and Bluffs	Small Patch	7	X	X	X	X
Northern Oak Woodlands	Small Patch	7		X	X	X
Willamette Oak Woodlands	Large Patch	6	X			
Dry Evergreen Forests and Woodlands	Small/Large Patch	12	X	X	X	X
Douglas-fir–Western Hemlock–Western Red Cedar Forests	Matrix/Large Patch	13	X	X	X	X
Shrub Barrens	Large Patch	Extirpated?	H	H	H	
Silver Fir–Western Hemlock Forests		Not a target				X

Key:
*Spatial Pattern, see Table 2.3 for definitions.
X = Known, extant occurrences with EO ranks of fair/good
H = Historically known, may be extirpated, or very few poor/fair –ranked EOs known
? = Suspected to occur, but undocumented

TABLE 2.3 Spatial Patterns Used to Describe Ecological Systems and Plant Associations (modified slightly from Anderson et al. 1999).

SPATIAL PATTERN	DEFINITION	TYPICAL RANGE OF OCCURRENCES
Matrix	Communities or systems that form extensive and contiguous cover, occur on the most extensive landforms, and typically have relatively wide ecological tolerances.	2,000 - 500,000 ha.
Large Patch	Communities or systems that form large areas of interrupted cover. Typically not limited by localized environmental features. Disturbance regimes and successional processes are typically important in the formation and maintenance of these systems or communities.	50-2,000 ha.
Small Patch	Communities or systems that form small, discrete areas of vegetation cover typically limited in distribution by localized environmental features.	1-50 ha.
Linear	Communities or systems that occur as linear strips and are often ecotonal between terrestrial and aquatic systems.	NA

Two ecological systems found in the ecoregion were not included as conservation targets: a single example of mid-montane forest, characterized by Abies amabilis (Pacific silver fir), and a dry shrubland type with scattered trees. The mid-montane forest ecological system was considered peripheral and more abundant in the adjacent Northwest Coast ecoregion. The dry shrubland, or "Shrub Barrens", was considered functionally extirpated in the ecoregion. Shrub-dominated communities with scattered Douglas-fir or oak trees are documented from pre-settlement times and once covered substantial areas of the Willamette Valley. This type of dry shrubland often occurred between areas of prairie or savanna and areas of conifer forest. A few tiny remnants occur in urban areas, and there are some tree plantations in the Puget Trough section that appear to have similarities to this system. The Shrub Barrens was probably maintained by a particular fire frequency. This system could be recognized in the future as a conservation target if restorable occurrences are identified.

2.1.3 Collecting Plant Association and Ecological Systems Data

The available information on the distribution of known occurrences of individual plant communities and ecological systems varied considerably in quantity and quality both among associations and ecological systems and across jurisdictions. We combined the best available data from a number of sources.

Most of these data were obtained from the British Columbia Conservation Data Centre (CDC), Oregon Natural Heritage Information Center (ONHIC), and Washington Natural Heritage Program (WNHP) In addition, data were obtained from the U.S. Geologic Service (USGS), the U.S. Environmental Protection Agency (EPA), the U.S. Fish and Wildlife Service (USFWS), and individual experts.

Plant Associations

Plant association occurrence data were obtained from the Heritage and Conservation Data Centre's plant association occurrence records, site basic records, and specialized data sets such as the British Columbia Sensitive Ecosystems Inventory database. The Heritage Programs and Conservation Data Center map separate examples or occurrences generated from field inventories. Heritage Programs and Conservation Data Center have minimum ecological integrity standards for occurrences (see Table 2.4 and Appendix 8). Ecological integrity is an integrated measure of ecological condition, size, and landscape context.

Plant association occurrence information was extensive for Washington and British Columbia and largely absent from Oregon. Data were primarily available for particularly high-integrity occurrences and particularly imperiled associations. Data on depressional wetlands and bogs, late-successional forests, grasslands, and oak woodlands were well represented, while data on riparian communities and large second-growth forest occurrences were poorly represented. Each plant association occurrence record was assigned to an ecological system. To supplement the above-described plant association occurrence data, the team collected additional occurrence data from botanical and ecological experts using a standard format (Appendix 6). These occurrences were either included as plant association occurrences or as ecological systems occurrences depending on the specificity of the information. This was especially important in Oregon where we had little data on plant association occurrences.

Ecological Systems

An ecological systems layer was created by overlaying a combination of existing land cover and vegetation data layers along with a biophysical model developed for the ecoregion (Appendix 9). The base layer land cover data for this effort came from four sources: the Land Use/Land Cover layer updated by Pacific Meridian in 1999 for the USGS (used for Washington and the Lower Columbia section of Oregon); a British Columbia land use/land cover layer provided by the CDC; and a vegetation data layer provided by ONHIC (used for the Willamette Valley section).

Additional vegetation layers covering smaller geographic areas or a subset of the ecological systems were integrated into these base layers. For example, the Oregon Natural Heritage Information Center supplied a map of wetland and riparian ecological systems developed by Titus et al. (1996) covering portions of the ecoregion in Oregon. In addition, WNHP provided the Puget Lowland Oak and Grassland Layer (Chappell et al. 1999). This layer was easily crosswalked to the ecological systems classification. It is based on aerial photo review in combination with extensive ground truthing of oak woodlands and grasslands in the ecoregion within Washington. Also, the CDC provided the British Columbia Sensitive Ecosystems Inventory (SEI) and the Fraser Wetlands Inventory (described by Ward et al. 1992). Both are geographic databases developed by Environment Canada, the British Columbia Ministry of Sustainable Resource Management and Ministry of Water, Land and Air Protection (as described in Ward et al. 1998). The SEI database was derived from detailed aerial photo review combined with ground truthing. The inventory covers Vancouver Island, the Gulf Islands, Bowen, and Gambier Islands. The data describe the extent of existing natural vegetation/ecosystem types similar to the ecological systems defined by the technical team. The Fraser Wetland Inventory is an integrated set of spatial data of wetland systems in the Fraser Valley (Ward et al. 1992). The SEI ecosystems and Fraser wetland systems were easily crosswalked with our ecological systems.

For Oregon and Washington, we also included a subset of mapped wetlands from the National Wetlands Inventory (NWI) using methods of Cowardin et al. 1979 (http://www.nwi.fws.gov/index.html). The wetland types were crosswalked for a subset of the wetland systems where major data gaps existed. The crosswalk for some wetland types was problematic, because NWI does not distinguish wetlands in riparian landforms from those in other situations. For example, we removed small, isolated occurrences of ecological systems derived from modeled or LANDSAT data, e.g., National Wetlands Inventory.

We overlayed a land use/land cover layer from the Institute for a Sustainable Environment (1999) and a Willamette Valley Pre-Settlement Vegetation, (c. 1851) developed by the ONHIC and the Conservancy (Appendix 9) to improve the representation of oak woodlands in the Willamette Valley. Polygons mapped as oak woodland in the Willamette Valley Vegetation layer that were mapped as "conifer-dominated forest" in the land use/land cover layer or the historic vegetation layer were reclassified as dry evergreen forests.

We created a Washington Riparian Layer by intersecting natural vegetated cover types from the National Land Cover Data (version 02-22-2000) with 100-year floodplain maps to help represent riparian systems in Washington. The National Land Cover Data was produced as part of a cooperative project between the USGS and the EPA to provide a consistent, land cover data layer for the conterminous U.S. based on 30-meter Landsat thematic mapper data. The Floodplain maps were developed by the Federal Emergency Management Agency.

We developed a biophysical model of ecological land units (ELUs) depicting the abiotic variables influencing vegetation patterns using available spatial data on elevation, landform, and substrate characteristics and used it to refine the ecological systems layer. In particular, we used the ELU's to distinguish between the Douglas-fir–western hemlock–western red cedar forests and the dry evergreen forests and woodlands. It was particularly difficult to make this distinction in the southern portion of the ecoregion. The ELU was probably less effective at accurately representing the distinction between the two forests in the Willamette Valley section of the ecoregion perhaps as a result of the historical importance of fire in the Willamette Valley and its effect on landscape-level tree species distribution.

Our confidence in the ecological systems data relative to their application to this assessment varied as follows:

- **High:** British Columbia Sensitive Ecosystems Inventory, the Fraser Wetlands Inventory, the Puget Oak and Grassland Layer, and the Willamette Valley Wetlands Inventory. Each involved substantial field verification and the classification units were relatively similar to our ecological systems.

- **Moderate:** Willamette Valley Vegetation Layer, Washington Riparian Layer, the Willamette Valley Vegetation Layer, and the Washington Riparian Layer were not extensively ground-truthed. The Washington Riparian Layer misrepresented some areas as riparian systems that would be better classed as depressional wetlands, but generally appeared fairly accurate.

- **Low:** National Wetlands Inventory, because of the lack of a clear crosswalk between our ecological systems In spite of the low confidence, it was used because it was the only data source we had for certain systems in some sections of the ecoregion. Occurrences generated from NWI (see Appendix 8) within sites chosen for other features should be examined on the ground to verify the ecological systems present on site.

2.1.4 Target Representation and Ranking

Target Representation

As a framework for mapping all terrestrial targets, including ecological systems, the Core Team divided the ecoregion into 750-ha hexagon assessment units. (The selection of this type of assessment unit is further described in section 2.4.). Data for mapping target occurrences were assembled from various sources (as specified below), and occurrences were represented as points and/or polygons. For terrestrial portfolio selection, we represented most small patch ecological systems as points, and most large patch, linear, and matrix systems as both polygons (area-based) and points (see Appendix 8).

- **Autumnal Freshwater Mudflats, Wet Prairies, Vernal Pools, and Upland Prairies and Savannas:**

  ONHIC, WNHP, CDC, and expert interviews provided virtually all data for mapping these target occurrences.

For the remaining systems, we used a combination of known occurrence and expert interview data where available and data from one or more geographic information system layers to map target occurrences (Appendix 8). In representing some of our ecological systems with polygons, we chose to set minimum areas for each system and geographic section within a single hexagon. For a hexagon to show a polygonal area for a particular system, it had to meet the minimum area for that system and section. We defined minimum size standards for occurrences for each ecological system by section.

- **Riparian Forests and Shrublands:**

  Although roughly linear in nature, we represented this system with polygons for two reasons: First, much of their area has been converted to agriculture or development in this ecoregion. The added detail of polygonal depiction is warranted to capture as much information as possible. Second, there is considerable technical difficulty involved when trying to convert discontinuous polygon data into linear segments using inconsistent base linear features. In British Columbia, we used the SEI data; in Oregon, we used the Willamette Valley Wetlands and Riparian Inventory (Titus et al. 1996); and in Washington, we used the Washington Riparian Layer to represent the Riparian Forests and Shrublands system. The minimum area for this system was 10 ha/hexagon in all sections.

- **Douglas-fir–Western Hemlock–Western Redcedar Forests and Dry Evergreen Forests and Woodlands:**

  We used the ecological systems layer to represent polygons of these systems. We also used points to represent known occurrences with extensive young stands that have never been logged, or mature (>100 years) or old-growth stands, since such stands are rare in the ecoregion. Thus, some occurrences of these systems were represented by both area (polygonal data) and a point.

  For Douglas-fir–Western Hemlock–Western Redcedar Forests in the Georgia Basin, Puget Trough, and Lower Columbia sections, and for Dry Evergreen Forests and Woodlands in the Willamette Valley section, the minimum area was 60 ha/hexagon. For Douglas-fir–Western Hemlock–Western Redcedar Forests in the Willamette Valley section, and for Dry Evergreen Forests and Woodlands in the Georgia Basin, Puget Trough, and Lower Columbia sections, the minimum area was 20 ha/hexagon. Minimum areas vary by section because of landscape-scale differences in the distribution of these systems between the Willamette Valley section and the other sections.

♦ **Willamette Oak Woodlands:**

To represent this system, we overlaid a land use/land cover layer (Institute for a Sustainable Environment, University of Oregon, 1999) on the oak woodland polygons from the Willamette Valley Vegetation Layer. Any polygons that were mapped as "conifer-dominated forest" by the land use/land cover layer were removed from the Willamette Oak Woodlands system map because conifer-dominated forest is by definition not oak woodland (even when it includes some oaks). Thus, the probability that such polygons represented viable oak woodlands was low. We have moderate confidence in the accuracy of the resulting representation of Willamette Oak Woodlands because it is a layer that is largely derived from interpretation of satellite imagery that has not been ground-truthed.

♦ **Rare and Vulnerable Plant Associations:**

Known occurrences were documented on the ground by experts or NHP/CDC staff (as opposed to remotely sensed or modeled data) and converted to single points, with each mapped point representing one occurrence. Plant associations were represented by occurrences that met minimum standards for ecological integrity (see Table 2.4 and Appendix 8). Ecological integrity is an integrated measure of ecological condition, size, and landscape context. We represented all such occurrences as points.

♦ **Special case: Prairie Remnant Plant Communities as surrogate targets for declining plant species**

We know of many plant species that have declined based on habitat loss, but we did not identify them as targets per se. These species were represented by proxy through their associated communities. Prairie remnant plant communities were used by the plant technical team to track and capture many rapidly declining plant species populations, since prairie losses have exceeded 90% of historical levels.

Appendix 10 shows plant species with a high fidelity to native prairie and savanna communities. The diversity of prairie-dependent species at a site was used as one of several condition criteria for element occurrence (EO) ranking of occurrences of these systems.

Points were used in addition to polygons for all system types (including matrix and large) to represent higher integrity occurrences. However, points were most appropriate for all small-patch and those large-patch system types that are greatly reduced from historic extent (> 90% loss) and occupy relatively discrete, small areas. Because these types occupy small areas, and area is the least important ranking factor for small-patch occurrences, setting goals based on the area occupied is not warranted. Furthermore, polygonal data does not exist for target occurrences in some political jurisdictions. Using points, we could consistently map target occurrences across the ecoregion. For some systems, we converted polygons in base data layers (which were surrogates for occurrences based on modeled or remotely sensed data) to points using minimum sizes for each system (Appendix 8). In these situations, the polygons (or multiple points in one hexagon) were converted to one (surrogate occurrence) point for each hexagon containing one or more polygons meeting size criteria. For surrogate occurrences based on modeled data, we used one point per hexagon because: (1) it was difficult to apply element occurrence specifications and delineate occurrences based on separation distances and minimum sizes, where there were many polygons within one hexagon or where polygons spread across multiple hexagons, and (2) with modeled data we had no information on condition or landscape context and were not confident that the modeled system data met our minimum standards for ecological integrity.

Occurrence Ranking

The Heritage Programs and Conservation Data Centre rank plant association occurrences based on relative ecological integrity (Table 2.4). We used the same approach to rank the ecological integrity of new plant association and ecological systems occurrences we collected from other sources.

TABLE 2.4 Ranking factors and components used to assess ecological integrity of ecological systems and communities.

FACTOR	COMPONENT
Size	Area of occupancy (minimum dynamic area concept)
Condition	Development/maturity (stability, old-growth)
	Species composition and biological structure (richness, evenness of species distribution, presence of exotics)
	Abiotic physical/chemical factors (stability of substrate, physical structure, water quality) excluding processes
Landscape Context	Landscape structure and extent (pattern, connectivity, *e.g.*, measure of fragmentation/patchiness, measure of genetic connectivity)
	Condition of the surrounding landscape (*i.e.,* development/maturity, species composition and biological structure, ecological processes, abiotic physical/chemical factors)

We developed element occurrence rank specifications (EO Rank Specs) using standard NatureServe methodology (The Nature Conservancy and Association for Biodiversity Information, 1999) for all of our ecological systems (Appendix 11). To inform the rankings, we collected information from experts on size, condition, and landscape context of known occurrences. We also used the presence of plant species with a high fidelity to prairie and savanna plant associations (Appendix 10) as a criteria to rank the condition of these systems. We assigned a rank of K (unranked) to the majority of surrogates for occurrences of systems, generated by conversion of GIS layers to points, due to inadequate information necessary to rank them. Known occurrences had to be ranked at least C (fair) to be considered in portfolio selection, though D (poor) occurrences were retained in the data set.

2.1.5 Data Gaps

A number of ecological systems and many rare plant association targets were either underrepresented in our data sets or were potentially misrepresented to varying degrees by our data. Many of the data sets include information on occurrences not collected recently. In a rapidly changing ecoregion such as the WillametteValley-Puget Trough-Georgia Basin, occurrences documented in the past may no longer be in the same condition or even still present at all. For ecological system occurrences generated from remotely sensed data, it is difficult to assess condition or landscape context. Therefore, it is likely that some of the “occurrences” do not meet minimum element occurrence rank specifications for ecological integrity.

Coniferous Forests

Collectively, Douglas-fir–Western Hemlock–Western Redcedar Forests and Dry Evergreen Forests and Woodlands are depicted with acceptable accuracy as to their extent as mapped areas of forest on land cover layers. At the site level, however, there is considerable uncertainty about the size and condition of the two different systems, especially in the Willamette Valley and Lower Columbia sections. In our mapping, we were unable to distinguish between tree plantations and naturally regenerated forests. We believe, however, that for this highly-altered ecoregion, it is appropriate to include plantation forests in potential conservation areas due to the lack of alternate habitat, the potential for restoration in these stands, and the support that these stands provide for many native species.

The area of remaining forest within the ecoregion was difficult to estimate. The ecological systems layer that we constructed from a number of existing landcover maps (see section 2.1.3) was used to represent the current extent of forests. However, we discovered that the landcover classification techniques used to construct the maps often could not distinguish between forest and rural residential areas with high tree canopy cover. We concluded that conifer forest highly fragmented by residential development would not adequately function as a coarse filter for much of the biodiversity dependent upon these ecological system types. To correct for these difficulties in mapping of forest, we used digital orthophotos (1:12,000 scale) to locate and manually digitize large contiguous blocks of upland forest representing Douglas-fir–Western Hemlock–Western Redcedar Forests and Dry Evergreen Forests and Woodlands that were later used in the portfolio selection process.

Riparian Forests and Shrublands

The Riparian Forests and Shrublands system is inadequately represented in the mainland British Columbia portion of the ecoregion. This system was mapped from both Heritage/CDC occurrence data and GIS systems layers for all other portions of the ecoregion, while the source for this GIS layer for British Columbia (the British Columbia Sensitive Ecosystems Inventory) did not cover the mainland (Ward et al. 1998).

Due to the lack of mapped floodplains, Riparian Forests and Shrublands data were not plotted for almost all of Kitsap County. In some other areas in Washington, there are probably some depressional forested or scrub wetlands that have been mapped as Riparian Forests and Shrublands, thus artificially inflating the amount of riparian area that is mapped and reported. This knowledge is based on field work and aerial photo examination suggesting that some headwater depressional wetlands are included in the 100-year floodplain maps and the resulting Washington Riparian Layer. We did remove some of the large, obvious examples of headwater depressional wetlands from the riparian layer, but there are still some depressional wetlands in the riparian data layer.

Wetlands and Aquatic Beds

Because we had few ground-truthed occurrences of Depressional Wetland Broadleaf Forests, we attempted to fill the gap with the ecological systems layer. While this layer did give us many locations that purportedly met our minimum size criteria, our confidence that these locations actually represent occurrences with minimum ecological integrity of that system is fair at best. These unranked “occurrences” of Depressional Wetland Broadleaf Forests need to be verified on the ground before they become actual targets of conservation activity.

Depressional Wetland Shrublands and Freshwater Aquatic Beds in the Willamette Valley and Lower Columbia sections were mapped using the National Wetlands Inventory. Our confidence in these unranked occurrences is relatively low in terms of their assignment to a particular ecological system because the National Wetlands Inventory does not distinguish between wetlands in riparian versus depressional settings. Their condition is also completely unknown. One particular problem noted was that many occurrences showed up in riparian riverine floodplains where, at least for the shrublands, most of them probably should have been part of larger Riparian Forests and Shrublands occurrences. Any of these unranked occurrences of Depressional Wetland Shrublands and Freshwater Aquatic Beds need to be ground-truthed before they become actual targets of conservation activity. It is important to re-emphasize that no sites were included in the portfolio solely based on point occurrences of remotely sensed or modeled ecological systems.

We had few occurrences of Coniferous Forested Wetlands, Tidally Influenced Freshwater Wetlands, and Autumnal Freshwater Mudflats. We did not have adequate data from other sources to be able to fill these data gaps.

Oak Woodlands

Willamette Oak Woodlands were moderately well represented by our modified Oregon Vegetation Layer. However, we know very little to nothing about the condition of most of the mapped areas. In many cases, these woodlands are also extremely fragmented by agriculture or development. The lack of information about condition and landscape context information for particular sites with this system means that mapped areas targeted for this type may have relatively poor ecological integrity and should be examined on the ground before major site-based conservation activities.

Rare and Unusual Habitats

Cliffs, talus, and caves are relatively rare ecological systems that were not specifically targeted. Cliffs and talus are likely to be captured as part of larger sites containing forests and herbaceous balds and bluffs. Caves appear to be very rare in the ecoregion and have not been studied for their biota, as far as we know, other than for bats. The Townsend's big-eared bat is a fine filter target in the ecoregion that occurs in caves and there are occurrences of caves that are thereby represented in the portfolio via this species.

Most of the rare plant association targets have not been inventoried well enough to have sufficient occurrences to meet our goals. Inventory for these associations has been uneven across the ecoregion and is the least adequate in Oregon. Because plant associations cannot be identified without expert field inventory, we relied solely on known occurrence data and did not meet our goals for most associations. However, we compensated at least in part for this shortcoming by setting relatively high numerical goals for ecological systems (see Section 2.1.6 and Table 2.5) that were designed to represent the full range of variation in composition of the systems (the full range of plant associations). Further inventory for rare plant associations is warranted.

2.1.6 Setting Goals

The analytical tool used in this assessment requires goals. We also recognize the importance of attempting to set goals in order to answer the question of how much is enough in order to maintain species, communities, and systems. However, these goals were primarily a device for assembling an efficient conservation portfolio, and should not be interpreted as guaranteeing the necessary and sufficient conditions for long-term survival of plant communities and ecological systems. Ideally, when setting goals, we are attempting to capture ecological and genomic variation across the ecoregion and ensure species persistence by spreading the risk of extirpation. However, the science of setting goals is young and evolving. There is very little theory and no scientific consensus regarding how much of an ecological system or habitat area is necessary to maintain most species within an ecoregion (Soule and Sanjayan 1998).

We had no scientifically established method for setting goals for coarse filter targets. Hence, we relied on the best professional judgment of ecologists from the technical team and state Natural Heritage Programs. These scientists have settled on a generic goal for matrix-forming, large-patch, and linear ecological systems. This generic goal is 30% of the historic extent (Marshall et al. 2000, Neely et al. 2001, Rumsey et al. 2003).

The Coarse Filter Goal

The decision to use 30% of historic extent as a conservation "goal" or benchmark was informed by species-area curves. The species-area curve is arguably the most thoroughly established quantitative relationship in all of ecology (Conner and McCoy 1979, Wilcox 1980, Rosenzweig 1995). The curve is defined by the equation $S=cAz$, where S is the number of species in a particular area, A is the given area, c and z are constants. The equation states that the number of species (S) found in a particular area increases as the habitat area (A) increases. Conversely, the equation also means as habitat area decreases the number of species also decreases. In fact, empirical studies have demonstrated the relationship between habitat loss and species loss (Pimm and Askins 1995, Brooks et al. 1997). With a little algebra we can create an equation that relates the number of species existing in the present to the number of species that existed in the past:

$$S_p/S_h = cA_p^Z / cA_h^Z = (A_p/A_h)^Z \quad (2\text{-}1)$$

where the subscripts p and h mean present and historic, respectively. The parameter z takes on a wide range of values depending on the taxa, region of the earth, and landscape setting of the study. Most values lie between 0.15 and 0.35 (Wilson 1992). However, the value 0.25 is thought by some ecologists to be representative of most situations (Sugihara 1980, Pimm and Askins 1995). Figure 2.1 shows species area curves for these three values of z.

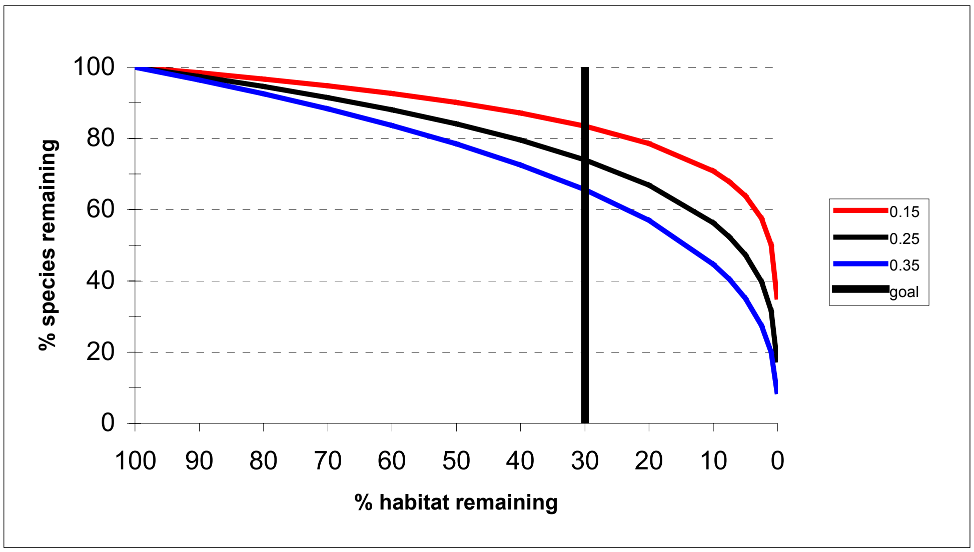


FIGURE 2.1 Species-area curves for different z values. Most values of z lie between 0.15 and 0.35 (Wilson 1992). However, the value 0.25 is thought by some ecologists to be representative of most situations (Sugihara 1980, Pimm and Askins 1995). Vertical line shows standard TNC goal for matrix-forming, large-patch, and linear ecological systems.

According to the species-area curve, the goal 30% of historic extent might maintain somewhere between 66 to 83% of all species that existed in the ecoregion immediately prior to European settlement (circa 1850). Assuming z is about 0.25, the percent of species maintained might be close to 74%. This coarse filter goal results in an undesirable loss of species: 17 to 34% of those that existed before European settlement. However, an important assumption buttressing the coarse filter goal is that special actions to conserve fine filter targets, which are the species most likely to be lost, will compensate for some of the species losses projected by the 30% coarse filter goal. In addition, fine filter targets may also act as umbrella species for species not specifically targeted for conservation.

The coarse filter/fine filter approach makes good sense for identifying efficient and effective conservation areas. However, we have no way of predicting how well conservation of fine filter targets will prevent species losses due to insufficient amounts of coarse filter targets. Furthermore, estimates of species loss using species-area curves are questionable (Simberloff 1992), so such estimates are more heuristic than predictive. However, we adopted this generic coarse filter goal, which might conserve well over half of the ecoregion's biodiversity, as a reasonable benchmark for identifying high priority places for conservation.

Examining the Coarse Filter Goal in a Heavily Altered Landscape

The generic goal we selected for ecological systems (i.e., 30% of historic extent) was developed for ecoregions that are largely intact. However, the Willamette Valley-Puget Trough-Georgia Basin ecoregion is far from intact. Decades of human settlement and intensive land use have altered substantial amounts of habitat. For example, we estimated that over 98% of the historic extent of prairies has been lost (Christy et al. 1999, Chappell et al. 2001). Using species-area curves, these losses in habitat can be translated to estimated species losses (Figure 2.2). Assuming that remaining prairies are about 2 to 4% of their historic extent, then the species/area curve predicts that between 38 to 75% of all prairie species will eventually be lost. A reduction in the current extent of prairie habitat would cause even greater species loss. Therefore, the goal for prairies was set at 100% of all that remains.

Note that we projected that somewhere between 38 to 75% of all prairie species will eventually be lost. Species loss has been demonstrated to lag behind habitat loss (Diamond 1972, Brooks et al. 1999). Therefore, prairies in the ecoregion will continue to lose species for the foreseeable future. Based on the results of Brooks et al. (1999), we can rather roughly depict the current status of prairie biodiversity (Figure 2.3). Prairies in the Willamette Valley-Puget Trough-Georgia Basin ecoregion could still support between 70 to 75% of species that existed prior to European settlement. In other words, about 8 to 50% of historic prairie biodiversity may be lost in the future unless action is taken to prevent it. The values just stated are extremely rough estimates based more in theory than empirical evidence. Nevertheless, the message they convey is valid. Maintaining 100% of all remaining prairie is not sufficient to maintain all currently existing prairie biodiversity.

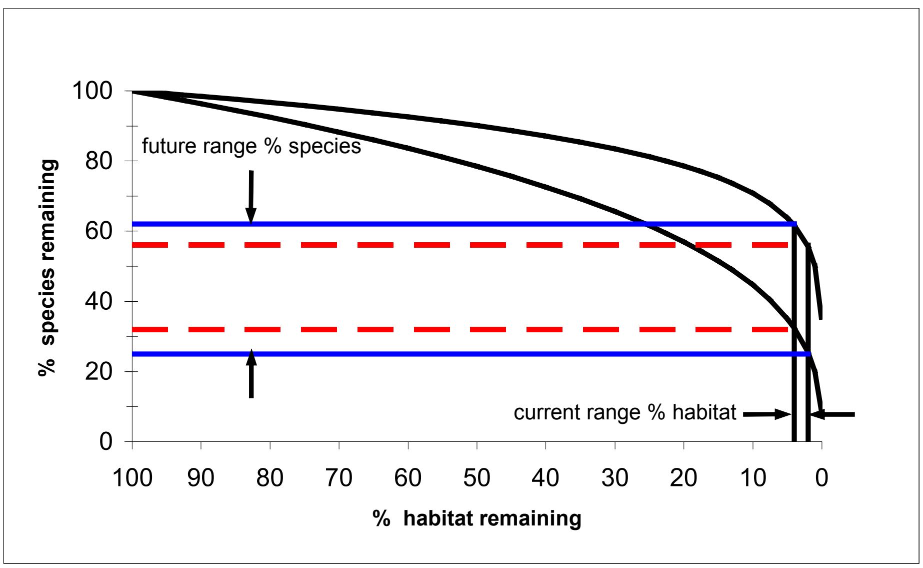


FIGURE 2.2 Future number of species due to current amount of prairie habitat. Horizontal axis is prairie habitat remaining expressed as the percent of historic extent (i.e., circa 1850). Vertical axis is species remaining expressed as the percent of all species existing in ecoregion immediately prior to European settlement. Due to past destruction of prairie habitat, approximately 38 to 75% of prairies species could belost. Two species-area curves represent a likely range of biodiversity response to habitat loss. top curve z= 0.15, bottom curve z = 0.35

Because maintaining 100% of all remaining prairie is not sufficient to sustain all existing prairie biodiversity, restoration of this ecological system is needed. In other words, the goal for prairie habitat should be greater than 100% of all remaining prairies, requiring the restoration of additional habitat to sustain a greater proportion of existing species. We did not attempt, however, to identify suitable places for restoration in this assessment.

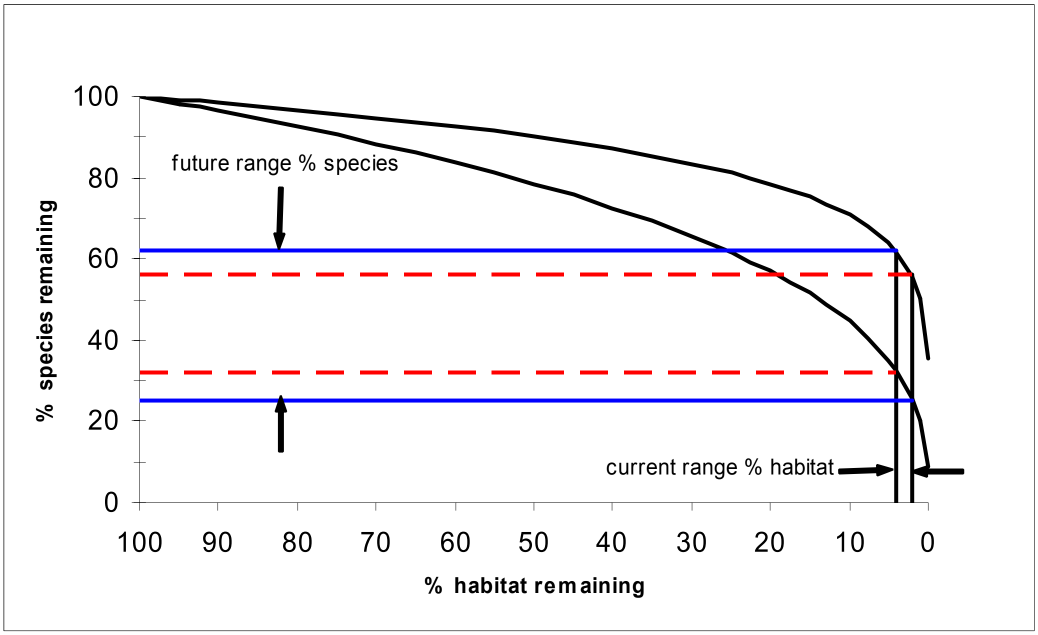


FIGURE 2.3 Theoretical explanation of current and future states of prairie biodiversity. Current amount of prairie habitat is estimated to be 2 to 4% of historic extent. However, species extinctions lag behind habitat loss. Hence, the current number of species is greater than will exist in the future once equilibrium is established. Value of z for species area curve equals 0.25.

The situation for most other ecological system types is similar to that of the prairies but is not as severe. For these highly-reduced systems, goals were effectively set to 100% of all that remains. (Appendix 12a summarizes these coarse filter goals.) For this reason, the goals established for these highly-reduced system types should not be regarded as an assurance of long-term sufficiency. That is, while protecting the remaining occurrences of these reduced systems is vital, it will not be sufficient to carry all remaining species in those systems into the long-term future. Rather, the coarse and fine filter goals used in this assessment collectively function as a device for establishing priorities.

Determining Historic Habitat Extent and the Rate of Loss in order to Set Goals

For matrix-forming, large-patch, and linear ecological systems, we expressed goals as a percentage of estimated historic extent (circa 1850). For the purpose of setting area goals, we considered the spatial pattern and distribution of each ecological system across the ecoregion (Anderson 1999). Goals were expressed in different forms depending on the typical pattern and distribution of target occurrences in their natural state.

We used 1850 as an approximate historical baseline from which to estimate vegetation changes. While 1850 marks the approximate beginning of the most extensive and rapid European technology-driven changes to Willamette Valley-Puget Trough-Georgia Basin ecosystems, it is recent enough to reflect vegetation patterns under modern climatic conditions and therefore provides a useful and important reference point.

For each ecological system, we estimated percentage loss or decline of the system from 1850 to the present in ten percent intervals using current land use/land cover data and, where available, pre-settlement land cover reconstructions (Van Pelt 1997, Christy et al. 1999, Crawford and Hall 1997, Chappell et al. 2001). For systems where the loss was greater than 75%, and therefore less than 30% of its historic existence is remaining, we set a goal of "all extant relatively viable (ecological integrity C or better) occurrences" (see Appendix 11 for integrity ranking). These ecological systems are in need of restoration.

For the Willamette Oak Woodlands system, the application of this latter goal (all remaining extant occurrences) was not readily feasible because of the large total extent involved and the large degree of uncertainty about condition and delineation of occurrences. We had a map of Willamette Oak Woodlands as our guide, but we did not delineate it into occurrences. For this system, we specifically targeted hexagons that had at least 65 ha of mapped oak woodland. We counted Willamette oak woodlands toward the goals for the system if at least 10 ha of mapped oak woodland were within a hexagon chosen for multiple targets.

For systems with more moderate areal losses over time, we used maps of pre-settlement vegetation (Van Pelt 1997, Christy et al. 1999, Crawford and Hall 1997, Chappell et al. 2001) to determine the total area that would represent 30% of the extent of historic cover. We calculated these figures by section because of differences in historic and current landscape patterns among the sections. We then compared the 30% of historic area by section with the current extent as modeled by our land use/land cover layers or riparian vegetation layers. We then generated a percent of modeled extant area for each system and section. The latter became the SITES (analytical) goal. We did not have pre-settlement vegetation coverage for British Columbia; we had to use expert opinion to estimate historic loss in relation to the modeled extant area for the Georgia Basin section.

We did not set area goals for seral stages of coniferous forest ecological systems even though seral stages are a fundamental characteristic of these matrix-forming ecological systems. This was a practical decision based on the extremely limited extent of many seral stages (particularly mature and old growth forests) in the ecoregion. We did capture most remaining mature and old growth forests in the ecoregion by setting occurrence goals that corresponded to all remaining good condition occurrences.

How Representing Coarse Filter Targets Affected Goal Setting

For the purpose of setting coarse filter goals, we considered the spatial pattern and distribution of each ecological system across the ecoregion (Anderson 1999). Ecological goals were expressed in different forms depending on the typical pattern and distribution of target occurrences in their natural state. For matrix-forming, large-patch, and linear ecological systems, we expressed goals as a percentage of estimated historic extent (circa 1850). Goals for small-patch systems and all rare plant associations were expressed as number of occurrences.

The Coastal Spits, Dunes, and Strand ecological system was represented as points, even though it is roughly linear in nature. We set numerical SITES goals for this system as a percent of estimated historic occurrences based on an estimate of historic loss (Appendix 11).

For rare and vulnerable plant association targets and for small-patch ecological systems, we expressed goals in numbers of "extant minimally viable (C rank or better) occurrences". We used the interaction of spatial pattern in the landscape and distribution of plant associations in relation to the ecoregion to guide us in determining numerical goals for occurrences of systems and associations (Table 2.5).

TABLE 2.5 Ecoregion-wide numerical goals for number of occurrences in priority conservation areas for ecological systems and rare plant associations on distribution and landscape pattern. Numbers in parentheses are for ecological systems that have a high level of internal variability (see text).

	LANDSCAPE PATTERN			
DISTRIBUTION RELATIVE TO WILLAMETTE VALLEY-PUGET TROUGH-GEORGIA BASIN ECOREGION	MATRIX	LARGE PATCH	SMALL PATCH	LINEAR
Endemic	18(54)	18(54)	25(75)	25(75)
Limited	9(27)	9(27)	13(39)	13(39)
Widespread		5(15)	7(21)	7(21)
Peripheral		2(6)	3(9)	3(9)

For each ecological system, we used the distribution of component plant associations to determine the distribution of the system in relation to the ecoregion (endemic, limited, widespread, or peripheral). For ecological systems where there was a high degree of internal variability in the composition of the ecological system (i.e., a substantial proportion of associations that do not occur at each occurrence of the system), we increased the number of occurrences that were targeted (as illustrated by the numbers in parentheses in Table 2.5). For example, if we wanted to capture 13 occurrences in the portfolio of a small patch, limited distribution system such as Intertidal Salt Marshes, we multiplied the number of occurrences chosen by three (13 X 3) to give 39 occurrences, in the hope that this would result in each of the component associations being represented at a minimum of 13 sites in the portfolio. The number 3 was chosen as the multiplier because we estimated that for systems with high internal variability, any one association on average would be found at one-third of all occurrences of the system. This process ensured adequate replication of system occurrences to capture some redundancy in occurrences of actual plant associations, which are the underlying targets which the systems are designed to represent or capture.

Point Goals for Portfolio Assembly

In addition, the SITES goals were expressed in points, as opposed to number of occurrences, in order to satisfy the input requirements of SITES. Each occurrence was assigned a point value based on its element occurence rank according to the following scheme, shown in Table 2.6:

TABLE 2.6 Applying SITES Point Values to Basic Element Occurrence Ranks

EO RANK	DESCRIPTION	POINTS
A	Excellent estimated integrity	1000
B	Good estimated integrity	1000
C	Fair estimated integrity	500
D	Poor estimated integrity	50
K*	Unranked (unknown integrity)	500 (250 if from modeled data)
H	Historical	N/A
X	Extirpated	N/A

*Ks were assigned 500 points for known Natural Heritage Program element occurrences but only 250 points if the occurrences were derived from coarse filter data layers such as the National Wetlands Inventory (NWI). The 250-point modeled Ks were unique to the goal setting of the plant communities team.

The relative point values for occurrences of systems and communities are a reflection of estimated relative conservation value of individual occurrences. These are comparable to values used for species, except that they are less related to the concept of persistence. These differing point values help to direct the SITES model toward sites with occurrences of higher ecological integrity. For unranked occurrences, we used a number of intermediate ranked occurrences (between C and D) due to the relatively high probability of a modeled occurrence being of poor integrity (D) in this ecoregion.

For the purposes of using the SITES computer model, these numbers were then translated into point values by the following formula:

Overall Point Goal = (Number of occurrences) x (Points per occurrence) (2-2)

For example, we assumed that if we needed 25 occurrences, half of them could be A's or B's and half could be C's, or an average of 750 points per occurrence. Hence, the overall point goal for endemic associations was (25) x (750) or 18,750 points, which we rounded to 19,000 as the overall point goal in the SITES algorithm.

2.1.7 Expert Review

Expert input was solicited at two workshops held at Silver Falls State Park, Oregon and Victoria, British Columbia in Spring 2000 and through personal interviews throughout the planning process (see list of experts in Appendix 2). Experts were asked for two kinds of input: 1) to review draft target criteria and target lists and provide recommendations for additions and deletions, and 2) to provide occurrence information for communities or systems on the target list (Appendix 5).

2.2 Identifying Plant Species Fine Filter Targets

2.2.1 Technical Team

The plant technical team was composed of experts from The Nature Conservancy (TNC), the Washington Natural Heritage Program (WNHP) and the Conservation Data Center of British Columbia (CDC) and dealt with vascular and non-vascular plants. The team members were:

Ed Alverson, team leader	TNC Oregon, Eugene, OR
John Gamon	WNHP, Olympia, WA
George Douglas	British Columbia CDC, Victoria, BC

2.2.2 Selecting Fine Filter Target Species

The team selected the fine filter plant species targets from the following groups, based on the Heritage Program Global Rank Definitions, Endangered Species Act Status Definitions, and Criteria for Combined Global Ranks (see Appendix 6):

- **Imperiled species** having a global rank of G1, G2, or G3 as determined by the Natural Heritage Programs in Washington and Oregon, and the Conservation Data Centre in British Columbia (Appendix 6 gives full definitions of G ranks). G1 and G2 species are critically imperiled globally and imperiled globally (typically 5 or fewer occurrences and 6 to 20 occurrences, respectively). G3 denotes globally rare or uncommon (typically 21-100 occurrences) species. Ranking designations T1, T2, or T3 represent the same status for subspecies or varieties. The use of 'N' or 'S' in a species' rank indicates its status at a national or subnational level respectively. These rankings are regularly reviewed and updated by experts in state Natural Heritage Programs.

- **U.S. federally listed species and British Columbia provincially listed species** are classified as endangered or threatened by the U.S. Fish and Wildlife Service and by the British Columbia Conservation Data Centre. (In British Columbia, "red listed" species correspond to endangered and threatened.)

its geographic range, or 75% of its element occurrences, occurring within the ecoregion.

- ***Disjunct species*:** These species have populations that are geographically isolated from populations in other ecoregions. To the east and west, plants were considered disjunct if they did not occur in adjoining ecoregions (Northwest Coast, East/West Cascades and North Cascades). To the south, the Klamath Mountain Ecoregion includes three major interior valleys from north to south: the Umpqua, Rogue, and the Shasta/Scott which are separated from the Willamette and from one another by forested habitats of the Coast Range, Cascades, and Siskiyou Mountains. Species were considered disjunct if they were not present or were uncommon in the Umpqua Valley. Species were considered uncommon in the Umpqua Valley if they occurred in 10 or fewer of the 64 geographical areas of Douglas County identified by Hopkins et al. (1993).

♦ **Non-vascular species** (lichens, fungi and moss) were included as targets only if they had G1-2 or S1-2 rankings.

We did not use "declining" as a criterion because very little information is available on the historic or current trends of native plant species. In some cases, EO ranking criteria for plant communities were used to prioritize habitats that protect declining plant species. This method is explained in the section entitled, "Special case: Prairie Remnant Plant Communities as Surrogate Target for Declining Plant Species" in section 2.1.4.

2.2.3 Assembling and Organizing Data

The team gathered current lists of all at-risk species tracked by the Oregon and Washington Natural Heritage Programs and the British Columbia Conservation Data Centre. The team then compared the lists across the ecoregion. Species were added and deleted based on the criteria described in section 2.2.2. In Oregon and Washington, species that were only considered imperiled within a single state (S1, S2) were dropped if their status was secure in a different portion of the ecoregion. An N1 species in Canada that is more common elsewhere in the ecoregion was included as a target in the Canadian portion of the ecoregion.

Floras (Gilkey 1947, Hitchock and Cronquist 1973, Hopkins et al. 1993, Peck 1941, Piper 1906, Piper and Beattie 1915, Jolley 1988) and label data from herbarium specimens at the University of Washington and Oregon State University herbaria were used to select additional species that met the endemic or disjunct criteria for the ecoregion, but that are not tracked by any of the state Natural Heritage Programs. A few species were dropped from our data set due to taxonomic uncertainties.

In total, 239 vascular plant targets and 56 non-vascular plant targets were identified for the ecoregion. The vascular plants included 220 taxa that were considered targets across the ecoregion, including 35 imperiled species, 32 endemic species, and 165 disjunct species. Some species were both imperiled and endemic or disjunct. An additional 19 plant taxa that are ranked N1 in Canada were considered targets in the Canadian portion of the ecoregion. One hundred and four additional species were evaluated but were later rejected as ecoregional targets because they did not meet our selection criteria. Data records were eliminated from the portfolio selection process if they were: (1) dated before 1975, (2) too imprecisely located, (3) of questionable plant identification because the location was outside the plant's geographic range or outside its habitat type, or (4) at a location where the species' habitat was known to have been destroyed.

2.2.4 Target Representation and Ranking

Target Representation

The locations of a plant species were represented as target occurrences (i.e., element occurrences). Target occurrences are constructed from data points that record where a target species has been observed. For vascular plants, target occurrences represent the location of a population or subpopulation.

We obtained occurrence data from the Oregon and Washington Natural Heritage Programs, the British Columbia Conservation Data Centre, and the Oregon Flora database. Data were also obtained from herbarium specimens, from site plant lists, and local and county floras. In total, 1,869 plant target occurrences were included in the analysis (413 from state Natural Heritage Programs and 1,456 from other sources).

Occurrence Ranking

Target occurrences were ranked according to their relative probability of persistence. (see Map 2.2: "EO Rank for Fine Filter Occurrences").

We used the NatureServe ranking system (NatureServe and TNC, 2002), which considers three factors when assigning ranks: size, condition, and landscape context as discussed in Table 2.4 of section 2.1.4. In the case of plant species, size refers to the population size or habitat patch size. Condition refers to population trend or habitat integrity. Landscape context refers to how the occurrence is situated with respect to surrounding land cover and land uses.

Target occurrence rank criteria were developed individually for each taxon using EO Ranks shown in Table 2.6. Typically, the ranks were based in standard ranges of population numbers that are based upon life history and condition, as shown in Table 2.7.

TABLE 2.7 Population, Condition, and Context

POPULATION	RANK
Long-lived perennials	A ≥ 2,500 individuals (genets)
	B between 250 and 2,500
	C between 25 and 250
Clonal perennials	A ≥ 1,000 individuals
	B between 100 and 1,000
	C between 10 and 100
Annuals	A ≥ 10,000 individuals
	B between 1,000 and 10,000
	C between 100 and 1000
CONDITION AND CONTEXT	
Roadsides	The rank for any occurrence along a roadside was dropped one rank from what they otherwise would have received based on population size. This factor is more related to context than condition. Condition in the ecoregion is not particularly good anywhere and may be characterized as uniformly mediocre. Therefore, condition did not bear a great influence on plant target occurrence ranks.

Target occurrence ranks for plant species in Oregon and Washington were reviewed and in some cases re-ranked to provide for consistent application of the criteria based on available information. Ranks for occurrences from British Columbia were not changed. As discussed in the plant communities section, if insufficient viability information was available, the occurrence was assigned a "K" rank. Occurrences of non-vascular plants such as lichens and fungi, for example, were given K ranks.

2.2.5 Data Gaps

No occurrence or habitat data were available for 42 of the 240 target plant species (see Table 2.8). Of these 42 targets, all are presumed extirpated from the ecoregion. Most are disjunct species that are known from a small number of historic herbarium records. It is possible that with future field searches, extant populations could be located within the ecoregion. However, many of the extirpated vascular plants occur in prairie or riparian habitats, both of which have experienced major loss or alteration of extent or habitat integrity over the last 150 years, and it is a certainty that some of these taxa are truly lost from the ecoregion.

TABLE 2.8 Terrestrial plant species for which there were no occurrence data collected since 1975. Distribution and status information pertain to the Willamette Valley-Puget Trough-Georgia Basin Ecoregion.

SPECIES	DISTRIBUTION PATTERN	WV STATUS	LC STATUS	PT STATUS	GB STATUS	# OF SECTIONS
Abroniam umbellate ssp. acutalata	L			H		1
Agoseris elata	D			H		1
Androsace filiformis	D	H				1
Apocynum medium	D			H		1
Arenaria paludicola	D			H		1
Balsamorhiza hookeri	D		H			1
Bergia texana	D		H			1
Blepharipappus scaber	D	H				1
Cyperus acuminatus	D	H				1
Cyperus schweinitzii	D			H		1
Eriophorum vaginatum ssp. spissum	D			H		1
Eupatorium maculatum var. bruneri	D			H		1
Floerkea proserpinacoides	D		H			1
Gilia sinistra ssp. Sinistra	D	H				1
Hieracium parryi	D	H				1
Juncus hemiendytus var. hemiendytus	D	H				1
Juncus torreyi	D		H		H	2
Lathyrus lanzswertii var. lanszwertii	D			H		1
Lepidium nitidum	D	H				1
Lithophragma tenellum	D	H				1
Lithospermum ruderale	D				H	1
Mimulus douglasii	D	H				1
Minuartia cismontana	D	H				1
Muhlenbergia glomerata	D			H		1
Navarretia leucocephala ssp. Leucocephala	D	H				1

TABLE 2.8 (Cont'd.) Terrestrial plant species for which there were no occurrence data collected since 1975. Distribution and status information pertain to the Willamette Valley-Puget Trough-Georgia Basin Ecoregion.

SPECIES	DISTRIBUTION PATTERN	WV STATUS	LC STATUS	PT STATUS	GB STATUS	# OF SECTIONS
Nymphaea tetragona	D			H		1
Pellaea andromedifolia	D	H				1
Penstemon rydbergii (hesperius)	E		H			1
Plantago aristata	D			H		1
Plectritis ciliosa	D	H?				1
Polemonium micranthum	D				H	1
Polygonum californicum	D	H?				1
Potamogeton fibrillosus	D			H		1
Potentilla biennis	D		H	H		2
Potentilla rivalis (=P. millegrana)	D		H	H		2
Romanzoffia thompsonii	L	H				1
Scutellaria antirrhinoides	D	H	H			2
Stachys palustris var. pilosa	D		H			1
Thelypodium lasiophyllum	D			H		1
Toxicodendron rydbergii (Rhus radicans)	D			H		1
Zigadenus paniculatus	D			H		1
Zizia aptera var occidentalis	D		H			1

Notes:
L = Limited - restricted to a particular portion of the ecoregion
D = Disjunct - having populations that are reproductively isolated from each other by geography
H = Historic - presumed to no longer exist in the ecoregion
E = Endemic - primarily or only occurring in the ecoregion
WV = Willamette Valley
PT = Puget Trough
LC = Lower Columbia Valley
GB = Georgia Basin

2.2.6 Setting Goals

Section 2.1.6 and Table 2.6 describe how occurrence goals were translated to point goals for the purposes of running the optimal reserve selection algorithm (SITES). For species targets, the goal was expressed as a numerical value representing the number of occurrences needed in each section of the ecoregion. Goals for the spatial distribution and number of species occurrences were set based upon the expert opinion of the plant species team. We developed generalized goals that could be applied to many species.

According to the national Natural Heritage Program network (a.k.a., NatureServe), if a species is known to occur at fewer than 20 locations in a state, then the species is considered "imperiled" within that state. If a species is known to occur at 20 to 100 locations in a state, then it is considered rare or uncommon but not imperiled (Master 1991). The team determined that to maintain a species in an ecoregion, it should be more secure than "imperiled". Hence, for plant species endemic to the ecoregion, we set a goal of 25 A or B ranked occurrences. For species with wider distribution, we made the assumption that some populations would be conserved elsewhere, and reduced the goal according to their distribution pattern, as shown in Table 2.9.

TABLE 2.9 Setting Goals for Non-endemic Species

DISTRIBUTION	GOAL (# OCCURRENCES)
Limited	**13**
Disjunct	**13**
Widespread	**7**
Peripheral	**3**

These plant species goals are roughly the same as those used for ecoregional assessments by the Conservancy and Natural Heritage Programs throughout the western states (Marshall et al. 2000, Neely et al. 2001, Rumsey et al. 2003).

As discussed in Section 2.1.6, setting a goal of 25 occurrences (the general goal for plant species endemics) resulted in a SITES point goal of 19,000. The same method was used to translate the remaining occurrence goals into point goals. For example, to determine the points to apply to disjunct species, we multiplied the 13 occurrences recommended by the team by 750 to equal 9,750 (rounded to 10,000) points; for the 7 occurrences needed for widespread species, we multiplied 7 times 750 to equal 5,250 (rounded to 5,500); and for the 3 occurrences needed for peripheral species, we multiplied 3 by 750, or 2,250 (rounded to 2,500).

2.2.7 Expert Review

Expert review for fine filter plant targets was combined with that for plant communities (see Appendix 2, and section 2.17). Experts outside the assessment team participated in the development of the vascular plant targets lists and identification of occurrences through individual interviews and experts workshops held at Silver Falls State Park (OR) and Victoria, BC.

Experts were asked for two kinds of input: 1) to review draft target criteria and target lists and provide recommendations for additions and deletions, and 2) to provide occurrence information for species on the target list.

2.3 Identifying Animal Species Fine Filter Conservation Targets

2.3.1 Technical Team

The animals team dealt with all terrestrial animals and was composed of experts from The Nature Conservancy (TNC), Washington Department of Fish and Wildlife (WDFW), the Washington Natural Heritage Program (WNHP), the Oregon Natural Heritage Program (ONHP), and the Conservation Data Center of British Columbia (CDC) and. Team members included:

Marcy Summers, team leader	TNC, Seattle, WA
David Rolph	TNC, Seattle, WA
John Fleckenstein	WNHP, Olympia, WA
George Wilhere	WDFW, Olympia, WA
Eric Scheuering	ONHP, Portland, OR
Terry Frederick	TNC, Portland, OR
Syd Cannings	British Columbia CDC, Victoria, BC

2.3.2 Selecting Target Species

Animal target species were chosen from the following groups:

- **Imperiled species** having a global rank of G1, G2, or G3 as determined by the Natural Heritage Programs in Washington, Oregon, and British Columbia (refer to Heritage definitions in Section 2.2 or Appendix 6).

- **Imperiled subspecies** having a global rank of T1, T2, or T3 as determined by the Natural Heritage Programs in Washington, Oregon, and British Columbia.
- **Government classified as endangered** or **threatened** (or proposed for listing) by the U.S. Fish and Wildlife Service and by the British Columbia Conservation Data Centre. (In British Columbia, "red listed" species correspond to endangered and threatened.)
- **Species of special concern include:**

  Species of state or provincial concern that are: (1) ranked as S1, S2, or S3 by one of the state natural heritage programs or the provincial conservation data centre; or (2) listed or candidates for listing as endangered or threatened by state or provincial government agencies.

  Declining species that (1) have exhibited a significant, long-term decline in habitat and or numbers, and (2) are subject to a continuing high degree of threat.

  Endemic species restricted to the ecoregion or a part of the ecoregion. We defined endemic as one for which at least 75% of its geographic range occurs in the ecoregion.

  Disjunct species with populations that are geographically isolated from populations in other ecoregions.

  Vulnerable species are usually abundant, may not be declining, but some aspect of their life history makes them especially vulnerable, such as habitats needed for migratory stopovers or winter range.

  Keystone species are those whose impact on a community or ecological system is disproportionately large for their abundance. They contribute to ecosystem function in a unique and significant manner through their activities. Their removal causes major changes in community composition.

  Wide-ranging species that depend on vast areas. These species include top-level predators such as the gray wolf and northern goshawk. Wide-ranging species can be especially useful in examining linkages among conservation areas in a true conservation network.

  Globally significant examples of species aggregations like migratory stopover sites or over-wintering areas that contain significant numbers of individuals of many species.

  Partners in Flight (PIF) species for whom a conservation priority score for a species indicated need for special attention. This guideline applies only to birds.

  Species Guilds. Groups of species that share common ecological processes or patterns. It is often more practical to target such groups as opposed to each individual species of concern.

Peripheral Species

A number of species are peripheral to the ecoregion. Peripheral species are those that have only a very small portion of their natural geographic range in the ecoregion or have been subjected to a significant range contraction due to habitat destruction. The natural geographic ranges of the Pacific water shrew, tailed-frog, Van Dyke's salamander, Larch Mountain salamander, and the torrent salamander species overlapped the ecoregion only slightly. Our data indicated that these species occur in the ecoregion; however, this may be because ecoregion boundaries are mapped at a very coarse scale, and hence are inexact.

Before European settlement, northern spotted owl and marble murrelet nests were probably quite common in the ecoregion. Today, active nests of these species are extremely rare in the ecoregion. The major parts of both species' breeding ranges are now in ecoregions to the east and west.

Since the overall goal of ecoregional planning is to maintain species in an ecoregion, the team decided to keep all peripheral species as targets. Furthermore, individuals at the edges of a species geographic range are assumed to have evolutionary significance since they may be adapted to extreme habitat conditions. Targeting peripheral species may enhance the evolutionary potential of those species.

Wide-Ranging Species

In other ecoregional assessments, wide-ranging species have been used to assess landscape linkages between conservation areas (see Rumsey et al. 2003). In the Willamette Valley-Puget Trough-Georgia Basin ecoregion, no species were selected as targets because of their wide-ranging nature. Most wide-ranging species are functionally extirpated in the ecoregion, with minimal potential for their reestablishment in the foreseeable future. These include the gray wolf, grizzly bear, and fisher.

Partners in Flight (PIF) and Terrestrial Bird Targets

The PIF conservation priority scores were developed by Carter et al. (2000). (Also refer to Beissinger et al. 2000.) PIF developed their prioritization system to assist continent-wide conservation planning efforts. The PIF system is intended to establish clear and consistent priorities for the conservation of nongame land birds. The score is a function of seven parameters: breeding distribution, nonbreeding distribution, relative abundance, threats to breeding, threats to nonbreeding, population trend, and area importance. When using the PIF scores for selecting target bird species we followed the methods of Mehlman and Hanners (1999). A species was a target if it had a PIF score of 23 or greater, or had a score between 19 and 22 but also either exhibited a significant population decline or the ecoregion is an important portion of the species' range (Table 2.10).

TABLE 2.10 Terrestrial bird targets selected using PIF conservation priority scores

COMMON NAME	TOTAL SCORE	AREA IMPORTANCE[1]	POPULATION TREND[2]
Hermit warbler	26	5	2
Rufous hummingbird	26	5	5
Spotted owl	26	4	3
Trumpeter swan	25	2	3
Blue grouse	24	3	5
Black-throated gray warbler	23	5	2
Chestnut-backed chickadee	23	5	4
Lewis's woodpecker	23	2	3
Pacific-slope flycatcher	23	5	3
Band-tailed pigeon	22	5	4
Olive-sided flycatcher	22	4	5

TABLE 2.10 (Cont'd.) Terrestrial bird targets selected using PIF conservation priority scores

COMMON NAME	TOTAL SCORE	AREA IMPORTANCE[1]	POPULATION TREND[2]
Townsend's warbler	22	3	5
Vaux's swift	22	5	2
Bullock's oriole	21	3	5
Golden-crowned kinglet	21	5	5
Willow flycatcher	21	5	3
Western bluebird	20	2	5
Western wood-pewee	20	4	5

[1] Area importance scores: 1 = accidental to peripheral, 2 = occurs regularly but uncommon, 3 = present in low relative abundance, 4 = present in moderate to high relative abundance, 5 = present in highest relative abundance. [2] Population trends scores: 1 = significant increase, 2 = possible increase or stable, 3 = trend uncertain, 4 = possible decrease, 5 = significant decrease.

We used PIF scores for birds breeding in the Southern Pacific Rainforest Physiographic Province of which the WPG ecoregion is a small part. Hence, the proper magnitude of PIF area importance ranks was reconsidered for many species.

The scoring method resulted in some surprising results. For example, common species such as the chestnut-backed chickadee and the golden-crowned kinglet were identified as target species. The chickadee had a PIF score of 23. The kinglet had a PIF score of 21 but the ecoregion is an important part of its geographic range and the species has exhibited significant decline. In total, eighteen birds met the PIF criteria for targets.

Terrestrial Animal Targets

The animals team identified 127 terrestrial animal targets in the ecoregion: 20 mammals, 45 birds, 8 reptiles, 16 amphibians, 31 insects, 6 molluscs, and 1 earthworm (see Appendix 13). Five target species were ranked G1 (critically imperiled), all of which were endemic or nearly endemic invertebrates. Three vertebrate and two invertebrate species were ranked G2 (imperiled). The G2 vertebrates were amphibians endemic to adjacent ecoregions. Seventeen species were G3 (rare or uncommon) or G2G3. Over half of the target species were ranked G4 or G5 but met some other criterion for species target selection (see Appendix 14). Fourteen species, all invertebrates, do not have a G rank or have a questionable G rank due to insufficient information.

Forty-four species had some sort of U.S. federal status: six were listed, 3 were candidates for listing and 35 were species of concern. State and provincial governments also list species as threatened or endangered with extinction. Thirteen species were listed by Washington, 5 species were listed by Oregon, and 34 species were red-listed in British Columbia.

Table 2.11 shows thirteen special animal targets, based primarily on important aggregation areas for collection of target and non-target species. Even though many species listed below were not targets per se, it was determined that some areas of large concentrations of non-target species should be considered targets due to the potential vulnerability of large groups or breeding colonies.

TABLE 2.11 Special animal targets

FEATURE	COMMENT
Mineral springs	Necessary habitat feature for band-tailed pigeon, a target species
Shorebird concentrations (non-marine)	At least 7 species and at least 5000 individuals present
Federal critical habitat for marbled murrelet	In Washington portion of ecoregion, nesting habitat for marbled murrelets is imperiled. Federally designated critical habitat will help to maintain what remains (36431 ha)
Federal critical habitat for northern spotted owl	In Washington portion of ecoregion, spotted owls are functionally extirpated. Federally designated critical habitat has highest potential for functional owl habitat in future (67866 ha)
Bald eagle communal roosts	Winter communal roosts with at least 100 individuals
Great blue heron rookeries	At least 20 nests, and rookery active for at least 3 years
Dabbling duck concentrations[1]	Species guild that relies on over-wintering areas: American wigeon used as surrogate species
Diving duck concentrations[1]	Species guild that relies on over-wintering areas: scaup species used as surrogate
Sea duck concentrations[1]	Scoter species and harlequin duck used as surrogate species
Loon and grebe concentrations[1]	Species guild that relies on over-wintering area
Winter raptor concentrations	Mapped through expert review process
Bat roost sites	Hibernacula or diurnal roosts for any species; at least 30 individuals present
Seal and sealion pupping areas, and sealion haul-out areas[1]	Stellar sealions and harbor seals

[1] Dealt with in analysis for nearshore marine portfolio only

Extirpated Species

Some target species are considered functionally extirpated in portions of the ecoregion (see Table 2.12). From historical records of the animals, we can document these extirpations by section of the ecoregion.

With a few exceptions, these species are not targets in the section where they are thought to be extirpated. Exceptions are the northern spotted owl in the Puget Trough section, and the western pond turtle in the Puget Trough and Lower Columbia sections. The ecological goal for the spotted owl in the Puget Trough section equaled the critical habitat designated on Fort Lewis. The goal for the western pond turtle corresponded to the sites where species reintroduction efforts are occurring. Certain extirpated species, such as the white-breasted nuthatch, should be considered for reintroduction. Reliable information on regional extinction of invertebrates is not available.

TABLE 2.12 Terrestrial vertebrate species extinct or functionally extirpated in the WPG Ecoregion. Georgia Basin, Puget Trough, and Willamette Valley roughly correspond to the British Columbia, Washington, and Oregon portions of the ecoregion.

	VERTEBRATE CLASS		
	MAMMALS	BIRDS	HERPETOFAUNA[3]
Georgia Basin[1]	Long-tailed weasel Grizzly bear	Streaked horned lark Lewis's woodpecker Western bluebird Western meadowlark Yellow-billed cuckoo California condor	Western pond turtle Pacific gopher snake
Puget Trough[2]	Fisher Gray wolf Grizzly bear Tacoma pocket gopher	Sandhill crane Lewis's woodpecker White-breasted nuthatch Yellow-billed cuckoo[5] Northern spotted owl	Western pond turtle[4] Sharptail snake Racer Pacific gopher snake
Willamette Valley[2]	Fisher Gray wolf Grizzly bear	California condor yellow-billed cuckoo	Oregon spotted frog

[1] Source: Conservation Data Centre of British Columbia
[2] Sources: Altman et al. (2001), Iten et al. (2001), and WDFW Wildlife Heritage database.
[3] Altman et al. (2001) state that the western fence lizard is "functionally extirpated" in Puget Trough, but recent observations of the species prove they are not (K. McAllister, pers. comm.).
[4] Altman et al. (2001) state that the western pond turtle is "functionally extirpated" in the Puget Trough, but reintroduction and recovery efforts are underway.
[5] No evidence of breeding yellow-billed cuckoos has been found in over 60 years.

2.3.3 Assembling and Organizing Data

There were four main sources for animal species data: Oregon Natural Heritage Information Center, Washington Natural Heritage Program, Washington Department of Fish and Wildlife, and the British Columbia Conservation Data Centre. Each of these four agencies store their data in slightly different formats; consequently, considerable time was spent reconciling these formats. The data were then filtered for currency and accuracy. Data records were eliminated if they were: (1) dated before 1980, (2) too imprecisely located, (3) a questionable species identification because the location was outside the species' geographic range or outside the species' habitat type, or (4) at a location where the species' habitat was known to have been destroyed. The habitat data, i.e., the coarse filter ecological systems, are described in Appendices 9-12.

2.3.4 Target Representation and Occurrence Ranking

The locations of a species were represented as target occurrences (or element occurrences). For species with small home ranges and low mobility, such as salamanders and butterflies, target occurrences may represent the location of a population or subpopulation. For more mobile species or those with large home ranges, such as bald eagle and peregrine falcon, a target occurrence usually corresponds to a nest site. For other species, such as purple martin, western bluebird, or western pocket gopher, an occurrence may simply correspond to a portion of the population or to an area where the species is concentrated.

Target occurrences are constructed from data points that record where a target species has been observed. For example, a GIS database for amphibian locations may contain multiple points for Van Dyke's salamander along a first order stream. Each point is not a separate target occurrence. Instead, the set of points is assumed to represent the location of a population or subpopulation, thus corresponding to a single occurrence. Data points are grouped into occurrences based on a species-specific separation distance and on the presence of movement barriers often correspond to large gaps in suitable habitat. Due to the paucity of data, for some species a single observation corresponded to a target occurrence.

The state Natural Heritage Programs or the provincial Conservation Data Centres grouped observational data into target occurrences. The grouping process resulted in a reduction of data records and an improvement in data quality. For instance, Washington had 2,677 point records for all target animal species. After filtering the data for currency and accuracy, about 2,300 records remained. The points were converted to target occurrences resulting in 569 occurrences for Washington.

Target occurrences were ranked according to their viability, or relative probability of persistence. The ranks are qualitative and subjectively assigned by experts in a fashion similar to that described in section 2.2.4.

The locations of a species' habitats were represented as polygons. Species habitat maps have been produced by Washington Gap Analysis Program (GAP)(Dvornich et al. 1997, Johnson and Cassidy 1997, Smith et al. 1997) and by the Oregon Natural Heritage Information Center (ONHIC 2002). The habitat maps produced by Washington GAP lacked the spatial precision and classification accuracy needed for our application. Hence, Washington GAP habitat maps were used for only one species (see Table 2.13). Developing new habitat maps for the other species was beyond our resources. Consequently, the animals team decided to let the coarse filter system and plant association targets serve as a surrogate for most species-specific habitats (see Table 2.14). The ONHIC habitat maps were used for Oregon.

TABLE 2.13 Species for which GAP or GAP-like habitat maps were used as surrogates for known species occurrences. Goals for these species were in hectares of habitat.

SPECIES	HABITAT ASSOCIATIONS
BIRDS	
Acorn woodpecker[2]	Landcover: oak savanna, deciduous-open forest
Western meadowlark[2]	Landcover: oak savanna, native grasslands
Western bluebird[2]	Landcover: early shrub-tree, open mixed conifer/deciduous forests, oak savanna
REPTILES	
Western pond turtle[2]	Landcover: marsh, open water, riparian areas
Sharptail snake[2]	Landcover: early shrub-tree, mixed conifer/deciduous forests, oak savanna, chaparral, native grasslands
Western fence lizard[1]	Zones: Puget Sound Douglas-fir and Western Hemlock Landcover: coastal beaches
AMPHIBIANS	
Foothill yellow-legged frog[2]	Landcover: streams and rivers

[1] Washington only. Source Dvornich et al. (1997)
[2] Oregon only. Source ONHIC (2002)

TABLE 2.14 Species for which ecological system targets were used as surrogate for individual species ecological goals.

SPECIES	COARSE FILTER SYSTEM TARGETS OR HABITAT TYPES
MAMMALS	
Gray-tailed vole[1]	Depressional wetland shrublands Depressional wetland broadleaf forest Wet prairies Upland prairies and savannas Oak woodlands
Camas pocket gopher[1]	Upland prairies and savannas Oak woodlands
Pacific water shrew[2]	Douglas-fir–western hemlock–western redcedar forests Dry evergreen forests and woodlands Riparian forests and shrublands
BIRDS	
Band-tailed pigeon	Douglas-fir–western hemlock–western redcedar forests Dry evergreen forests and woodlands Oak woodlands
Black-throated gray warbler	Douglas-fir–western hemlock–western redcedar forests Dry evergreen forests and woodlands Oak woodlands Riparian forests and shrublands Depressional wetland broadleaf forests
Hermit warbler	Douglas-fir–western hemlock–western redcedar forests Dry evergreen forest and woodlands
Townsend's warbler	Douglas-fir–western hemlock–western redcedar forests Dry evergreen forest and woodlands
Blue grouse	Douglas-fir–western hemlock–western redcedar forests Dry evergreen forest and woodlands
Pacific-slope flycatcher	Douglas-fir–western hemlock–western redcedar forests Riparian forests and shrublands Depressional wetland broadleaf forests
Willow flycatcher	Riparian forests and shrublands Douglas-fir–western hemlock–western redcedar forests (early-seral) Dry evergreen forests and woodlands (early-seral)
Olive-sided flycatcher	Douglas-fir–western hemlock–western redcedar forests Dry evergreen forests and woodlands
Western wood-pewee	Dry evergreen forests and woodlands Oak woodlands Riparian forests and shrublands Depressional wetland broadleaf forests
Chestnut-backed chickadee	Douglas-fir–western hemlock–western redcedar forests Dry evergreen forests and woodlands
Golden-crowned kinglet	Douglas-fir–western hemlock–western redcedar forests Dry evergreen forests and woodlands
Rufous hummingbird	Douglas-fir–western hemlock–western redcedar forests Dry evergreen forests and woodlands Riparian forests and shrublands Coniferous forested wetlands

[1] Oregon only
[2] Washington only

2.3.5 Data Gaps

No occurrence or satisfactory habitat data were available for 21 of 127 target animal species (see Table 2.15). About half of these species were invertebrates. This reflects our extremely poor understanding of invertebrate species diversity, geographic distribution, and habitat requirements. Thirty-eight other terrestrial species had less than 5 known occurrences in the ecoregion. This reflects a low survey effort, but in this ecoregion it is mostly due to the lack of suitable habitats for these species.

TABLE 2.15 Terrestrial species for which there were either no occurrence data collected since 1980 or no reliable habitat data. All comments pertain to the WPG Ecoregion only.

SPECIES	COMMENTS
MAMMALS	
Black-tailed jackrabbit	Found in Willamette Valley section
Shaw Island Townsend's vole	Endemic to Washington
Baird's shrew	Endemic to Oregon
Brush Prairie pocket gopher	Endemic to Washington
Western pocket gopher, ssp tumuli	Extirpated
BIRDS	
black tern	No occurrence data for colonies > 5 nests
REPTILES	
Racer	Functionally extirpated in Washington
Pacific ringneck snake	Declining; only extant south of Vancouver, WA
Pacific gopher snake	Extinct in Washington; declining in Oregon
AMPHIBIANS	
Dunn's salamander	Known occurrences within 1 mile of ecoregion
INSECTS	
Plebeius saepiolus insulanus	Vancouver Island blue
Speyeria callippe ssp.	Willamette callippe fritillary
Acupalpus punctulatus	Marsh carabid beetle
Ceratocapsus downesi	a mirid bug
Clivenema fusca	a mirid bug
Derephysia foliacea	Foliaceous lace bug
Donacia idola	Big idol leaf beetle
Eanus hatchii	Hatch's click beetle
MOLLUSCS	
Cryptomastix devia	Puget Oregonian; a terrestrial snail
Deroceras hesperium	Evening fieldslug
Hemphillia glandulosa	Warty jumping-slug

2.3.6 Setting Goals

Goal setting followed the same general approach and was constrained by the same issues as described for plants in Section 2.2. For most terrestrial animal targets goals were set by section of the ecoregion. The animals team developed two types of goals for terrestrial animals: occurrence goals and area goals.

Occurrence Goals

The goals for species occurrences were based on the state-level (a.k.a., subnational) ranking system of the Natural Heritage Program (a.k.a., NatureServe) (see Appendix 6). According to NatureServe, if a species is known to occur at less than 20 locations in a state, then the species is considered "imperiled" within that state (see 2.2.6 for more information).

The team determined that to maintain a species in an ecoregion, it should be more secure than imperiled. Hence, we set a goal of 20 secure occurrences, and stipulated that the occurrences be distributed equally among the four sections of the ecoregion, i.e., 5 per section. Furthermore, we desired at least a 0.90 probability of maintaining 5 occurrences per section over the long-term (the duration of long-term is arbitrary, but was understood to be at least 50 years).

We recognized that no population persists forever. That is, all populations have a possibility of local extirpation. Furthermore, we assumed for the purposes of this analysis that: (1) no new occurrences of target species would be discovered in the future, and (2), no new populations would be established through natural mechanisms. Therefore, in order to maintain 20 occurrences over the long term, some redundancy is needed to compensate for future losses.

To determine the amount of redundancy, R, needed, we used an equation from system reliability theory (Wolstenholme 1999):

$$R = \sum_{k=m}^{n} \frac{n!}{k!(n-k!)} p^k (1-p)^{n-k} \qquad (2\text{-}3)$$

where p is the persistence probability of an occurrence, m is the desired number of occurrences over the long term (i.e., 5), and n is the number occurrences one must have to ensure that at least m survive. This equation calculates the probability that m-out-of-n occurrences (or subpopulations) will survive. The amount of redundancy needed equals n-m.

This equation is simply a probabilistic calculation, but it requires assigning persistence probabilities to the element occurrence viability rankings. For example, the qualitative rankings might roughly correspond to the following persistence probabilities:

TABLE 2.16 Persistence probabilities

EO RANK	RANGE FOR PROBABILITY OF PERSISTENCE	MIDPOINT OF RANGE
A (excellent)	0.90 - 1.00	0.95
B (good)	0.75 - 0.90	0.825
C (fair)	0.55 - 0.75	0.65
D (poor)	0.25 - 0.55	0.4

However, due to the current degraded condition of the ecoregion and the extreme likelihood of further degradation, the animals team agreed that a typical A occurrence had about a 0.7 probability of long-term persistence. According to our calculations, a 0.90 probability of maintaining 5 (=m) such occurrences over the long-term requires starting with 9 (=n) occurrences (see Figure 2.4). Therefore, the standard ecological goal is 9 A occurrences per section if the species is found in all 4 sections. This equals a standard ecological goal of 36 A occurrences for the ecoregion.

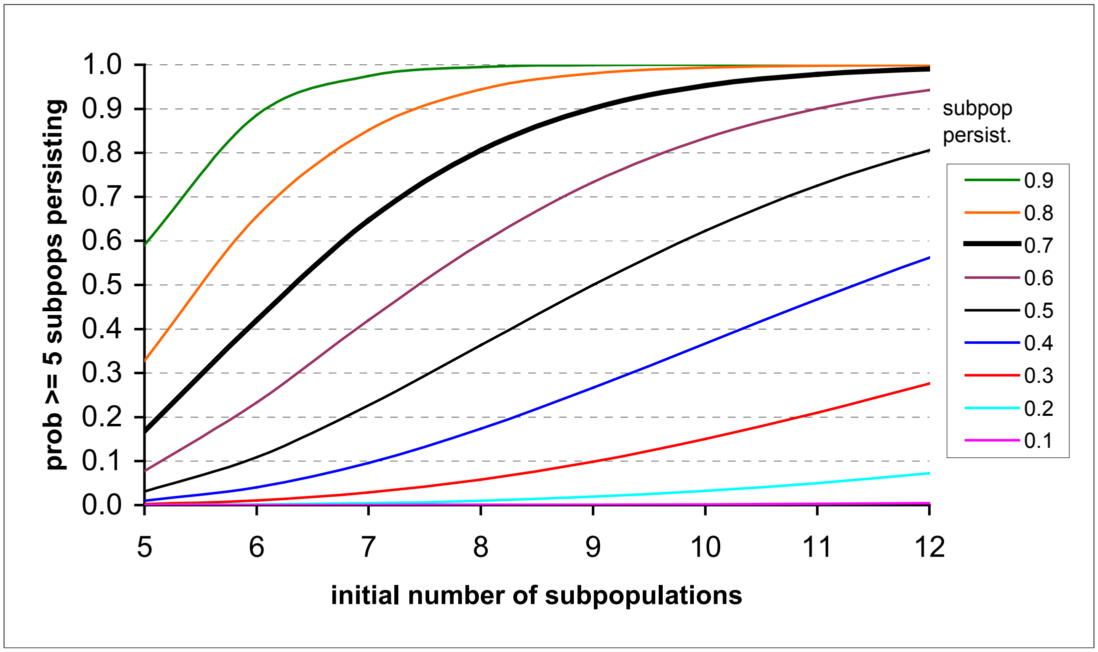


FIGURE 2.4 Number of initial populations needed to ensure that at least 5 populations (or occurrences) will persist over the long-term. For the purposes of goal setting, we assumed that A occurrence have a 0.7 probability of persistence (heavy black curve). Where the 0.7 probability curve intersects 0.9 on the vertical axis, the number of subpopulations needed is given on the horizontal axis, i.e., nine subpopulations.

This method has a number of shortcomings. First, the rank of each occurrence was based on expert opinion, an opinion informed with rather little empirical data. Second, assigning a probability of persistence of 0.7 to all A occurrences lacks scientific rigor and is rather arbitrary. Ideally, occurrence ranks would be based on a number of factors affecting viability, such as population size, population trends, local habitat quality, and landscape conditions. Unfortunately, this information is rarely available. Third, the animals team did not take into account connections across ecoregional boundaries. If populations in an ecoregion obtain demographic support from populations in neighboring ecoregions, then the number of populations (or occurrences) needed to maintain the species in the ecoregion could be reduced.

Area Goals

Area goals state the amount of a species' habitat to be included in the conservation portfolio. A subset of all target animal species (Tables 2.12 and 2.15) had area goals rather than occurrence goals. However, area goals were still based on the idea that we need at least 9 A occurrences per section to be more secure than imperiled. For the purposes of setting area goals, we equated an occurrence with a subpopulation. Hence, the goal was 9 subpopulations per section. According to Cox et al. 1994 (see also Kautz and Cox 2001), approximately 100 breeding pairs should yield a "potentionally secure population." Therefore, the goal was set to 9 subpopulations with 100 pairs each. The area needed to support 100 pairs was based on the average home range for the target species. For example, most songbird species have a mean home range of 3 ha or less; thus, a minimum area of approximately 300 ha is needed to support a songbird subpopulation. To account for habitat fragmentation and edge effects, the area per subpopulation was increased by 25% to 400 ha and the area goal needed for each songbird species is nine 400 ha patches of the species' habitat. Band-tailed pigeons have much larger mean home ranges than songbirds, about 50 ha. Hence, 6250 ha (50ha X 100pairs X 1.25) is needed to support a band-tailed pigeon subpopulation.

We recognized a substantial redundancy between area goals for target species and area goals for the coarse filter ecological systems. The landcover data used to develop the habitat models were the same landcover data used for the ecological systems. Furthermore, the goals for ecological systems were much larger than the area goals we established for animal target species; the ecological systems goal was 30% of the historic area. To simplify the analysis, the team decided to dispense with area goals for most animal species and to rely on the coarse filter to supply adequate habitat for these species (see Table 2.14). However, a small number of species retained area goals (see species listed in Table 2.13).

Goals in the Site Selection Algorithm

Decades of human settlement and intensive land use across the ecoregion have altered substantial amounts of habitat. Consequently, most target species did not have enough known occurrences to meet the goal. For these species the goal became all known occurrences (Appendix 14). For many species, the goals could not be met with all known occurrences in a section. To compensate for this shortfall, the goal was set to all known occurrences in the section plus additional occurrences in other sections. For instance, the goal for western gray squirrel was all known occurrences in the Puget Trough section and 12 occurrences in the Willamette Valley section.

Conservation Portfolio Assembly

The analysis tool for portfolio assembly, SITES, needs a quantitative goal for every target. For habitat types or plant community types, this goal was expressed as acres. For species occurrences the goal could be expressed as a number of occurrences. However, all of our occurrences were not equivalent; occurrences were ranked as A, B, C, and D. We wanted to express ecological goals in a way that would utilize this information. Based on expert opinion, we translated the qualitative ranks into quantitative scores: A =1000, B = 1000, C = 500 and D = 50. The absolute quantitative value assigned to each rank is unimportant; the relative values are. If effect, we surmised that A and B occurrences had an equivalent likelihood of persistence, or at least would exhibit no significant differences in persistence over the long term, and that B occurrences were about twice as likely to persist as C occurrences. K occurrences were assigned 500 points. By assigning 500 points to C occurrences and 50 points to D occurrences the team is saying that C and D occurrences have a 0.4 and a 0.04 probability of persistence, respectively.

Since the ecological goal for fine filter targets was 9 A occurrences per section, the quantitative goal used in the analysis was actually 9000 points. The goal might also be attained with different combinations of A, B, C, and D occurrences. For example, the goal could be attained with 18 C occurrences or with 5 A occurrences and 8 C occurrences.

2.3.7 Expert Review

External experts helped to improve the main input and output of the assessment process. Experts commented on the target species list (the main input), and species were added or subtracted (usually added) per their recommendations (see Appendix 2 for a complete list of experts).

2.4 Assessments Units and the Terrestrial Suitability Index

2.4.1 Assessment Units

Assessment units are the spatially-explicit units used in the optimal site selection algorithm. Assessment units are attributed with the amount and quality of all targets located within them. A suitability index value (described below) is calculated for each unit. Assessment units can be anything from a regular grid, such as the U.S. land survey system of Township-Range-Section, to ecologically meaningful units such as watersheds or coarse-scale habitat patches.

Choosing the assessment unit involves some trade-offs. The unit size determines the spatial resolution of the analysis. If the assessment unit is too large, then potential conservation areas will be mapped too imprecisely and the utility of the assessment will be compromised. If the assessment unit is too small, then the resolution of the analysis will surpass the precision of the data, resulting in an inaccurate mapping of potential conservation areas. Because of the time and cost involved in creating GIS-based assessment units, the use of a readily available GIS layer, such as watershed boundaries, is preferable to creating a new GIS layer. However, given the idiosyncrasies of each ecoregion, it is often the case that no readily available GIS layer is perfectly suited for use as assessment units.

The assessment unit chosen was a 750 hectare hexagon (Map 1.1). We chose this unit for the following reasons:

1. In considering watersheds, we were not able to acquire digital watershed boundaries (i.e., GIS data) that met our size criteria. We only had U.S. Geological Survey HUC6 watersheds available which were too large in size to be useful for assessment in this ecoregion.
2. Using a cadastral system such as Township-Range-Section might have provided very practical assessment units but we had no equivalent system in the British Columbia portion of the ecoregion.
3. The use of a regular polygonal grid allowed us to define a unit size that was appropriate for an ecoregion-scale assessment of a fragmented, intensively used landscape. 750 hectares seemed a reasonable size for identifying small potential conservation areas.
4. Assessment unit area can be a factor in the suitability index. Using a single size for all assessments units eliminated size as a factor.
5. Large hexagonal units have been used in other environmental assessments such as the U.S. EPA Environmental Monitoring and Assessment Program (EMAP).
6. Hexagons aggregate easily into larger units.

Hexagons have some deficiencies, such as:

- Hexagons are sometimes difficult to interpret because they are an abstract representation of the landscape.
- Hexagons do not follow any on-the-ground ecological reality. They often split watersheds, forest blocks, or other landscape features. This was the main reason we refined conservation area boundaries by overlaying selected hexagons on aerial photos (see Chapter 5).
- Hexagonal assessment units were particularly problematic for developing a nearshore portfolio. Some spits or bays were split into multiple assessment units. This was unacceptable, so we created linear-assessment units using actual shoreline data for this portion of the assessment (see Chapter 4).

From a technical perspective, covering the entire ecoregion with 750 ha hexagonal assessment units was easy to do using GIS. This resulted in 8107 assessment units (Map 1.1).

2.4.2 Terrestrial Suitability Index

Optimal site selection analyzes trade-offs between conservation value and conservation costs to arrive at an efficient set of conservation areas that satisfies conservation goals (Possingham et al. 2000, McDonnell et al. 2002). Conservation cost corresponds to the cost of maintaining the conservation value present at a particular place. The actual cost of conservation encompasses many complicated factors appropriate to each site such as restoration costs, management costs, and the cost of failing to maintain a species at the site. Because determining the monetary cost of conservation at a particular place is difficult, optimal site selection often uses a surrogate measure for conservation cost called a suitability index. A place with a high cost for indicates the likelihood of successful conservation at a particular place relative to other places in the ecoregion.

In this assessment we used optimal site selection techniques to identify the best opportunities for conservation in the ecoregion (see Map 2.3: “Building the Suitability Index”), where best opportunity is thought of as the combination at a site of high biodiversity value and high suitability for conservation. We developed a suitability index based on two simple assumptions:

1. Existing public land is more suitable for conservation than private land
2. Rural areas are more suitable for conservation than urban areas

and on three well-accepted principles of conservation biology (Diamond 1975, Forman 1995):

1. Large areas of habitat are better than small areas
2. Habitat areas close together are better than areas far apart
3. Areas with low habitat fragmentation are better than areas with high fragmentation

The first assumption was based on the work of the Gap Analysis Program (Cassidy et al. 1997, Kagan et al. 1999). Both the Oregon and Washington GAP projects rated nearly all public lands as better managed for biodiversity than most private lands. Furthermore, eminent conservation biologists have noted that existing public lands are the logical starting point for habitat protection programs (Dwyer et al. 1995). The team also reasoned that by focusing conservation on lands already set aside for public purposes, the impact on private or tribal lands and the overall cost of conservation would be less than if public and private lands were treated equally. Therefore, existing public lands could form the core of large multiple-use landscapes where biodiversity is a major management goal.

The second assumption was based on the meaning of urban area. In general, urban areas make intensive use of land for the location of buildings, structures, and impermeable surfaces to such a degree as to be incompatible with large-scale conservation of native biodiversity. This notion of urban does not preclude a need for critical areas or habitat restoration within the urban environment. Nevertheless, efficient and effective conservation of most native species will most likely occur outside of urban areas.

We expressed these assumptions and principles quantitatively through an equation for terrestrial suitability or “cost” (C):

$$C = a * \text{GAP cost} + b * \text{UGA cost} + d * \text{LANDUSE cost} \qquad (2\text{-}4)$$

where GAP cost, UGA cost, and LANDUSE cost are average values for each hexagon.

The spatial data for each term in the equation were generated as follows:

***Urban Growth Areas (UGAs)*:** We assembled GIS data for UGAs in Oregon, Washington, and British Columbia. UGAs delineate the location of current urban areas and future urbanization. The ecoregion was enlarged by a 10 km buffer to include any UGAs that were just outside the ecoregion but might impact the ecoregion. Each UGA was buffered by 10 concentric rings. Width of the buffers was a function of the UGA area. Area of the first concentric buffer was approximately half the UGA’s area. The next nine buffers had the same width as the first. Bigger UGAs had wider buffers because we would expect their negative influence to extend further out from their boundary. Inside the UGA, the cost was maximum (1000), outside the ten concentric buffers the cost was zero, and the values assigned to each successive concentric buffer decreased linearly from 1000 to 0. Where buffers from two or more nearby UGAs overlapped, the costs at that point in space were added to reflect the cumulative impacts of multiple UGAs on a conservation area (Map 2.3).

***GAP protection status*:** Every state GAP project has rated all lands in their state according to the protection they afford biodiversity (Cassidy et al. 1997, Kagan et al. 1999). All lands are assigned a value 1 through 4. One is the most protective of biodiversity and 4 is the least protective. We assembled this information along with similar information for British Columbia. We used the values assigned by Cassidy et al. (1997) and Kagan et al. (1999) except for Department of Defense lands which we changed from 4 to 3. The ecoregion boundary was buffered by 10 km to include any existing public lands that were just outside the ecoregion but could be part of the conservation network. Each polygon with GAP status 1, 2, or 3 was buffered by 10 concentric rings. Width of the buffers was a function of the polygon area. Area of the first concentric buffer was approximately half the GAP polygon area. The next nine buffers had the same width as the first. Bigger "reserves" had wider buffers and so their influence extended further out from their boundary. One purpose of the buffers is to "attract" new conservation areas to existing protected areas in portfolio assembly, thereby building large, well-connected conservation landscapes. Inside GAP 1 polygons the cost was zero, inside GAP 2 polygons the cost was 10, inside GAP 3 polygons the cost was 100, and outside the GAP polygons the cost was 1000. The values assigned to each successive concentric buffer increased linearly from 0 (or 10 or 100) to 1000. Where buffers from two or more GAP polygons overlapped, the costs at that point in space were reduced to reflect the conservation benefits of multiple nearby conservation areas (Map 2.3).

***Land use*:** Using a number of data sources, we developed a GIS grid with five land use categories: water, natural, low intensity agriculture, high intensity agriculture, and urban. The term, "natural," refers to landcover that has not been converted to other vegetation types by direct anthropogenic disturbance. In this ecoregion, natural consists of mostly conifer and deciduous forest, including oak woodlands. Forests are mostly second growth managed forest or low-density residential. The cost of natural land use was modified according to the road density in that category. This was done hexagon by hexagon. The area of each land use category and the length of road in each land use category were tabulated for every hexagon. From this, road density was calculated for the natural category for each hexagon. The completeness of road data for Washington, Oregon, and British Columbia varied, with Washington having the most complete, and British Columbia the least. To correct for this, we weighted the road density impact using the median hexagonal road density of each state or province. Thus, hexagons in Washington with the highest natural land use road density in Washington received the same negative weight as hexagons in Oregon with the highest natural land use road density in Oregon. For hexagons with natural land use road density between zero and the highest densities, we used a logistic function to assign the impact (Figure 2.5). The inflection point of each curve is [x, y] = [median natural land use road density of state's hexagons, 5], where the median natural land use road densities for hexagons in Washington, Oregon, and British Columbia were 3.23, 2.05, and 0.83 km/km^2, respectively.

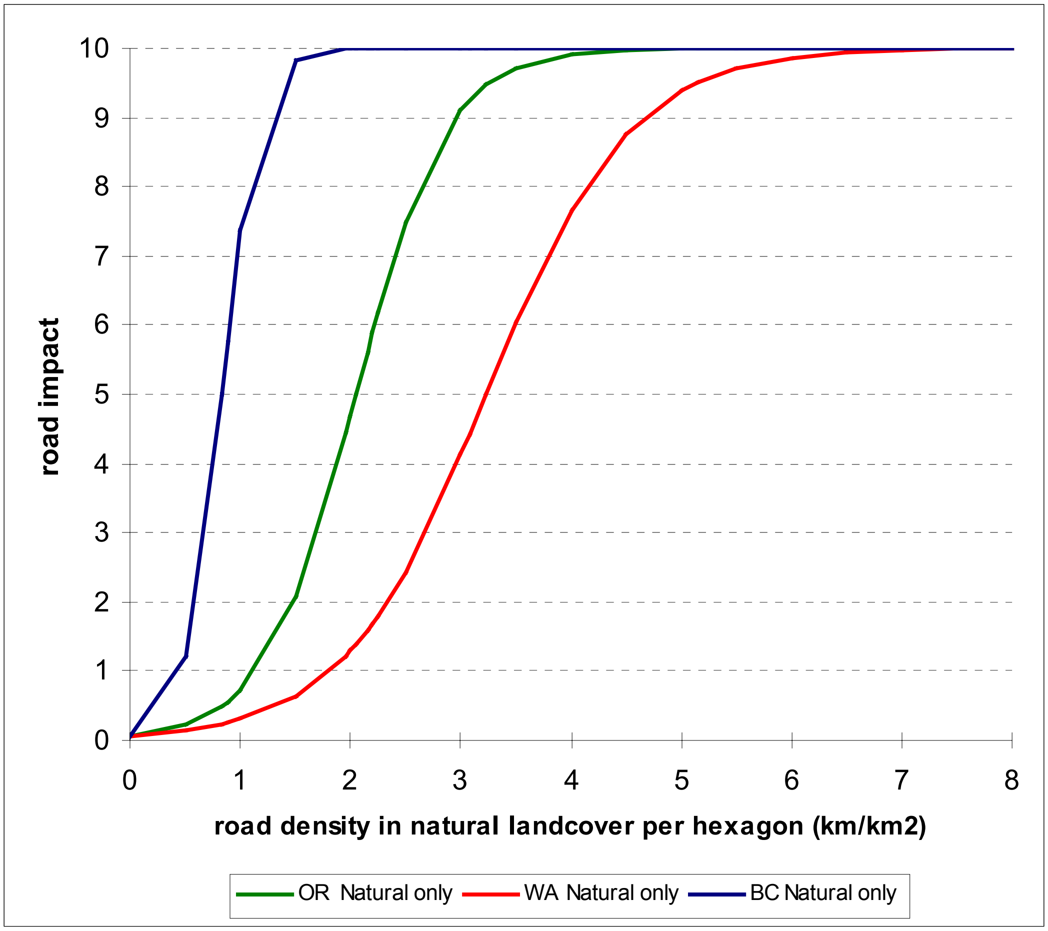


FIGURE 2.5 Logistic functions used to modify cost of forest land use category with road density.

As shown in Figure 2.5, British Columbia has a lower road density, and consequently, lower road impact than Washington or Oregon. One way to deal with poor data quality is to use a logistics function. It can convert continuous quantitative data into roughly two discrete qualitative categories with a smooth transition between the categories. For our roads data, it classifies most hexagons as either “good” hexagons (low roads impact, below the median road density) or “bad” hexagons (high roads impact, above the median road density) for conservation.

The land cover weights used in calculating the land use costs were water = 0; urban = 1000; high intensity agricultural = 600; low intensity agricultural = 300; natural, highest road density = 300; natural, zero road density = 0; natural, road density between 0 and highest = value between 0 and 300. The equation for calculating land use costs per hexagon is an average of pixels in the hexagon, and is given by:

$$\text{LANDUSE cost} = [0{*}N_w + 1000{*}N_u + 600{*}N_{ha} + 300{*}N_{la} + \Sigma f(P_n)] / N_{total} \qquad (2\text{-}5)$$

where N_w , N_u , N_{ha} , N_{la} are the number of pixels in a hexagon that are water, urban, high intensity agricultural, low intensity agricultural, respectively, N_{total} is the total number of pixels in a hexagon, P_n is a single natural pixel, and $f(P_n)$ is the logistic function that assigns cost to the natural landuse pixels. Map 2.3 shows the resulting land use/land cover map used to build the suitability index.

To combine the three GIS layers, equation (2-4) was used. The weights in the equation were: a = 3, b = 1, d =1. Therefore, the GAP term was considered to be most important. These values were subjective, but based on expert opinion. The relative cost between hexagons is shown in Map 2.4.

TABLE 2.17 Values used for independent variables in the suitability index. All values were based on expert opinion.

CONDITION	COST
URBAN GROWTH AREAS (UGA)	
Inside UGA	1000
Outside, near to UGA	>0 & <1000
Outside, far from UGA	0
GAP PROTECTION STATUS	
1: high protection	0
2: Moderate protection	10
3: Low protection	100
4: Unprotected, near to GAP 1,2, or 3	>0 & <1000
4: Unprotected, far from GAP 1,2, or 3	1000
LAND USE	
Urban	1000
High intensity agriculture	600
Low intensity agriculture	300
Natural, highly roaded	300
Natural, unroaded	0
Water	0

Table 2.17 shows the range of cost values assigned to the three components of suitability. These values were combined with the weights a, b, and d in equation 2-4 to produce suitability index values.

The methods just described are a quantitative, spatially-explicit expression of the assumptions and principles which form the conceptual basis of the suitability index. Using this suitability index (Map 2.4), the optimal site selection algorithm will prefer hexagons in and near public lands over hexagons far from public lands, lands in or near rural areas over lands in or near urban areas, and lands with natural or semi-natural land cover over lands with agricultural or urban land cover.

The three principles mentioned at the beginning of this section are well-founded in science, but the two assumptions are debatable. That is, other organizations or stakeholders may contend that biodiversity conservation on private lands is just as feasible as conservation on public lands, or that no distinction should be made between urban areas and rural areas with respect to biodiversity conservation. Certainly, there are situations where both these contentions are true. However, for this assessment we assumed that public lands are the most sensible starting point for biodiversity conservation and that "UGA" is a land use designation that is mostly incompatible with maintaining a full suite of existing biodiversity.

2.5 Terrestrial Portfolio Assembly

The preceding sections have described the steps that enabled us to gather and organize information necessary to run the optimal reserve selection algorithm. This section describes the final two steps in the creation of the terrestrial portfolio: (1) running the optimal site selection algorithm to create the automated terrestrial portfolio from the separate efforts of the plant communities, plant species, and animals species teams; and (2) reviewing and refining the automated portfolio through the input of core team members and outside experts to produce the final terrestrial portfolio.

2.5.1 The Optimal Site Selection Algorithm

The volume and complexity of the information developed in the steps described in sections 2.1 through 2.4 precluded simple inspection by experts to arrive at the most efficient, yet comprehensive, set of priority conservation areas. To help us identify and map a set of priority conservation areas we used SITES (Andelman et al. 1999), an optimal site selection algorithm.

Background

The selection of conservation areas through the application of systematic procedures has been a research topic for over 30 years (Ratcliffe 1971, as discussed in Justus and Sarkar 2002). The motivation for this research has been and continues to be the realization that protecting every site of biological value is both economically and politically infeasible (Ando et al. 1998, Pressey and Cowling 2001). Since the 1980s much research has concentrated on procedures that maximize the representation of biological diversity with the smallest number or smallest total area of conservation sites. The most efficient set of conservation sites, the optimal set, has the smallest area for a given level of biodiversity conservation.

Kirkpatrick (1983) and Margules et al. (1988) are the earliest examples of using algorithms to address the problem of optimality. These algorithms were heuristic, in that the solutions were computed by trial and error. The desire for truly optimal solutions and advances in computer technology motivated the development of more mathematical algorithms (Cocklin 1989, Church et al. 1996). Over the past twenty years many different optimal site selection algorithms, both heuristic and mathematical, have been developed and tested (Bedward et al. 1992, Underhill 1994, Pressey et al. 1996, Pressey et al. 1997, Csuti et al. 1997, McDonnell et al. 2002). Most of these algorithms do not yield a truly optimal solution, only nearly optimal solutions. Nearly optimal solutions are considered satisfactory for the practical purposes of conservation planning. Optimal reserve selection algorithms have been applied to conservation problems in Australia (Cocks and Baird 1989), South Africa (Lombard et al. 1995), the United States (Davis et al. 1999, Polasky et al. 2001) and in marine conservation (Beck and Odaya 2001). See Pressey et al. (1996), Williams (1998), Possingham et al. (2000), and McDonnell et al. (2002) for overviews of optimal site selection algorithms and methodology.

The Conservancy has developed considerable experience and expertise in the application of optimal site selection algorithms. The Conservancy has applied the technique to numerous ecoregions including the Southern Rockies (Neely et al. 2001), Great Basin (Nachlinger et al. 2001), Sonoran Desert (Marshall et al. 2000), and Canadian Rockies (Rumsey et al. 2003). All of these ecoregional assessments used SITES.

The SITES Algorithm

SITES uses a mathematical algorithm known as simulated annealing (Kirkpatrick et al. 1983). The algorithm works toward finding a set of assessment units (i.e., hexagons) that minimize an objective function. The objective function consists of three terms corresponding to unit suitability, unit adjacency, and a penalty for failing to meet target goals. SITES begins by selecting a random set of hexagons. Next, it iteratively explores improvements to this random set by randomly adding or removing other hexagons. At each iteration, the new set is compared with the previous set and the one with the lower objective function is retained. The simulated annealing algorithm utilizes some mathematical tricks to reject sub-optimal portfolios, thus greatly increasing the chances of converging on the most efficient portfolio. An optimal solution is not guaranteed, but near optimal solutions will always be achieved given enough iterations. Typically, the algorithm is run for 1 to 2 million iterations. Appendix 4 provides more details about SITES.

SITES Inputs

SITES has five main input files (Table 2.18) and three main input parameters. One file, BOUND.DAT, informs SITES on the spatial relationships of the hexagonal assessment units. The COST.DAT file has the suitability index (see section 2.4.2) values for every assessment unit. The PUVSPR.DAT file reports the biological contents of every hexagon. That is, it reports the location of every target occurrence by hexagon. The main function of the PUSTAT.DAT file is to assign certain hexagons a special status. The fate of most hexagons is determined by the selection algorithm, but some hexagons may be locked into the solution or locked out of the solution with the PUSTAT.DAT file. Section 2.5.2 explains the hexagons that were locked into and out of the SITES analysis.

The SPECIES.DAT file contains three pieces of information about every conservation target: goal, minimum area, and penalty factor. The goal is a device to select conservation priority areas. These goals are only a first approximation of how much area or how many occurrences are sufficient for a target's long-term viability. As mentioned in Chapter 1, we cannot guarantee that meeting these goals will ensure any species' long-term persistence. The goal is expressed as points or hectares. Points are a function of the number of target occurrences and the quality rank of those occurrences. Hectares correspond to the amount of ecological system or habitat type that should be captured by the selected hexagons. Goals for all targets are explained in sections 2.1 through 2.3.

TABLE 2.18 SITES input files

INPUT FILE NAME	FUNCTION	MAIN DATA FIELDS
BOUND.DAT	1 record for each adjacent pair of assessment units	common boundary length, unit A ID., unit B ID
COST.DAT	1 record for each assessment unit	unit ID, suitability index value
PUVSPR.DAT	1 record for every target occurrence	unit ID, target name, amount in unit
PUSTAT.DAT	1 record for each assessment unit	unit ID, status
SPECIES.DAT	1 record for each conservation target	target name, goal, minimum area, penalty factor

We made a distinction between goals and SITES goals. The former goals provide benchmarks for identifying high priority places for conservation by making a first attempt at answering the question of how much is enough. The latter goals were the actual inputs to SITES. Whenever possible, the latter equaled the former. There were three situations when the SITES goals did not equal our original goals. First, where insufficient occurrences of a target remain in the ecoregion to meet a goal, we set the SITES goal to 100% in order to select all remaining occurrences. The SITES goals for 119 of our 526 fine filter targets were altered to require inclusion of all known occurrences with sufficient quality rankings (see Appendix 15a). Second, for systems where area-based goals were appropriate, we also set SITES goals for number of moderate- to high-integrity (ranked C or better) occurrences in order to direct the selection algorithm toward sites with known moderate- to high-integrity occurrences, e.g., old-growth forests. Third, we customized the SITES goals for Willamette Oak Woodlands to capture the best integrity remaining occurrences for which data is available.

Minimum area refers to the minimum amount of an ecological system or habitat type in a cluster of hexagons necessary to be selected by SITES. However, minimum area does not refer to contiguous area. If several isolated patches occur in a single hexagon, then they appear to SITES as a single patch. Likewise, if several isolated patches occur in a cluster of adjacent hexagons, then they appear to SITES as a single patch. If the total area of an ecological system in a cluster of hexagons is below the minimum area, then it will not be counted toward the goal. The minimum area feature of SITES acts to reduce fragmentation of the selected portfolio by in a cluster of hexagons is below the minimum area, then it will not be counted toward the goal. The minimum area feature of SITES acts to reduce fragmentation of the selected portfolio by forming hexagon clusters containing the same ecological system. The minimum area values for coarse filter targets are given in Appendix 12b.

The penalty factor is applied to conservation targets that do not meet the goal. Every target can be assigned its own penalty factor. The higher a target's penalty factor, the more the target will influence the solution of the optimization algorithm. The higher a target's penalty factor, the more likely the solution will meet 100% of the target's goal. The penalty factor is used in the calculation of the algorithm's objective function (see Appendix 4). For our analysis we set the penalty factor of all fine filter targets to 2 and of all coarse filter targets to 1, the minimum value allowed by SITES. These values for the penalty factor place a greater emphasis on the known locations of species.

SITES has three main input parameters: the number of iterations, the number of replicates, and the boundary modifier. The number of iterations significantly influences the ability of the algorithm to achieve an optimal or near optimal solution. The number of iterations also determines the execution time of SITES, which for typical applications runs on the order of 30 minutes to 2 hours. Shorter execution times allow more analysis and hence are desirable. We explored a range of iterations from 1 to 10 million and found that solutions generated using different iteration values were indistinguishable above 2 million iterations. Hence, we used 2 million iterations for our analyses.

A single SITES run actually entails multiple individual replicates using identical parameter values and input data. An input parameter determines how many replicates comprise a single SITES run. Each replicate yields a near optimal solution somewhat different than the rest. The replicate with smallest objective function is the "best solution" or the best set of assessment units. Variation in the solutions (i.e., in the replicate sets of selected units) reflects the degree of flexibility for achieving an optimal solution. Some hexagons will be included in every solution. These hexagons are irreplaceable. Other hexagons will be included in a subset of solutions. With respect to conservation targets and suitability, these hexagons are quite similar to some other hexagons. The frequency with which a hexagon was selected strongly indicates its importance for biodiversity conservation. We refer to this selection frequency as hexagon relative importance. The output known as the "sum solution" is the number of times a hexagon was selected by multiple individual replicates. We ran 25 replicates per SITES run.

A third input parameter, the boundary modifier, controls the spatial arrangement of assessment units. This parameter can be used to promote clustering (or adjacency) of selected assessment units. Clustering will reduce fragmentation and build larger conservation areas. Clustering will also reduce edge, and SITES tracks the degree of clustering by calculating the amount of external edge (or boundary length) in the selected set of assessment units. The larger the boundary modifier value, the more important is the clustering of units. If the boundary modifier equals zero, then clustering is not considered in the objective function. Selecting the best value for boundary modifier involves some tradeoffs. If boundary modifier is too low, then selected hexagons may be too isolated. But, if the value is too high, then SITES will select hexagons with low biodiversity value or low suitability just to minimize external edge. We explored a range of values from 0.001 to 0.05, and arrived at a value of 0.01 which had a minimal effect on clustering. The Willamette Valley-Puget Trough-Georgia Basin ecoregion is a very fragmented landscape, so clumping multiple hexagons into one is frequently not realistic. Many small and isolated sites would have to be selected to come close to meeting our SITES goals. We made it our first priority to meet goals for our targets, then to meet goals with the fewest assessment units, and finally to select a portfolio in the most suitable places according to our suitability index. Given this low value, boundary length becomes a more influential factor when the algorithm has multiple options for meeting goals.

2.5.2 Creating the Automated Terrestrial Portfolio

This step focused on selecting the appropriate automated SITES run, that consisted of selected assessment units from the combined plant communities, plant species, and animals species results, and served as the foundation for subsequent portfolio refinement.

This ecoregional assessment was one of the first uses of the algorithm by team members. Hence, it was a process of exploring, testing, and learning. Over a period of twelve months the team ran hundreds of SITES analyses with varying inputs. Results were reviewed in relation to the following criteria: How well does the portfolio meet our goals? Which assessment units are consistently selected? Which assessment units are replaceable? Is the algorithm selecting places we expect it should? Did it select anything we did not expect? Through this exercise we learned about the idiosyncrasies of the algorithm, the quality of our data, and the validity of our assumptions.

As the team explored the initial SITES outputs, two major issues emerged. First, for many fine filter targets, too few known occurrences exist to meet the goals set by the plants team. For example, out of 239 plant targets, only 18 had enough data to meet our original goal. In the face of this, it was not acceptable to allow SITES to exclude any of the known occurrences in selecting assessment units for the portfolio; the tenuous outlook for the long-term survival of these rare targets demanded inclusion of all known occurrences. For this reason, the goal instructions to SITES for 119 of our 526 fine filter targets were altered to require inclusion of all known occurrences with sufficient data confidence ratings (see Appendix 15a).

Second, for the most common coarse filter targets, the total occurrence area included in the automated portfolio when SITES was instructed to meet a goal of 30% of historic extent was, in fact, significantly in excess of this goal. This can happen in SITES when the ecoregion contains more area of a coarse filter target than is necessary to meet the goal. In selecting assessment units for other targets, occurrences of coarse filter targets are brought into the portfolio incidentally, with the end result that the goal for many common coarse filter targets is exceeded. For example, a 30% goal for Douglas-fir–Western Hemlock–Western Red Cedar Forest in the Willamette Valley section resulted in a portfolio with 35% of historic extent. To address this, the team tested alternate goals to determine which one would produce an end result in the portfolio of roughly 30% of historic extent. For some targets, it was not possible to reduce the goal sufficiently to end up with only 30% in the automated portfolio.

In running SITES with these customized (lowered) goals for common coarse filter targets, the model has more occurrences to choose among. The influence of the suitability index on selection of assessment units became more pronounced in this situation. One visible result is the selection of assessment units on the fringes of the ecoregion, mostly rural and forested uplands, particularly in the Willamette Valley.

Table 2.19 provides a summary of SITES input parameters used to create the automated terrestrial portfolio.

TABLE 2.19 Values for SITES parameters used in development of portfolio

PARAMETER	FUNCTION	VALUE
Assessment units	Sets the spatial resolution of the analysis	8107 hexagons of 750 ha
Replicates	Number of times to repeat full optimization	25
Iterations	Number of times to test new combination of hexagons	2,000,000
Boundary modifier	Weighting factor for "cost" of nonadjacent hexagons	0.01
Species penalty factor	"Cost" of not meeting a species' goal	2 for all fine filter targets 1 for all coarse filter targets (1 = minimum allowed value)
Hexagon status	Initial state of each hexagonal assessment unit	1 for high biodiversity units (locked in) 1 for forest block units 0 for all other hexagons

The resulting automated terrestrial portfolio consists of 2621 assessment units selected or about 32% of the ecoregion (see Map 2.5). This automated portfolio was completely SITES driven. It is not the final portfolio. From this beginning, expert review and integration with marine and freshwater information are needed to build a portfolio that is a reliable guide for conservation (see chapter 5).

2.5.3 Expert Review of the Terrestrial Portfolio

Using the automated terrestrial portfolio, we conducted a series of portfolio review workshops to incorporate terrestrial expert comments, including some comments relating to the marine and freshwater portfolios. These workshops were an effort to test the results of our model and document any comment experts might have to either verify results or correct errors of omission or inclusion.

We recorded comments according to the relevant assessment unit(s) and asked participants to delineate sites by recording which hexagon or group of hexagons might best represent a potential conservation area. Members of the core teams reviewed comments and made final changes to the portfolio. The following categories of changes (also summarized in Table 2.21 and illustrated in Map 5.1) were made as a result of this expert review:

- **High Biodiversity Units-** Areas identified in the automated portfolio and confirmed by expert opinion or areas in the automated portfolio omitted but known by experts (and verified by further review) to have high biological significance were added to the portfolio. These assessment units were always included, or 'locked in' for inclusion by SITES in all successive portfolio runs.

- **Intact Forest Blocks-** Forest systems form the dominant vegetation matrix in the northern portion of the ecoregion. Due to limitations in the vegetation map for the ecoregion regarding its age and level of resolution, some of what was classified as forest cover was or has since been converted to other uses.

To address these shortcomings, we consulted with forest ecologists familiar with the ecoregion and aerial photographs to identify the remaining large tracts of forest in the ecoregion. We defined a forest block as an area that consisted of at least 1000 continuous ha (including early-successional areas recently harvested that are being managed as forestlands) with little or no development (less than 1 house per 16 ha). Forest blocks were selected for the value of their target occurrences as well as their contribution to larger landscape integrity by connecting areas of biological significance. For example, the forest blocks delineated in the Washington portion of the Lower Columbia section provide the only link between the Cascades and the Willapa Hills, and were selected based on this value.

- **Riparian Corridors-** This is a special category that was primarily used to select major riparian corridors that might not otherwise be captured in the portfolio because we wanted to make sure that we were able to include continuous stream reaches. In addition to riparian areas selected in the portfolio, the Willamette river was designated as Urban Riparian Corridor where it runs through urban areas (i.e., through Eugene, Corvallis, Albany, Salem, and Portland) (Table 2.20b). These Urban Riparian Corridor assessment units were not locked into the portfolio and most were not selected as part of the final portfolio. They were documented as such to record the importance of the entire river corridor in future implementation and conservation planning. Map 5.1 shows Urban Riparian Corridors along with units that were locked into the portfolio.

- **Wintering Bird Areas (WBA)-** Areas important for wintering birds were not included as target occurrences for selection by SITES. Experts classified assessment units as important Wintering Bird Areas to highlight areas of importance for these aggregations. One example is the Skagit River delta, a very important area for migrating birds that was not selected in its entirety in the automated portfolio because we did not specifically target many of the abundant species in our analysis that congregate there. Wintering Bird Area assessment units were not locked into the automated portfolio analysis but were used to guide area delineation later in the portfolio assembly process.

- **Lock-outs-** Nine hexagons were locked out of subsequent SITES runs due to expert input confirming data errors or non-viable target occurrences. All nine are in highly urbanized areas.

TABLE 2.20 Expert input to the automated portfolio

a. Terrestrial Assessment Units Locked into the Portfolio:

CATEGORY	COUNT OF ASSESSMENT UNITS
High Biodiversity	684
Intact Forest Block	577
Riparian Corridor	71
Total	**1332**

b. Assessment Units Tracked with Expert Information not Locked into the Portfolio:

CATEGORY	COUNT OF ASSESSMENT UNITS
Urban Riparian Corridor	30
Wintering Bird Area	166
Total	**196**

Willamette Valley Section Special Case

Based on expert review, we found that the automated terrestrial portfolio needed some additional modification in the Willamette Valley section. Since many target occurrences there were more widely scattered and of poor quality, a problem arose where it was difficult to discern the relative quality among the large number of selected hexagons. Many selected hexagons contained only a few low quality target occurrences. For this reason, a special SITES run was created for this section using only 50% of the target goals, resulting in a much smaller "footprint" of higher quality hexagons relative to the other sections. Following this exercise hexagons were added to this "50% portfolio" based on several factors, including hexagons with 8 or more targets, A or B occurrences, or at least 65 hectares of oak woodland. This bottom up approach of building the hexagon portfolio from an initially smaller core of hexagons was compared with the original automated portfolio map and found to be a more efficient way to meet target goals. This modified hexagon map of the Willamette Valley section was used for the subsequent integration and delineation process described in Chapter 5.

Chapter 3 – Freshwater Systems and Species

This chapter describes the methods used for identifying important freshwater conservation areas. The freshwater technical team adhered to the same assessment process and principles as the terrestrial and marine teams, but the freshwater analysis was not confined to the Willamette Valley-Puget Trough-Georgia Basin ecoregion. Instead, the freshwater analysis used a type of region more suited to freshwater ecosystems called an ecological drainage unit (EDU). Six EDUs intersect the ecoregion and extend beyond the ecoregion boundary. Thus, the freshwater assessment and portfolio described includes all of the area within the 6 EDUs.

The freshwater assessment in its current form is preliminary; both the methodology and the preliminary portfolio are still in the process of peer and expert review. While the analyses are a useful beginning for assessing freshwater biodiversity, they are limited in their precision, comprehensiveness, and reliability as described in this chapter. Therefore, the freshwater analysis was not used to identify priority conservation areas but was used to influence the boundaries of priority areas identified by the terrestrial analysis.

The freshwater team did not specifically address anadromous salmonids as conservation targets. Major programs are in place by government, tribes, academia, and other non-governmental organizations to develop and implement salmonid conservation strategies for the ecoregion. This assessment should be used as additional information to complement that body of work.

Topics described in this chapter include the following:

3.1 Technical Team

The technical team that identified the freshwater ecological systems and species in the Willamette Valley-Puget Trough-Georgia Basin was composed of experts from The Nature Conservancy (TNC) and the Nature Conservancy of Canada (NCC). The team consisted of the following people:

Mark Bryer	TNC, Arlington, VA
Kristy Ciruna	NCC, Victoria, BC
Tracy Horsman	TNC, Seattle, WA
Pierre Iachetti	NCC, Victoria, BC
Cathy MacDonald	TNC, Portland, OR
Peter Skidmore	TNC, Seattle, WA

3.2 Selecting Conservation Targets and Collecting Target Data

Our analysis of freshwater biodiversity in the Willamette Valley-Puget Trough-Georgia Basin ecoregion included the identification of targets at both the species (fine filter) and ecological system (coarse filter) levels. Methods used to identify targets at both levels are described in this section and are based largely on Groves et al. (2000 and 2002) and Higgins et al. (1998).

3.2.1 Defining Ecological Drainage Units

As a basis for the freshwater assessment we mapped ecological drainage units (EDUs). EDUs are groups of watersheds that share a common zoogeographic history, physiography, and climatic characteristics, and are therefore likely to have a distinct set of freshwater communities and habitats. Several researchers have demonstrated that drainage basin and physiography are important determinants of freshwater biodiversity distribution patterns (Jackson and Harvey 1989; Pflieger 1989; Maxwell et al. 1995; Angermeier and Winston 1999; Angermeier et al. 2000; Oswood et al. 2000; Rabeni and Doisy 2000). Additionally, drainage and physiography have been incorporated into region-specific aquatic classification schemes in Missouri (Pflieger 1989) and California (Moyle and Ellison 1991).

EDUs are spatial units that are more appropriate than ecoregions for analysis of freshwater biodiversity. Their boundaries follow major watershed boundaries and take into account biogeographic patterns of aquatic fauna. They are subdivisions of aquatic zoogeographic units (sensu Maxwell et al. 1995) and spatially stratify ecological variation across larger zoogeographic regions. Ecological draining unit boundaries are geographically independent of ecoregion boundaries. Typically, several will intersect a single ecoregion.

We defined EDUs based on two main sources of information:

1. ***Native species zoogeography*** determined at a regional scale by Hocutt and Wiley (1986), World Wildlife Fund's freshwater ecoregions (Abell et al. 2000), and the U.S. Forest Service (USFS) (Maxwell et al. 1995). Additional data consulted included the US National Marine Fisheries Service (ESU boundaries for salmonids), Haas (1998), and McPhail and Carveth (1994).
2. ***Ecoregional/ecozone attributes*** as defined by the USFS (McNab and Avers 1994, Pater et al. 1998) and ecozones from Environment Canada (http://www.ec.gc.ca/soerree/English/Framework/NarDesc/).

We aggregated the USGS 8-digit Hydrologic Unit Code (HUCs) (Seaber et al. 1987) or British Columbia Watershed Atlas units based on the following criteria:

- ♦ Similarity in patterns of physiography and climate, which were visually interpreted from USFS and Environment Canada resources
- ♦ Similarity in fine scale patterns of zoogeography, interpreted from the following sources:

  1. Descriptions of fish biogeography found in Hocutt and Wiley (1986) and Haas (1998)

  2. Results of a multivariate (cluster) analysis performed using historical presence/absence data of fish at the scale of the 8-digit HUC (data from Larry Master, NatureServe)

- ♦ Similarity in patterns of watershed connectivity (i.e., the networks formed by freshwater systems, including lakes, wetlands, glaciers, streams, and coastal waters)

The team defined six EDUs intersecting the Willamette Valley-Puget Trough-Georgia Basin ecoregion (Map 3.1, Table 3.1).

TABLE 3.1 EDUs intersecting the Willamette Valley-Puget Trough-Georgia Basin Ecoregion

EDU	PHYSIOGRAPHY	CLIMATE	ZOOGEO GRAPHY	STREAM TYPES
Georgian Strait	high, irregular, steeply-sloping mountains; large, steep-sided, transverse fjords dissect the region	high precipitation (1500 – 3400 mm/yr)	Pacific coast	crystalline gneisses and granitic rocks; many large glaciers extend to low elevations
Vancouver Island	numerous, steep-sided, transverse valleys, inlets, and sounds dissect the north and western portion; east and south: generally low relief mixed with areas of sharp crests and narrow valleys	in the north and west, mild and wet (1500 to 3800 mm/yr); in the east and south it is also mild but drier (800 – 2500 mm/yr)	North Pacific coast	short, steep coastal systems) with some blackwater systems in the northern lowlands; lakes have high flushing rates; depauperate fauna
Puget Sound	low elevation morainal valley surrounded by mid- to high-elevation glaciated mountains; complex of oceanic islands	high variability between valley and mountains (20–150 in/yr)	North Pacific coast	small to medium river systems (e.g., Skagit, Snohomish, Nooksack) with predominantly volcanics at high elevations and sedimentary rock at lower elevations, estuaries and wetlands abundant
Olympic-Chehalis	mid-elevation predominantly unglaciated mountains	high precipitation (up to 250 in/yr)	North Pacific coast	small to medium, deeply incised, steep river systems connected to coast; predominant geology greenschist and greywacke
Willamette Valley	low elevation outwash plain surrounded by mid- to high-elevation mountains	high variability between valley and mountains (20–150 in/yr)	Lower Columbia	large river (Willamette) with many coldwater tributaries merging from mountains; scattered lakes; volcanic geology dominates
Lower Columbia	valley through portions of Cascade and Coastal Ranges	high variability between valley and mountains (20–150 in/yr)	Lower Columbia	mainstem Columbia river from Cascades to ocean, and associated Cascadian and coastal tributaries (Cowlitz, Klickitat, Sandy)

The EDUs that intersect the ecoregion include a variety of freshwater habitat types influenced by highly variable geology and dramatic moisture and elevation gradients. Thus, the freshwater ecological systems are also varied, from large rivers like the Columbia and Willamette, to high gradient glacial-fed forested tributaries.

3.2.2 Selecting Conservation Targets

We selected conservation targets at multiple spatial scales and levels of biological organization. Targets and target goals were determined for each EDU intersecting the ecoregion. This ecosystem-level approach to conservation is particularly important for freshwater biodiversity, since region-wide data exist for few non-game species and rarely, if ever, for communities.

3.2.3 Coarse Filter Targets – Aquatic Ecological Systems

Due to the lack of species occurrence data, the freshwater technical team applied the same coarse filter/fine filter approach detailed in Chapter 2 Terrestrial Systems.

Comprehensive information on freshwater communities and ecological systems was not available for the region. To address this gap, we developed a freshwater classification system using the hierarchical classification framework described in Higgins et al. (1998 and 2003). The classification system was used to identify coarse filter targets—158 aquatic ecological systems—for all of the area within the 6 EDUs intersecting the Willamette Valley-Puget Trough-Georgia Basin ecoregion (Maps 3.2a, 3.2b and 3.2c). Aquatic ecological systems are defined as follows:

1. Assemblages of macrohabitats which commonly occur together and exhibit similar geomorphological patterns;

2. Assemblages of macrohabitats which are tied together by similar ecological processes (e.g., hydrologic and nutrient regimes, access to floodplains and other lateral environments) or environmental gradients (e.g., temperature, chemical, and habitat volume); and,

3. A cohesive and distinguishable spatial unit.

The multi-scale, landscape-based classification framework for freshwater ecological systems is based on key principles of and empirical studies in freshwater ecology. For example, local patterns of aquatic physical habitats and their biological components are the product of a hierarchy of regional spatial and temporal processes (Tonn 1990; Angermeier and Schlosser 1995; Angermeier and Winston 1999; Mathews 1998; Frissell et al. 1986). Continental and regional aquatic zoogeographic patterns result from drainage connections changing in response to climatic and geologic events (e.g., Hocutt and Wiley 1986). Regional patterns of climate, drainage, and physiography determine aquatic ecological system characteristics (morphology, hydrologic, temperature and nutrient regimes) that, in turn, influence biotic patterns (Hawkes et al. 1986; Maret et al. 1997; Poff and Ward 1989; Poff and Allan 1995; Pflieger 1989; Moyle and Ellison 1991). Within regions, there are finer-scale patterns of stream and lake morphology, size, gradient, and local zoogeographic sources that result in distinct aquatic assemblages and population dynamics (e.g., Maxwell et al. 1995; Seelbach et al. 1997; Frissell et al. 1986; Rosgen 1994; Angermeier and Schlosser 1995; Angermeier and Winston 1999; Osborne and Wiley 1992. See Mathews 1998 for an extensive review).

There are two principle steps in identifying the freshwater coarse filter classification: classification of macrohabitats (reach level) and classification of aquatic systems (repeatable patterns of aggregations of macrohabitats).

Macrohabitats

Macrohabitats are units of streams and lakes that are similar with respect to their size, thermal, chemical, and hydrological regimes. Each macrohabitat type represents a different physical setting that correlates with patterns in freshwater biodiversity (Vannote et al. 1980).

We reviewed relevant literature (e.g., Whittier et al. 1988, Altman et al. 1997, Carpenter and Waite 2000, Waite and Carpenter 2000) and consulted with regional experts to determine which physical attributes were most important for structuring aquatic communities. We identified the attributes shown in Table 3.2, and modeled them as individual variables in the Willamette Valley-Puget Trough-Georgia Basin.

Using GIS, we applied this classification framework to partition and map environmental patterns that strongly influence the distribution of freshwater biodiversity from the stream reach to regional basins. A manuscript describing the classification framework in greater detail is currently in preparation (Higgins et al. 2003). The overall basis for our approach stems from an expert workshop that the Conservancy held in 1996 (Lammert et al. 1997).

We applied the classification framework in a two step process to identify our freshwater coarse filter targets in the Willamette Valley-Puget Trough-Georgia Basin. In the first step, we classified and mapped the diversity of freshwater habitats at a reach scale resulting in hundreds of macrohabitats for each EDU. In the second step, we combined adjacent macrohabitats into aquatic ecological systems. The resulting 158 aquatic ecological systems identified for all 6 EDUs became the coarse filter conservation targets. The following paragraphs describe this process in greater detail.

TABLE 3.2 Macrohabitat Attributes of Aquatic Systems in Willamette Valley-Puget Trough-Georgia Basin Ecoregion

FACTOR	DESCRIPTION	
Size[1]	Measured as contributing drainage area to each segment of stream as mapped in the GIS database. Watershed area is applied as a correlate for channel morphology, hydrologic flow regime (assuming constant climatic gradients throughout an EDU), and dominant discharge. The classes chosen reflect broad changes in stream habitat and flow rates.	
	Class	**Class Value**
	1	0 – 100 km^2 (headwaters, creeks)
	2	100 – 1000 km^2 (small rivers)
	3	1000 – 10,000 km^2 (medium rivers)
	4	> 10,000 km^2 (large rivers)
Geology[2]	Dominant geology measured in the contributing watershed area for each segment in the GIS database. This variable is a surrogate intended to represent the variability in flow regime (in conjunction with topography to determine groundwater versus surface water contribution) (Seelbach, 1997), water chemistry, stream substrate composition, and stream morphology. The classes chosen were based on an integration of geological types from three separate data sources, and were selected using guidelines from Quigley et al. (1997) to reflect major differences in hydrology, chemistry, and stream substrate. The following is a list of geologic classes included in the classification, though not all classes applied to all EDUs due either to absence of geologic units within the EDU, or absence of data.	
	Class	**Class Value**
	1	Alluvium-colluvium
	2	Basalt-mafic-extrusive
	3	Glacial drift
	4	Granitic-silicic
	5	Quaternary lakeplain
	6	Sandstone
	7	Shale
	8	Siltstone
	9	Ice
	10	Eolian sand
	11	Erodable volcanics
	12	Coarse outwash
	13	Carbonate-limestone
	14	Peat
	15	Ultramafic-serpentine
	16	Slate
Stream Gradient[3]	Slope of segment measured for each segment in GIS. This variable influences stream morphology, stream power (energy), and habitat types. Classes were derived from a combination of sources including Rosgen (1994), Ian Waite at USGS (personal communication), and Tony Cheong at the British Columbia Ministry of Sustainable Resource Management (personal communication).	
	Class	**Class Value**
	1	<.005
	2	.005 –.02
	3	.02 –.04
	4	.04 –.10
	5	.10 – .20
	6	>.20

TABLE 3.2 (Cont'd.) Macrohabitat Attributes of Aquatic Systems in Willamette Valley-Puget Trough-Georgia Basin Ecoregion

FACTOR	DESCRIPTION	
Elevation[4]	Average elevation of segment. This variable corresponds to some species limits, flow regime (snow melt amount and timing), and stream temperature. Classes are based roughly on level 4 ecoregions from Pater et al. (1998).	
	Class	**Class Value**
	1	<100m
	2	100 – 300m
	3	300 – 1000m
	4	>1000m
Upstream and Downstream Connectivity[5]	Type of macrohabitat immediately upstream and downstream. Downstream connectivity captures local zoogeographic variation by considering differences in the species pool in downstream habitats; upstream connectivity captures effects from upstream segments on both hydrologic regime and chemistry.	
	Class	**Class Value**
	1	Unconnected
	2	Stream/river
	3	Lake
	4	reservoir
	5	wetland
	6	glacier (upstream) or coastal (downstream)

Key: Data Used

1. USGS National Hydrography Dataset (NHD) at 1:100,000 and USGS National Elevation Dataset (NED) at 30m resolution, for WA and OR. British Columbia Watershed Atlas Dataset at 1:50,000, and BC TRIM Dataset at 90m resolution.
2. Washington State Department of Natural Resources Division of Geology and Earth Resources at 1:100,000, USGS Geologic map of Oregon (1991) at 1:500,000, Bedrock Geology from BC Ministry of Energy & Mines at 1:250,000, and Surficial Geology from the Geological Survey of Canada at 1:5 million.
3. USGS National Hydrography Dataset (NHD) at 1:100,000 and USGS National Elevation Dataset (NED) at 30 m resolution, for Washington and Oregon. British Columbia Watershed Atlas Dataset at 1:50,000, and BC TRIM Dataset at 90 m resolution.
4. USGS National Hydrography Dataset (NHD) at 1:100,000 and USGS National Elevation Dataset (NED) at 30 m resolution, for Washington and Oregon. British Columbia Watershed Atlas Dataset at 1:50,000, and BC TRIM Dataset at 90m resolution.
5. USGS National Hydrography Dataset (NHD) at 1:100,000 and British Columbia Watershed Atlas Dataset at 1:50,000.

Each macrohabitat type can be defined as a unique combination of the variables shown above in Table 3.2. For example, a macrohabitat type could be a headwater stream (<100 km^2), dominated by volcanic geology, steep gradient (0.10–0.20), high elevation (>1000 m), unconnected upstream, and connected to a small river downstream.

Macrohabitats are easily mapped in GIS. Any single variable or combination of variables can be mapped to display patterns in the occurrences of each macrohabitat type. Within the 6 EDUs that intersect the Willamette Valley-Puget Trough-Georgia Basin ecoregion, we defined 599 macrohabitats from the over 4,000 potential macrohabitat types. This included 170 of 298 in the Puget EDU, 109 of 229 in the Lower Columbia EDU, 100 of 192 in the Vancouver Island EDU, 129 of 187 in the Willamette EDU, 42 of 99 in the Pacific Chehalis EDU, and 49 of 245 in the Georgia EDU.

Note that we have not created lake macrohabitats in this classification. Given the size and distribution of natural lakes in the region encompassing the 6 EDUs, we have assumed that the variety of aquatic habitats and communities that lakes encompass were captured in the watersheds that constitute aquatic ecological systems described below. Section 3.3.2 further describes our treatment of lakes.

Aquatic Ecological Systems

Macrohabitats create a detailed and often complex picture of physical diversity. Aquatic ecological systems provide a means to generalize patterns in streams and lakes, and to capture the ecological processes that link groups of macrohabitats. Aquatic ecological systems provide a practical tool that combines macrohabitats into a scale that can be used for the ecoregional planning process. They also provide a framework for selecting potential conservation areas at scales used by resource managers.

We defined the ecological system types in the EDUs that intersect the Willamette Valley-Puget Trough-Georgia Basin using multivariate analysis to group neighboring macrohabitats that share similar patterns. Four scales of watersheds—equivalent to the macrohabitat size classes of <100 km^2, 100–999 km^2, 1000–10,000 km^2, and >10,000 km^2—were used to assess macrohabitat diversity and classify ecological systems. System assessment boundaries were defined using these same watersheds in a nested fashion to prevent overlap (see section 3.5.1 for more detail). Macrohabitat lengths were measured relative to watershed area to discount differences in watershed size within class. We classified each set of watersheds within a size class separately, then attributed the system membership to only the macrohabitats which are of the same size class.

Using the PC-ORD multivariate program software (McCune and Mefford 1995), we determined the most consistent set of parameters for analysis to be an agglomerative clustering algorithm, Euclidean distance measure, and Ward's group linkage method. The final clusters for each EDU were determined with manual editing and review, comparison with other ecoregional units (e.g., Pater et al. 1998), and expert review with individuals from Washington Department of Fish and Wildlife, Washington Department of Natural Resources, US Army Corps of Engineers, US Fish and Wildlife Service, United States Forest Service, British Columbia Ministry of Sustainable Resource Management, University of British Columbia, and Canadian Department of Fisheries and Oceans.

The over 5200 watersheds within the six EDU were classified into 158 aquatic ecological system types and mapped in a GIS (see Maps 3.2a–c).

3.2.4 Fine Filter Targets – Aquatic Species

The freshwater technical team followed the same approach as the terrestrial animals team (see Chapter 2.3) to identify species that are naturally rare, under severe threat, endemic to the EDU, and/or declining in abundance. We identified a total of 36 aquatic species targets, including 13 fishes (excluding salmonids), 8 molluscs, 3 invertebrates, and 12 plants (Appendix 16). Target selection criteria and spatial representation information can be found in Appendix 17. As explained in the introduction to this chapter, salmonids were not selected as targets.

Data used to compile the list were obtained from the CDC, WNHP, ONHIC and state, provincial (e.g., Haas 1998), and federal sources (e.g., National Marine Fisheries Service). Spatial data used to map occurrences of each target were collected from the same sources, but were not available for all targets; these targets will need to be reviewed for inclusion in future iterations of this assessment as additional data are collected.

Original data sources represented occurrences of species targets as either points or lines in a GIS. For the purposes of portfolio assembly using SITES (described in detail in Appendix 4 and Chapter 5), we attributed these points and lines to the underlying ecological system occurrence polygons.

TABLE 3.3 Fine Filter Targets (species) for Freshwater Biodiversity in the Willamette Valley-Puget Trough-Georgia Basin Ecoregion.

TAXA	COMMON NAME	SCIENTIFIC NAME	G-RANK	OR RANK	OR OCCURS	OR GIS DATA USED	WA RANK	WA OCCURS	WA GIS DATA USED	BC RANK	BC LIST	BC OCCURS	BC GIS DATA USED	DISTRIBUTION
Fish	White sturgeon (Columbia River)	*Acipenser transmontanus pop2*	G4T?		Y	no		Y	no			N		Endemic
Fish	White sturgeon (Fraser River)	*Acipenser transmontanus pop4*	G4T2		N			N				Y	no	Endemic
Fish	Salish sucker	*Catostomus sp 4*	G1		N			Y	yes			Y	yes	Endemic
Fish	Vananda Creek benthic stickleback	*Gasterosteus sp*	G1		N			N				Y	yes	Endemic
Fish	Vananda Creek limnetic stickleback	*Gasterosteus sp*	G1		N			N				Y	yes	Endemic
Fish	Enos Lake limnetic stickleback	*Gasterosteus sp 2*	G1		N			N				Y	yes	Endemic
Fish	Enos Lake benthic stickleback	*Gasterosteus sp 3*	G1		N			N				Y	yes	Endemic
Fish	Paxton Lake limnetic stickleback	*Gasterosteus sp 4*	G1		N			N				Y	yes	Endemic
Fish	Paxton lake benthic stickleback	*Gasterosteus sp 5*	G1		N			N				Y	yes	Endemic
Fish	Pacific lamprey	*Lampetra tridentata*	G5		Y	yes		Y	yes			U	yes	Widespread
Fish	Olympic mudminnow	*Novumbra hubbsi*	G3		N			Y	yes			N		Endemic
Fish	Oregon chub	*Oregonichthys crameri*	G2		Y	yes		N				N		Endemic
Fish	Nooksack dace	*Rhinichthys sp 4*	G3		N			Y	no			Y	yes	Endemic
Mollusc	Willamette floater (mussel)	*Anodonta wahlametensis*	G2Q		Y	no		N				N		Limited
Mollusc	Shortface lanx	*Fisherola nuttalli*	G2		Y	no		Y	no			U		Widespread
Mollusc	Columbia pebblesnail	*Fluminicola columbiana*	G3		Y	no		Y	no			U		Widespread
Mollusc	Western ridgemussel	*Gonidea angulata*	G3		U			Y	yes			U		Widespread
Mollusc	Barren juga (snail)	*Juga hemphilli hemphilli*	G2?T2		Y	no		U				U		Endemic
Mollusc	Columbia duskysnail	*Lyogyrus sp 4*	G2		Y	no		U				U		Endemic?
Mollusc	Rotund physa (snail)	*Physella columbiana*	G2		Y	no		U				U		Endemic
Mollusc	Nerite ramshorn (snail)	*Vorticifex neritoides*	G1Q		Y	no		U				U		Endemic
Invertebrate	California floater (mussel)	*Anodonta californiensis*	G3		Y	no		Y	no			N		Widespread
Invertebrate	River jewelwing	*Calopteryx aequabilis*	G5		N			Y	no			N		Widespread
Invertebrate	Pacific clubtail	*Gomphus kurilis*	G4		N			Y	no			N		Widespread
Plant	*Elodea nuttallii*	*Elodea nuttallii*	G5	SU			SR			S2S3	BLUE		yes	Widespread
Plant	*Howellia aquatilis*	*Howellia aquatilis*	G2	SH		no	S2		no					Limited
Plant	*Hydrocotyle verticillata*	*Hydrocotyle verticillata*	G5	S1		no								Widespread
Plant	*Marsilea vestita*	*Marsilea vestita*	G5	SR			SR			S1				Widespread
Plant	*Myriophyllum pinnatum*	*Myriophyllum pinnatum*	G5							S1	RED		yes	Widespread

TABLE 3.3 (Cont'd.) Fine Filter Targets (species) for Freshwater Biodiversity in the Willamette Valley-Puget Trough-Georgia Basin Ecoregion.

TAXA	COMMON NAME	SCIENTIFIC NAME	G-RANK	OR RANK	OR OCCURS	OR GIS DATA USED	WA RANK	WA OCCURS	WA GIS DATA USED	BC RANK	BC LIST	BC OCCURS	BC GIS DATA USED	DISTRIBUTION
Plant	*Myriophyllum quitense (=M elatinoides)*	*Myriophyllum quitense (=M elatinoides)*	G4?				SR			S2S3	BLUE		no	Widespread
Plant	*Myriophyllum ussuriense*	*Myriophyllum ussuriense*	G3				SR			S3	BLUE		yes	Limited?
Plant	*Nymphaea tetragona*	*Nymphaea tetragona*	G5				SH		no	S2				Widespread
Plant	*Potamogeton fibrillosus*	*Potamogeton fibrillosus*	G5T2T4	SH			SR							Widespread
Plant	*Potamogeton oakesiansus*	*Potamogeton oakesiansus*	G4							S1?	BLUE		yes	Widespread
Plant	*Potamogeton obtusifolius*	*Potamogeton obtusifolius*	G5				S1		no	S3				Widespread
Plant	*Wolffia columbiana*	*Wolffia columbiana*	G5	S1		no				S1	RED		yes	Widespread

3.3 Data Gaps

We identified a number of data gaps within the freshwater analysis that should be addressed in subsequent analyses of this assessment.

3.3.1 Additional Data Sets

Although relevant information from a number of important data sets was incorporated in the site selection process, a number of other identified data sets were not used due to the difficulty of integrating them in the time given. These other data sets typically reflect expert knowledge about conditions in the field. Further portfolio refinement would benefit from incorporating the following sources of data:

- Oregon AFS high integrity watersheds (GIS data available from http://www.sscgis.state.or.us/)
- Existing protected areas (GAP level 3 and 4)
- FEMAT Key Watersheds (GIS data from http://www.reo.gov, 1993)
- Essential Salmonid Habitat from the Oregon Division of State Lands (pdf files from http://statelands.dsl.state.or.us/esshabitat.html showing critical habitat for salmonids in each 8-digit HUC in the basin dated April 1999)
- Haas (2000)- key watersheds for biodiversity conservation in British Columbia

3.3.2 Occurrences of Species Targets and Lakes

Data gaps for fine filter targets include incomplete solicitation of expert input on species of concern and insufficient occurrence or habitat data for many species. No documented occurrence or habitat data were available for 28 of the 36 species targets identified. One of these species, the Columbia River White Sturgeon (*Acipenser transmontanus*, population 2), had only expert opinion occurrence data and therefore was not considered "documented." This reflects our extremely poor understanding of non-game fishes, invertebrate species, and aquatic plants. Lack of occurrence data is likely a function of low survey effort or inconsistent data collection methods. As already noted, this assessment deferred to existing salmonid conservation planning efforts, and did not attempt to set goals or identify areas for salmonids as targets.

Finally, lakes were not targeted in this analysis. A more deliberate approach is required in future efforts in order to have confidence in adequately representing lakes within the freshwater portfolio.

3.4 Setting Goals

NOTE: Please see Chapter 2 for a general discussion on the challenges of setting goals. Chapter 2 provides a thorough discussion and explanation of the basis for establishing goals in the context of conservation of terrestrial species and communities.

3.4.1 Goals for Aquatic Ecological System Targets

For each of the six EDUs that intersect the ecoregion, we set a goal of 30% of mapped occurrences for each aquatic ecological system target. Number (rather than area) of occurrences was used in setting goals to capture entire watersheds, which is necessary to conserve ecological function. Any occurrence included in the portfolio was included in its entirety, regardless of its total area or stream length. Thus, for any given target in an EDU, the combined aerial extent of all occurrences included in the portfolio may be greater or less than 30% of its total area.

3.4.2 Goals for Aquatic Species Targets

Goals were set only for those species for which we had a high degree of confidence in the accuracy of the data (17 of the 36 species listed as targets). Targets for which we did not set goals are listed in Table 3.4.

TABLE 3.4 Species Targets with Inadequate Data to Support Goal Setting

TAXA	COMMON NAME	SCIENTIFIC NAME	NOTE
Fish	White sturgeon (Columbia River)	*Acipenser transmontanus pop2*	Expert opinion only – 7 occurrences
Fish	White sturgeon (Fraser River)	*Acipenser transmontanus pop4*	All occurrences listed are outside the EDUs analyzed for the Willamette Valley-Puget Trough-Georgia Basin
Mollusc	Willamette floater (mussel)	*Anodonta wahlametensis*	
Mollusc	Shortface lanx	*Fisherola nuttalli*	9 occurrences provided by WDFW, but all of them are outside the ecoregion and the EDUs.
Mollusc	Columbia pebblesnail	*Fluminicola columbiana*	
Mollusc	Barren juga (snail)	*Juga hemphilli hemphilli*	
Mollusc	Columbia duskysnail	*Lyogyrus sp 4*	
Mollusc	Rotund physa (snail)	*Physella columbiana*	
Mollusc	Nerite ramshorn (snail)	*Vorticifex neritoides*	
Invertebrate	California floater (mussel)	*Anodonta californiensis*	One occurrence listed in the Washington State Natural Heritage Program data, but it is outside of the ecoregion and the EDUs.
Invertebrate	River jewelwing	*Calopteryx aequabilis*	
Invertebrate	Pacific clubtail	*Gomphus kurilis*	
Plant	*Howellia aquatilis*	*Howellia aquatilis*	56 occurrences for this spp.
Plant	*Hydrocotyle verticillata*	*Hydrocotyle verticillata*	
Plant	*Marsilea vestita*	*Marsilea vestita*	
Plant	*Myriophyllum quitense (=M elatinoides)*	*Myriophyllum quitense (=M elatinoides)*	
Plant	*Nymphaea tetragona*	*Nymphaea tetragona*	
Plant	*Potamogeton fibrillosus*	*Potamogeton fibrillosus*	
Plant	*Potamogeton obtusifolius*	*Potamogeton obtusifolius*	4 occurrences for this spp. in WA.

Faced with a paucity of occurrence data for freshwater species targets, we set goals for portfolio assembly (i.e., the "SITES goal") at all available occurrences (Appendix 15a). It was assumed that by including all known occurrences in the goal, we would ensure some representation of poorly documented species in the portfolio.

3.5 Assembling the Portfolio

The portfolio of aquatic conservation areas (Map 3.3) was assembled using a combination of computerized spatial analysis and expert input. Spatial analysis required identifying assessment units, developing a suitability index, defining rules for assembly (boundary modifiers and target penalty factors) and applying goals. A preliminary portfolio was developed using SITES (see Appendix 4) to pick an efficient set of places that have high suitability for conservation and high co-occurrence of targets while meeting goals. The terrestrial and nearshore marine portfolios played an important role in defining this preliminary portfolio of aquatic priority sites. We weighted those areas identified by SITES in the terrestrial and nearshore marine analyses as preferential for inclusion in the aquatic portfolio (described in further detail below). This sequential approach allowed for greater efficiency in conservation design through selection of sites that conserve aquatic, terrestrial, and/or marine targets in integrated landscapes where possible. It is important to note, however, that this approach biases the selection of freshwater targets within an EDU towards those occurrences within the Willamette Valley-Puget Trough-Georgia Basin ecoregion, and against those outside of the ecoregion. As a result, we are potentially excluding lower cost or higher value freshwater sites outside of the ecoregion but still within the EDU.

3.5.1 Assessment Units

Assessment units for the freshwater portfolio differ from those used for both the terrestrial and nearshore marine portfolios (terrestrial and marine analyses used 750-ha hexagons as standard assessment units). We developed polygonal assessment units based on watershed boundaries nested at four different scales, as depicted in the Willamette Basin (Figure 3.1).

While there is a high degree of correlation between headwater watershed polygons and USGS 12-digit Hydrologic Unit Codes (HUCs), which are a commonly used assessment unit for watershed management, this correlation is lower for larger systems (Class 2 and greater). Instead of a one-to-one correlation, these larger systems are often roughly composed of multiple HUCs along the mainstem of a river. This shift in scale was made to reflect the entire contributing watershed area along larger riverine systems. The assessment and classification of all system classes was based on the entire contributing watershed area.

An important distinction exists between the assessment unit area used to define ecological system occurrences larger than headwater watersheds (>100 km^2) and the polygons representing the occurrences. For headwater streams and creeks, assessment units are equivalent to the system boundaries themselves. For systems larger than headwaters and creeks, the associated occurrence consists only of the reach of stream and its adjacent floodplain corridor (Figure 3.1). Thus, classification of a Class 3 river system (>1000 km^2) is based on the character of the entire contributing watershed assessment unit area upstream of the occurrence, which is represented graphically, and for planning purposes, as a corridor along the stream.

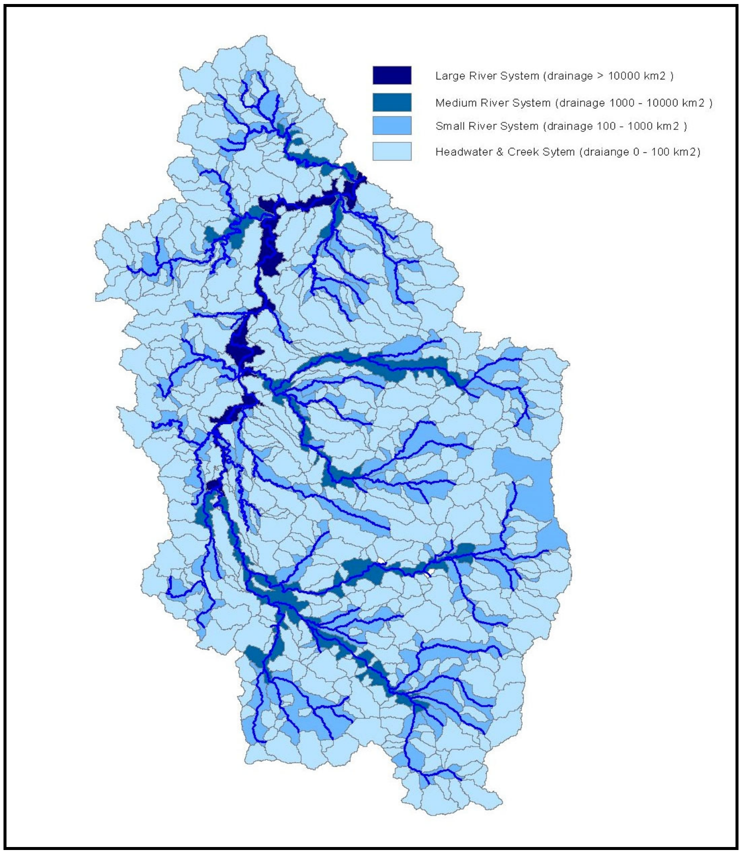


FIGURE 3.1 Example of assessment units in the Willamette Valley EDU used for the freshwater analysis. Gray lines represent assessment unit boundaries, color fill represents the system type that the assessment unit represents. Please refer to the map legend.

Addressing Target Integrity

The determination of the biological health or ecological integrity of freshwater biodiversity targets is a critical step to ranking occurrences and designing an ecoregional portfolio. From an assessment of the condition of the freshwater targets, planners can identify the best conservation opportunities as well as priorities for restoration. Integrity of target occurrences is generally measured according to three criteria: size, condition, and landscape context (Groves et al. 2000).

Our first step in assessing the integrity of freshwater targets was to identify and evaluate existing data relevant to these criteria for their availability, spatial extent, and accuracy. Natural Heritage Programs and Conservation Data Centres were a critical resource for species targets as many programs have already ranked occurrences according to their viability. Other relevant data came from government agencies (e.g., recovery plans from the U.S. Fish and Wildlife Service) and other freshwater experts. We developed and applied a GIS-based suitability index within the SITES algorithm as a surrogate for system integrity. Integrity was further assessed after initial portfolio development through consultation with experts with local knowledge of watersheds.

Suitability Index

A freshwater suitability index was created to indicate the relative integrity and likelihood of conservation success for every freshwater ecological system. Similar to Moyle and

Randall (2000) and Hitt and Frisell (1999), the index combines four factors that describe key threats to freshwater biodiversity and for which region-wide data were available:

- Road density (km/km^2) (data from WA and OR Department of Transportation and British Columbia Ministry of Environment)- The presence of roads that cross streams and road density within the watersheds which gives us information about land use and probable unnatural sedimentation. It also provides information concerning increased impervious surface in the watershed;

- Dam density (#/km^2) (data from: US EPA Basins version 2.0, US Army Core of Engineers National Inventory of Dams, and British Columbia Ministry of Fisheries)- Dam density and dam storage reveals whether or not the system's flow has been highly altered and might be a barrier to fish and other species;

- Land Use (% non-natural land cover) (data from: Pacific Meridian Land Use Land Classification and Baseline Thematic Mapping (BTM) from BC Ministry of Environment, Lands & Parks)- Land use included designation as either natural (e.g., forested) or unnatural (e.g., urbanized or agricultural);

- Point sources of pollution (#/km) (data from: US EPA Basins version 2.0)- The presence of point sources can indicate chemical and/or thermal pollutants and barriers to fish and other species.

We assessed the contributing watershed area of each system occurrence according to each of these four variables, giving each an occurrence rank between 0 and 1. Scores for all four variables were combined in a simple, unweighted average and subtracted from one to create a single suitability index for each target occurrence. Thresholds for each of these four factors were set to prevent a factor ranked very poorly from being masked by others that were ranked average or better. Ecological systems for which any factor ranked very poorly were given the lowest suitability index found in that EDU. For example, a system target that had relatively intact land cover, but had an extremely high density of dams would be given the lowest suitability value. Ecological systems with higher suitability indices were preferentially selected in the SITES algorithm as they were presumed to have higher integrity and greater potential for being successfully conserved.

A final step in the identification of a suitability index for each system occurrence was to note whether that occurrence overlapped with the terrestrial or nearshore marine portfolios. If it did, the unweighted average of the four factors was reduced by 50% (and therefore the suitability index was increased) to recognize the value of efficient conservation design for the ecoregion.

Invasive species could not be readily incorporated in the index due to the lack of data for most assessment units and incompatible scales of data that are available. However, where expert knowledge on invasives was available for an assessment unit, this was included in the portfolio selection process.

3.6 Expert Review

We sought review from experts across the ecoregion at all steps in the process, from developing a classification system to identifying targets through portfolio assembly. The preliminary portfolio that was produced using SITES was revised based on expert knowledge of local site conditions and biodiversity. This was solicited through workshops and individual meetings with biologists from a variety of state and federal agencies, local organizations, universities, and other researchers. A comprehensive list of experts who provided input is provided in Appendix 2.

Based on expert input, sites added or removed had a significant impact on the final portfolio. Of the approximately 1,600 sites included in the portfolio for the 6 EDUs (in their entirety) that intersected the Willamette Valley-Puget Trough-Georgia Basin ecoregion, approximately 250 were added by experts. In many cases, regional biologists highlighted streams they considered of great general value to freshwater conservation because of their condition or because they were unique, important for salmonid conservation, or which represented unique aquatic communities. This attribute information was recorded for each site. All expert-nominated sites were included in the portfolio.

Experts also identified sites that were included in the portfolio that they felt did not accurately represent the target, or where the selected occurrences were in poor condition. However, these sites were removed from the portfolio only if they did not contain fine filter targets and only if established goals could still be met for that EDU by selection of alternative sites for the same target.

The majority of input demonstrated the experts' knowledge of salmonids and their life histories and reflected a focus on salmonids by the region's scientific and natural resource management institutions. It points out the relative paucity of work on other elements of aquatic biodiversity. Thus, the resultant portfolio has an emphasis on expert-nominated Class 2 and Class 3 aquatic systems that are considered important to salmonid conservation for various life history stages, as well as to provide corridors for migration. The primary examples of this were the Skagit River, the Snoqualmie River, and streams within the Kitsap Peninsula.

3.6.1 Internal Review

Following expert review, the assessment team modified the portfolio to:

- Add or delete target occurrences, based on input received during expert review, as necessary to meet target goals;
- Promote hydrologic connectivity among sites selected in the portfolio;
- Maximize protection of contributing watershed area to selected Class 2 and greater ecological systems occurrences (Class 1 systems include all contributing watershed area within the occurrence).

For each EDU, coarse filter target occurrences were added, removed, or exchanged within the EDU to meet these objectives. For example, where experts nominated additional occurrences of aquatic systems targets that were already adequately represented in the portfolio, occurrences of the same system type were removed from elsewhere in the portfolio if they had previously been selected only by SITES and did not contain fine filter targets. Similarly, in instances where experts suggested that selected occurrences were poor examples, but no better occurrences exist, the sites remained within the portfolio to meet goals. These sites may be candidates for eventual restoration.

The integrity of aquatic biological communities associated with a given aquatic ecological system is often dependent on linkages to other aquatic ecological systems and the extent to which a contributing watershed is altered. To enhance connectivity among selected sites and the protection of contributing watershed area to key sites, portfolio occurrences selected by the SITES algorithm remaining in isolation (i.e., unconnected or relatively alone within larger class watersheds) were traded for the same occurrence type (coarse filter target) within key watersheds or in connection with expert-nominated occurrences. For example, occurrences of headwaters systems (Class 1 Systems) were connected to or concentrated within contributing watershed areas of expert nominated rivers and corridors (Class 2 or 3 Systems).

3.7 Goals Met

We evaluated the final aquatic portfolio with respect to how well it met established goals for species and for aquatic ecological systems. As discussed previously, goals can be roughly summarized as 100% of known occurrences for species targets and 30% of occurrences for systems targets. However, in the review of the draft portfolio, there were numerous examples of coarse filter targets that either substantially exceeded or failed to meet the goal of 30% of occurrences. This was a consequence of setting goals relative to the number of occurrences rather than by percent of available area and a function of the number of occurrences. For example, in order to meet the 30% goal for a coarse filter target with 7 occurrences, at least 3 occurrences would have to be selected. This is the equivalent of 140% of our goal of 30%. Alternatively, selection of 2 occurrences rather than 3 represents 95% of our goal of 30%. In these cases, we decided that coarse filter targets that achieved at least 90% of their occurrence goal would be treated as having met their goal in the portfolio. This is the same approach taken by the terrestrial communities team for coarse filter terrestrial targets.

A numerical summary of overall goal status is presented in Table 3.5, and a detailed per target goal performance relative to the portfolio is presented in Appendix 15a. Goals were met for all but five targets. The four species targets which failed to meet the goal are: Oregon chub where 28 of 36 occurrences (77%) were included; Olympic mudminnow where 59 of 63 occurrences (93%) were included; Salish sucker where 12 of 13 occurrences (92%) were captured; Pacific lamprey where 15 of 16 occurrences were captured (93%). These targets should be evaluated during the assessment of adjacent ecoregions in which they occur to identify additional occurrences for conservation. One coarse filter aquatic system target failed to achieve at least 90% of its goal of 30% of all known occurrences: Lower Columbia Tributary Medium Rivers (volcanic), where only 1 of 4 occurrences (25% of occurrences) was included.

TABLE 3.5 Portfolio Performance in Meeting Freshwater Target Goals

TARGET	TOTAL NUMBER OF TARGETS	NUMBER OF TARGETS WITH GOALS	NUMBER OF TARGETS THAT MET GOALS	PERCENT OF TARGETS THAT MET GOALS
Freshwater Systems	158	158	157	99%
Freshwater Species	36	17	13	76%
Fish	13	11	7	63%
Invertebrates	11	8	8	100%
Vascular plants	12	5	5	100%
TOTALS	**194**	**175**	**170**	**97%**

The fact that nearly 100% of goals were met or exceeded for most freshwater coarse filter targets must not be misinterpreted as saying that the freshwater environment is ecologically intact. Rather, success in meeting goals can be attributed to the process by which the suitability of these targets was defined and how goals were set within SITES. In the freshwater SITES assessment, suitability indices directed the model towards certain occurrences, but did not preclude occurrences from being incorporated based on suitability alone. This reflects a weakness in our suitability indices, in that they do not necessarily capture all habitat loss or degradation for all species. For example, while many streams have been significantly altered, dammed, or even relocated, the channel still exists in some form, even though suitable habitat may have been lost. Thus, the total pool of target occurrences from which to select portfolio sites includes the entire landscape, not just the remaining habitat relative to historic extent, as in the terrestrial targets. It follows, then, that there will always be a sufficient number of occurrences available for selection to meet goals for targets defined this way.

The freshwater portfolio selected using this approach contains a robust sampling of the full range of freshwater system types in the ecoregion. This 30% sample is not, however, guaranteed in any way to be sufficient for the long-term persistence of the full range of the ecoregion's aquatic biodiversity. The sufficiency of this sample must be determined through further study of the ecology of these aquatic ecosystems and the species that rely on them. As a practical next step, the sites selected in this portfolio should be surveyed as needed to fill gaps in our understanding of their ecological condition and to prioritize them for restoration or other management action.

3.8 Portfolio Assembly Gaps and Limitations

The aquatic portfolio is a first-iteration portfolio that will benefit from further consideration and review in future planning iterations and as site-based conservation planning is undertaken. As with any assessment, this portfolio reflects the time and personnel limitations imposed on it. The aquatic portfolio is limited by the following gaps in either the information available or the process applied to developing it.

- ***Little expert opinion was solicited on fine filter target occurrences.*** Expert input was limited primarily to assessment of coarse filter targets and was not consistent among EDUs. The Puget Sound EDU received substantial expert scrutiny, while other EDUs received little. Subsequent conservation planning will benefit from identification of experts for each fine filter target.

- ***Salmonids were not adequately addressed***. Salmonids were not incorporated into the quantitative analysis, although expert-identified streams of importance to salmonids were included in the portfolio. While it does not serve as a robust salmonid analysis, this assessment should assist in establishing a broader biodiversity context for salmonid conservation priority setting.

- ***Non-salmonid data and expert limitations.*** Because of the emphasis on salmon as an "icon in peril" in virtually all organizations and agencies in the ecoregion, experts, regardless of their special field, tended to focus on salmonid habitat. Often without acknowledging this focus, experts identified important salmon streams as key targets for conservation of general aquatic biodiversity. This may be a reasonable approach to capturing a variety of priority conservation areas in that salmonids make use of such a large range of the available freshwater habitats in the ecoregion, but it also reflects the serious shortfall in expert knowledge on other taxa.

Confidence ratings were developed for all portfolio sites to indicate the relative degree of analysis and review that supports the inclusion of each site in the portfolio. Confidence ratings are determined by a combination of factors that led to the selection of a site in the portfolio, including: selection by the SITES algorithm, expert nomination, fine filter occurrence, or some combination thereof. The following categorization of portfolio areas represents the current measure of confidence and implied data gaps:

- 0: not picked by model, no species data, no expert support, and therefore not in the portfolio;

- 1: picked by model only, either as a coarse filter target occurrence, or because it contains a fine filter species occurrence, or both;

- 2: not picked by model but selected by an expert;

- 3: picked by model and has **either** expert support or species data **OR** not picked by model but has **both** species data and expert support;

- 4: picked by model and has **both** species data and expert support.

Most (973, or 61%) of the sites in the freshwater portfolio have a confidence level of 1, i.e., they were selected by the SITES algorithm only. Of the remainder, 380 have a confidence level of 2, 227 have a confidence level of 3, and 18 sites have a confidence level of 4.

The ecological integrity of all freshwater portfolio sites was not assessed in a consistent fashion across all EDUs. Three criteria were identified as indications of integrity: the site's suitability index as calculated by the SITES algorithm, input received during expert review, and connectivity considerations. While all EDUs were evaluated using the suitability index (automated assessment), the degree to which sites were evaluated by experts and the degree to which experts nominated sites varied considerably among EDUs. The Puget Sound EDU benefited from the highest degree of review, due largely to our success in soliciting experts for input and our team's own knowledge of the area. The Olympic Chehalis EDU received the least scrutiny, with no expert input and little or no consideration of connectivity, largely because only a small portion of this EDU intersects the ecoregion. It was also assumed that this EDU would undergo greater scrutiny as part of adjacent ecoregional assessments (Northwest Coast).

In light of these limitations—varying degrees of expert input among EDUs, limitations of the suitability index, and the fact that the terrestrial ecoregional assessment biases the EDU assessments across the ecoregion— the team decided to use the current freshwater portfolio (for the 6 EDUs intersecting the ecoregion) only to inform the terrestrial and marine portfolio. For this reason, there are no sites included in the final Willamette Valley-Puget Trough-Georgia Basin integrated ecoregion portfolio (Chapter 5) that are designed for freshwater targets only. Chapter 5 describes how site information from the freshwater analysis was used to guide the refinement of terrestrial and marine portfolio sites. The freshwater portfolio for the EDUs intersecting the WPG ecoregion that has been discussed here will require considerable additional analysis before it can serve as a comprehensive habitat protection guide for freshwater conservation in the ecoregion.

Chapter 4 – Nearshore Marine Systems and Species

This chapter describes the assessment of nearshore marine ecological systems and nearshore marine species in the Puget Trough-Georgia Basin ecoregion. A combination of data-driven models and expert opinion was used to develop a portfolio of priority conservation areas that, if conserved, will protect a representative subset of the nearshore marine biodiversity.

This objective reflects the data limitations for the marine environment. The greatest limitation was the lack of comprehensive data for benthic habitats and other physical parameters in the offshore environment, i.e., the area beyond the 40-meter depth limit of our defined nearshore zone. Although we had comprehensive coverage of shoreline ecosystems down to the shallow subtidal, and species information within and extending below the nearshore zone (seabirds, marine mammals, and invertebrates), we felt that species data alone could not support decisions about conservation priorities in deeper water. This is, then, a nearshore marine (rather than a marine) ecoregional assessment. It addresses a few shoal areas away from the coast for which data were available.

Topics described in this chapter include the following:

4.1 Technical Team

The marine technical team included the following people:

Curtis Tanner, team leader	USFWS, Lacey, WA
Helen Berry	WDNR, Olympia, WA
Phil Bloch	People for Puget Sound, Seattle, WA
Megan Dethier	Friday Harbor Laboratories, University of Washington, San Juan Island, WA
Paul Dye	TNC, Seattle, WA

Zach Ferdaña	TNC, Seattle, WA
Gary Kaiser	NCC, Victoria, BC
Brian McDonald	WDFW, Olympia, WA
Mary Lou Mills	WDFW, Olympia, WA
Dave Nysewander	WDFW, Olympia, WA
Bob Pacunski	WDFW, Mill Creek, WA
Jacques White	People for Puget Sound, Seattle, WA
Mark Zacharias	Ministry of Sustainable Resource Management, Victoria, BC

4.2 Selecting Nearshore Marine Targets

The marine team identified the nearshore zone as the part of the marine environment to be covered by this assessment. This zone extends from the supratidal area above the ordinary or mean high water line (i.e., the top of a bluff or the extent of a saltmarsh in the upper intertidal) to the subtidal area. The subtidal begins at approximately the mean lower low water line (zero feet elevation) down to the -20 meter isobath. The limit on the lower extent was data-driven (see Berry et al. 2001). However, the team expanded the nearshore window to include the deeper subtidal (-40 meters), thus capturing rocky reef and rockfish species that utilize those habitats. This definition of the nearshore zone complemented the data used to conduct the regional analysis. Therefore, "shoreline" refers to the part of the nearshore down to -20 meters, and "nearshore" refers to the entire zone down to -40 meters. In assembling conservation areas (see Chapter 5), all places in the marine analysis are referred to as nearshore portfolio sites. The defined nearshore marine zone encompasses approximately 469,461 ha, or 31 percent of the total 1,509,733ha of nearshore marine zone within the ecoregion (Map 4.1).

The marine team identified 108 conservation targets, comprising 40 coarse filter targets (shoreline ecosystems and rocky reef habitat) and 68 fine filter targets (nearshore marine species). These targets were selected to represent nearshore marine biodiversity within the ecoregion, and highlight threatened or declining species and communities (e.g. rockfish species), or those that indicate the health of the larger ecosystem (e.g. intertidal communities). See Appendix 5 for a list of all nearshore marine targets.

The marine team did not use the formal ecoregion subsections (which were largely derived for terrestrial purposes), but rather stratified the waters into "estuarine" and "nearshore marine" sections (Map 4.2). These sections are intended to capture the larger marine patterns of salinity, temperature, and currents, based on a simplified Dethier classification (1990) and that of the Department of Fisheries and Oceans (Zacharias personal communication; 2001) using wave exposure, salinity, temperature and elevation of intertidal (hypsography) as primary factors in representing coarse filter targets across the ecoregion. The estuarine section is characterized by the major river systems draining into Puget Sound, including the Fraser and other rivers along the east side of Georgia Basin. The nearshore marine section is characterized by higher salinity and stronger currents, and lies in the San Juan Islands and the west side of Georgia Basin.

4.2.1 Coarse Filter Targets

Nearshore marine coarse filter targets were developed to correspond to the classification systems used by the ShoreZone mapping project in the Strait of Georgia and Puget Sound (Howes et al. 1993; Berry et al. 2001). Developed in British Columbia, this physical and biological ShoreZone mapping system is based on shore types after Howes et al. (1994) and Searing and Frith (1995). Shore types are biophysical types that describe substrate, exposure, and vegetation across the tidal elevation, as well as anthropogenic features such as shoreline segments that are 'armored' against erosion with bulkheads or riprap, and wharfs or other coastal manmade structures. The shore types also describe characteristics in the supratidal area such as the presence of overhanging vegetation and railroad beds.

Since the ShoreZone mapping system was also adopted in Washington, we used both the British Columbia classification scheme as well as the Dethier (1990) method to more precisely segregate intertidal communities. The British Columbia and Washington ShoreZone mapping system is built on shore types that aggregate precise community or habitat types according to their landform, substrate, and slope (Berry et al. 2001). There are 34 coastal classes and 18 representative types within the classification system (Table 4.1). See Berry et al. (2001) for the rationale and definitions of the 34 coastal classes. The definitions of the representative types follow Table 4.1. The coastal classes and representative types were used as a starting point to construct the shoreline coarse filter targets, which were ultimately defined by simplifying the available inventory data sets.

TABLE 4.1 British Columbia Coastal Classes, Representative Shore Types and Shoreline Ecosystem Types

CODE	CLASS DESCRIPTION	BRITISH COLUMBIA REPRESENTATIVE TYPE	BRITISH COLUMBIA SHORELINE ECOSYSTEM TYPES
0	Undefined	Undefined	
1	Rock ramp, wide	Rock Platform	Rock platform
2	Rock platform, wide	Rock Platform	Rock platform
3	Rock cliff, narrow	Rock Cliff	Rock cliff
4	Rock ramp, narrow	Rock Cliff	Rock cliff
5	Rock platform, narrow	Rock Platform	Rock platform
6	Ramp with gravel beach, wide	Rock with Gravel Beach	Rock w/sand and/or gravel beach
7	Platform with gravel beach, wide	Rock with Gravel Beach	Rock w/sand and/or gravel beach
8	Cliff with gravel beach	Rock with Gravel Beach	Rock w/sand and/or gravel beach
9	Ramp with gravel beach, narrow	Rock with Gravel Beach	Rock w/sand and/or gravel beach
10	Platform with gravel beach, narrow	Rock with Gravel Beach	Rock w/sand and/or gravel beach
11	Ramp with gravel and sand beach, wide	Rock with Sand & Gravel Beach	Rock w/sand and/or gravel beach
12	Platform with gravel and sand beach, wide	Rock with Sand & Gravel Beach	Rock w/sand and/or gravel beach
13	Cliff with gravel and sand beach	Rock with Sand & Gravel Beach	Rock w/sand and/or gravel beach
14	Ramp with gravel and sand beach, narrow	Rock with Sand & Gravel Beach	Rock w/sand and/or gravel beach
15	Platform with gravel and sand beach, narrow	Rock with Sand & Gravel Beach	Rock w/sand and/or gravel beach
16	Ramp with sand beach, wide	Rock with Sand Beach	Rock w/sand and/or gravel beach
17	Platform with sand beach, wide	Rock with Sand Beach	Rock w/sand and/or gravel beach
18	Cliff with sand beach	Rock with Sand Beach	Rock w/sand and/or gravel beach
19	Ramp with sand beach, narrow	Rock with Sand Beach	Rock w/sand and/or gravel beach
20	Platform with sand beach, narrow	Rock with Sand Beach	Rock w/sand and/or gravel beach
21	Gravel flat, wide	Gravel Flats	Sand & Gravel flat
22	Gravel beach, narrow	Gravel Beach	Sand & Gravel beach
23	Gravel flat or fan	Gravel Beach	Sand & Gravel beach
24	Sand and gravel flat or fan	Sand & Gravel Flat	Sand & Gravel flat
25	Sand and gravel beach, narrow	Sand & Gravel Beach	Sand & Gravel beach
26	Sand and gravel flat or fan, narrow	Sand & Gravel Flat	Sand & Gravel flat
27	Sand beach	Sand Beach	Sand beach
28	Sand flat	Sand Flat	Sand flat
29	Mud flat	Mud Flat	Mud flat
30	Sand beach, narrow	Sand Beach	Sand beach
31	Organics/fines	Estuary Wetland	Mud flat
32	Man-made, permeable	Man-made	Man-made
33	Man-made, impermeable	Man-made	Man-made
34	Channel	Channel	(Not used)

Note: w/ = with

Definitions of the British Columbia Representative Shoreline Types

Rock Platform Near horizontal rocky intertidal areas >30m in width. A thin sediment veneer may be associated with the ramps but the veneer is typically patchy and there are no organized beach features. Most commonly associated with sedimentary bedrock outcrops.

Rock Cliff Steep sloped (>20^{o}) rock coasts. Small pockets of sediment occur sporadically within the indentations along the coast.

Rock with Gravel Beach Rock and pockets of clastic sediments (rubble, boulder, cobble or pebble beach). Sediments can occur on well-developed beach forms, such as berms or beach terraces, or as large patches of sediment in an otherwise rocky shoreline. Beaches typically occur in the middle to upper intertidal zones and often include log deposits in the supra-tidal zone.

Rock, Sand and Gravel Beach Rock with pockets of clastic sediments including sand beaches; they typically occur in the middle to upper intertidal zones and often include log deposits in the supra-tidal zone. The gravel in the lower and middle intertidal zones frequently occurs as an armor over the sand gravel mixture. Distributions may be intermittent and patchy along the coast within small indentations.

Rock with Sand Beach This type has similar characteristics to a rock platform but it has a sand beach, with the sand content >90%. The beaches typically occur in the middle to upper intertidal zones and often include log deposits in the supra-tidal zone. Distributions may be patchy, occurring intermittently along the coast within small indentations.

Gravel Beach Sediments are usually comprised of a boulder, cobble, and pebble mixture with <10% sand content. Beach slopes are in the range of 5^{o} to 20^{o} with the berm the steepest part of the intertidal zone. Lower to middle intertidal zones are commonly armored. Because of the low sand content, these beaches are highly permeable.

Gravel Flat Sediments are usually comprised of a boulder, cobble, and pebble mixture with sand content <10%. Beach slopes are low, <5^{o} with the berm the steepest part of the intertidal zone. Lower to middle intertidal zones are commonly armored. Because of the low sand content these beaches are highly permeable.

Sand and Gravel Beach Sediments are a mixture of boulders, cobbles, pebbles, and sand (>10% sand content and >10% gravel content). Beach slopes are in the range of 5^{o} to 20^{o} with the berm the steepest part of the intertidal zone. Lower to middle intertidal zones are commonly armored by cobbles with the sand layer in the subsurface. These beaches usually have similar permeabilities to sand beaches.

Sand Beach Sediments are <10% gravel and >50% sand. Beach slopes are in the range of 5^{o} to 20^{o} with the berm the steepest part of the intertidal zone. Sediments are highly mobile in moderate to high energy exposured areas. Beach permeability may range from high to low depending on the mud content of the beach. Ridge and runnels or swash bars may occur in the lower or middle intertidal zones.

Sand and Gravel Flat Sediments are a mixture of boulders, cobbles, pebbles and sand (>10% sand content and >10% gravel content). Beach slopes are low, <5^{o} with the berm the steepest part of the intertidal zone. Lower to middle intertidal zones are commonly armored by cobbles with the sand layer in the subsurface. These beaches usually have similar permeabilities to sand beaches.

Sand Flat Sediments are <10% gravel and >50% sand in content. Beach slopes are low, <5^{o} with the berm the steepest part of the intertidal zone. Beach permeabilities may range from high to low depending on the mud content of the beach. Multiple ridge and runnels or swash bars are common in the lower or middle intertidal zones.

Mud Flat Sediments are <10% gravel and >50% mud. Beach slopes are low, <5° to 20° with the berm the steepest part of the intertidal zone. Berm sediments, located near the high-tide mark are usually coarser than those of the beach flat. Beach permeability is low due to the high mud content.

Estuary, Marsh or Lagoon Estuaries are characterized by high variable distributions in texture, although muds and organics are common. Marshes frequently rim the estuary at the high water mark. Brackish water conditions are common due to freshwater input to the estuary from stream runoff. Exclusively confined to low wave exposure environments.

Channel A current-dominated region in the intertidal area as opposed to a wave-dominated area in the intertidal area composed of either bedrock or sediment substrate.

Man-made These are man-made features or structures within the intertidal zone such as wharfs, seawalls, breakwaters, log dumps, boat ramps, marinas, piers, etc. Common construction materials used are concrete, timber, pilings, rubble, and rock. Intertidal zone widths are often narrow due to the vertical nature of most structures.

High Tide Lagoons Lagoons that have a tidal influence.

The marine team examined the 18 representative shore types within the original classification and aggregated them into 9 shoreline ecosystem types. This process generalized shoreline ecosystems into discernable coastal communities for planning purposes at the ecoregion scale. These shoreline ecosystems were considered significant and distinct, and were distributed across the ecoregion. The team decided that having too many classes overstated the detail necessary for tracking generalized coastal conservation targets that were comparable across the ecoregion.

Shoreline Ecosystems

In order to build coarse filter goals based on both physical and biological habitat features, the team augmented the shoreline classes with summary vegetation information. Three vegetation categories were identified to serve as surrogates for major biological communities between the supratidal and the shallow subtidal: saltmarshes (high and low tidal marshes, sedges), seagrasses (eelgrass, surfgrass), and kelps (canopy, non-canopy). These three vegetation categories are recognized to be ecologically important and are protected by governmental policy. They are known to be highly productive and sensitive to human impacts. Although these categories alone do not represent the entire range of intertidal habitats or the most diverse habitat types, they are believed to be good rough surrogates at the ecoregional scale.

Eight unique vegetation types were derived from the categories listed above and assembled for each of the 9 shoreline ecosystem types, creating 67 unique combinations. Unique combinations of multiple vegetation types (i.e., kelp and seagrass) were generally retained as separate categories to represent places with greater relative habitat diversity. The marine team distilled these combinations to 39 coarse filter targets by lumping vegetation categories that represented a small relative proportion of total area (less than 5% cover of one vegetation type) within a shoreline ecosystem type. For three shoreline ecosystem types (rock platform, rock cliff, man-made), all vegetation types were lumped into ‘vegetated’. Areas with salt marshes, kelp and/or seagrass were lumped into ‘subtidal vegetation’ to simplify the total number of targets (Table 4.2). These distillations were based on expert opinion, with each shoreline ecosystem type considered separately. The resulting vegetation categories were used in goal setting (section 4.5.1).

TABLE 4.2 Coarse Filter Shoreline Ecosystem Targets

SHORELINE ECOSYSTEM	INTERTIDAL VEGETATION	SHORE UNITS	LENGTH (KM)
Sand flat	Kelp	74	33.3
Sand flat	Kelp and seagrass	87	60.2
Sand flat	Saltmarsh	128	67.4
Sand flat	Saltmarsh and subtidal veg	183	113.7
Sand flat	Seagrass	446	232.9
Sand flat	Unvegetated	355	152.7
Mud flat	Saltmarsh	478	618.2
Mud flat	Saltmarsh and subtidal veg	161	136.7
Mud flat	Subtidal veg	72	47.8
Mud flat	Unvegetated	271	195.6
Man-made	Unvegetated	551	402.2
Man-made	Vegetated	200	134.3
Sand and gravel flat	Kelp	118	74.6
Sand and gravel flat	Kelp and seagrass	177	121
Sand and gravel flat	Saltmarsh	55	41.1
Sand and gravel flat	Saltmarsh and subtidal veg	81	56.6
Sand and gravel flat	Seagrass	401	207.8
Sand and gravel flat	Unvegetated	657	320.2
Rock platform	Unvegetated	335	129.4
Rock platform	Vegetated	315	155.5
Rock cliff	Unvegetated	2025	1027
Rock cliff	Vegetated	1013	424.6
Rock with sand and/or gravel beach	Kelp	568	255
Rock with sand and/or gravel beach	Kelp and seagrass	258	109.8
Rock with sand and/or gravel beach	Seagrass	149	80.5
Rock with sand and/or gravel beach	Unvegetated	2223	1042.2
Rock with sand and/or gravel beach	Saltmarsh and subtidal veg	44	18.4
Sand and gravel beach	Kelp	362	182
Sand and gravel beach	Kelp and seagrass	286	179.7
Sand and gravel beach	Saltmarsh	63	37.1
Sand and gravel beach	Saltmarsh and subtidal veg	69	36.7
Sand and gravel beach	Seagrass	477	262.7
Sand and gravel beach	Unvegetated	968	431.8
Sand beach	Kelp	230	135.7
Sand beach	Kelp and seagrass	139	63.9
Sand beach	Saltmarsh	111	66.8
Sand beach	Saltmarsh and subtidal veg	99	57.3
Sand beach	Seagrass	370	194.3
Sand beach	Unvegetated	342	162.8
-	Rocky reefs	-	-

These 39 shoreline ecosystem targets were then plotted across the entire shoreline of the ecoregion as inventoried by the ShoreZone mapping system. ShoreZone shoreline inventories published for British Columbia (Howes et al. 1993) and for Washington (Berry et al. 2001) interpreted flight surveys to spatially delineate linear reaches of shoreline with the aid of nautical charts, orthophoto and oblique photographs, and geological maps. The total shoreline length is 8,070 km or (5,014 mi), with 4,205 km in British Columbia and 3,865 km in Washington. Flight surveys for British Columbia were conducted between 1980 and 1990; those for Washington were flown between 1994 and 2000.

The ShoreZone inventories identified 14,942 distinct spatial shoreline units representing the occurrences of shoreline ecosystem targets that cover the ecoregion. These coarse filter ecosystem occurrences range from 10 to 17,617 m in length, with a mean length of 541 m. There are 7,043 shoreline units in Washington, ranging from 18 to 11,835 m with a mean of 549 m. In British Columbia, there are 7,899 shoreline units ranging from 10 to 17,617 m with a mean of 534 m.

Additionally, 1,802 shoreline units are completely man-made. The total combined length of anthropogenic or man-made shoreline is 1,162 km, or 14.4% of the ecoregion.

In addition to the shoreline ecosystems, rocky reef habitat information was also treated as a coarse filter target, bringing the coarse filter target total to 40. Including rocky reef as a target expanded our definition of nearshore, although this target was treated differently in the spatial analysis. Rocky reef habitat data was represented as points attributed with relief (elevation) and complexity (roughness of rock structures, crevices) values. Use of rocky reef information allowed us to analyze areas deeper than the intertidal zone and associate fine filter data on nearshore marine fishes with a subtidal benthic habitat. No comparable data were available to develop a portfolio of subtidal habitats deeper than -40 meters.

4.2.2 Fine Filter Targets

The marine team selected species as fine filter targets, generally following the criteria in Groves, et al. (2002). We also considered species that are "the focus of major international research, protection, management and conservation efforts" (West 1997, citing National Research Council 1996). Workshops with regional experts resulted in a long list of species for consideration. The marine team separated the fine filter targets into 2 lists: a master list, which comprised all the species nominated by experts that qualified under our criteria, and a list used for data analysis, which comprised those species best known in the ecoregion, with data suitable to drive a spatial analysis (see targets list in Appendix 5). The list of fine filter targets with spatial data (the data analysis list) included 33 species targets: 9 fish, 3 marine mammals, 11 seabirds, 10 invertebrates, and no vegetation types (Table 4.3). For seabirds, individual species either served as surrogates for groups of species (i.e., American wigeons were used as surrogates for various dabbling ducks), or individual targets represented multiple species (i.e., seabird nesting colonies represented 13 different species). The master list included 68 fine filter targets: 11 fish, 8 marine mammals, 12 seabirds, 26 invertebrates, and 11 species of intertidal and subtidal plants and alga.

An important consideration in choosing species targets was whether the species met target criteria across the ecoregion, or only within a portion of it. The latter case often occurred; a species was imperiled or listed within one section but was considered secure in another section of the ecoregion. We did not use such species as targets in the regional analysis, but we did track them in the portfolio. For example, nearshore marine fish species that met the criteria in Washington but not in British Columbia were included in the site selection algorithm with their goals set to zero. Consequently, the associated data did not affect the selection of sites, but the data can be reported as attributes of a portfolio site or assessment unit.

TABLE 4.3 Fine Filter Data List

CONSERVATION TARGET	SPATIAL TOTAL	DATA TYPE
American wigeon	323,250	EO - DENSITIES
American wigeon BC	106,500	EO
Basket star	4,750	EO
Bird colonies BCWA	29,350	EO
Black brant	60,550	EO - DENSITIES
Black brant BC	111,000	EO
Black rockfish	10,200	EO
Box crab	1,600	EO
Copper rockfish	103,450	EO
Gooseneck barnacles	3,000	EO
Harbor seal pups	11,000	EO
Harlequin duck	98,500	EO - DENSITIES
Harlequin duck BC	101,500	EO
Lingcod	55,050	EO
Loons	157,200	EO - DENSITIES
Loons BC	105,000	EO
Marbled murrelet	161,950	EO - DENSITIES
Marbled murrelet BC	136,000	EO
Orange sea pens	13,600	EO
Pacific Herring Spawn	33,286	Acreage
Pacific Herring Spawn BC	443,296	Linear meters
Pinto abalone	19,786	Acreage
Polyorchis jellyfish	4,000	EO
Quillback rockfish	110,050	EO
Red necked grebe	176,500	EO - DENSITIES
Red necked grebe BC	103,500	EO
Rock scallop	7,017	Acreage
Rocky reef	308,150	EO
Rosy tritonia	10,300	EO
Sand lance spawn	231,431	Linear meters
Scaups	173,950	EO - DENSITIES
Scaups BC	141,500	EO
Scoters	727,650	EO - DENSITIES
Scoters BC	138,000	EO
Sealion rafts	11,035	Acreage
Seawhip	1,550	EO
Shorebirds BC	97,100	EO
Shorebirds WA	90,500	EO
Spiny vermillion star	4,450	EO
Steller sealion hauls	8,000	EO
Surf smelt spawn	417,501	Linear meters
Tiger rockfish	2,650	EO
Western grebe	313,050	EO - DENSITIES
Western grebe BC	101,000	EO
Yelloweye rockfish	6,300	EO

BC = British Columbia, indicating a different spatial format from Washington EO = "Element Occurrence," though marine nearshore marine targets were not assessed for viability. These are point data that are valued similarly to terrestrial EO values, and only reflect aggregated observation data over time.

EO Densities = These are aggregated observation data over time with a density calculated per minute of latitude cell size.

4.3 Collecting Data and Representing Nearshore Marine Targets

The conservation target list consists of 40 coarse filter shoreline ecosystems and 66 fine filter targets, totaling 106 targets. Nearshore marine species targets presented a special data challenge. Most data used for this assessment was provided by agencies in a usable, or nearly usable, format. The marine team aggregated and manipulated available data to make it useful for this analytical approach. Unlike the terrestrial and aquatic realms, Natural Heritage Programs and the British Columbia Conservation Data Centres have not collected element occurrence (EO) information for nearshore marine targets. We adopted some of the methods used in creating EOs in the terrestrial environment in order to create concentration areas from survey data. To do this, we had to experiment with different generalization techniques that best matched traditional EO concepts.[1]

Filtering survey data into a nearshore marine EO, or nearshore marine species concentration, served to eliminate redundant data elements, speed up subsequent model computations, and adjust the accuracy of different data sets that were jointly processed. The team found that individual species aggregation increased attribute accuracy by producing trends. Because a generalized trend over time was more robust than an individual observation, this process was useful for aggregating nearshore marine fish, seabirds, and invertebrate data over a number of years, thus increasing the probability of a species to be found at that general location (see Appendix 18 for summarized seabird and shorebird aggregation and ranking tables).

We reviewed and summarized survey data, ranked them for estimated quality or ecological integrity using the EO ranking method of the Natural Heritage Program (described in Chapter 2), and used these ranks to assign point values (Table 4.4) to each occurrence for portfolio selection purposes. We included total number of observations and, in the case of rocky reefs, relief and complexity as ranking criteria.

TABLE 4.4 Applying SITES Point Values to Basic Element Occurrence Ranks

EO RANK	DESCRIPTION	POINTS
A	Excellent estimated quality	1000
B	Good estimated quality	1000
C	Fair estimated quality	500
D	Poor estimated quality	50
K	Unranked (unknown quality)	500
H	Historical	N/A
X	Extirpated	N/A

The team collected data from the sources described in sections 4.3.1-4.3.7.

4.3.1 ShoreZone

In Washington, the ShoreZone data set was accessed from the Department of Natural Resources (WDNR). In British Columbia, where this method for collecting information on shoreline ecosystems was first developed, this data was accessed from the Land Use Coordination Office, or LUCO (now referred to as the Ministry of Sustainable Resource Management, or MSRM). With this partnership, TNC and NCC were able to utilize Georgia Basin shoreline data on agreement not to redistribute original or derived spatial data.

[1] Generalization for analysis is termed model generalization, and is mainly a filtering process (Joao 1998). This is not used for display, but for data reduction in order to obtain a subset of an original database for analysis. Model generalization aims at minimum average spatial displacement, although some displacement does occur when aggregating multiple survey points into a single point.

The Strait of Georgia was one of the first regions in British Columbia to be inventoried using the ShoreZone mapping system. Surveys primarily focused on physical rather than biological aspects of the inventory, especially along the eastern shore of Georgia Basin. Along this shore, for example, the shoreline is largely attributed as "un-vegetated." This is primarily due to the lack of biological survey effort rather than an absence of vegetation (Mary Morris, personal communication, 2001). In 2000, the biological information was updated and attached to the older physical attributes data. Inconsistency in interpretative methods between survey years resulted, causing data collected for the shoreline to be of higher spatial and attribute quality in Washington than British Columbia. The team therefore collaborated with experts in British Columbia to understand these inconsistencies and compensate for them in both the creation of coarse filter targets and analyzing the biological data.

The team derived the two assessment units and the coarse filter targets from the shoreline segments. As stated under in section 4.2 ("Selecting Nearshore Marine Targets"), this data was used to create the shoreline ecosystem classification and summarize the amounts of each for the analysis. We also conducted attribute quality assessments of the shoreline data in both Washington and British Columbia, incorporating that information into the spatial data (see section 4.6.2, "Methods of Analysis").

4.3.2 Rocky Reef Habitats

The marine team utilized WDFW video survey data for the years 1993 through 1997 that had been collected throughout the Puget Sound. No comparable survey has been conducted for the Strait of Georgia, thus limiting our assessment of rocky reefs to U.S. waters. Attributes for each survey were derived from 3 pans of an underwater camera with a functional visibility diameter of 8 meters, recording information on complexity and relief of rocky habitat, and any associated information on vegetation. Camera drops went to a maximum depth of –40 meters. These data were represented as point locations; rocky reef habitat points were included in the data set whether or not rockfish species were observed.

Sampling observations for rocky reef habitat were aggregated into one-half square mile grid cells to represent observation points, which were comparable to the actual cells used in the video surveys. Relief and complexity values observed for multiple rocky reef points in a single grid cell were taken in order to interpolate the habitat over the entire cell. We assumed that more relief and complexity meant a higher value for that point. Relief/complexity values were classified and ranked in accordance with the approach used for assigning terrestrial EO ranks (Ferdaña 2002).

4.3.3 Forage Fish Spawning Sites

Information was collected on three species of forage fish: Pacific Herring, Surf Smelt, and Sand Lance. Pacific Herring had comprehensive coverage in Washington (WDFW) and British Columbia (MSRM); Surf Smelt and Sand Lance information was only available for Washington (WDFW). All spawning data were represented as presence/absence data, although in both regions an absence of spawned eggs may mean a lack of survey effort rather than a true absence.

In Washington we had data that represented historic and current Pacific Herring spawning beaches over the last 10 years. This information is continually being updated and is not meant as a long-term indicator of presence or absence. Rather, the methods of data collection have steadily improved; therefore, updates are meant to replace older spawning locations. The data was collected on U.S. Geological Survey (USGS) maps at 1:24,000, then digitized into polygons. The same methods were developed for Surf Smelt and Sand Lance, although these two species were represented as linear features.

In British Columbia the Pacific Herring data was assembled as linear features that coincide spatially with the ShoreZone mapping system. Attribute data indicate the Relative Importance (RI) of the feature per location. The RI values are only comparable within project regions (e.g., Strait of Georgia) and not to other coastal zones in British Columbia

We left both Pacific Herring data sets in their original spatial data formats (polygons measured in acres for Washington, lines measured in meters for British Columbia) and set goals accordingly. For Washington, we included historic site spawning locations for the analysis because of their known importance in the recent past. In British Columbia, we selected RI values between 3 and 5 (medium to very high) for analysis. Goals for the Washington Surf Smelt and Sand Lance data were set in linear meters.

4.3.4 Other Nearshore Marine Fish

WDFW provided monitoring data on rockfish and lingcod for the Puget Sound and the southern end of the Strait of Georgia. We relied most heavily on their video surveys, but also included their trawl surveys and dive surveys from a non-government organization called Reef Environmental Education Foundation (REEF). In addition, rocky reef attributes were recorded in the video surveys whether or not fish were present.

In British Columbia we did not have data on explicit locations of rockfish and lingcod, but used Department of Fisheries and Oceans (DFO), temporary closures as a beneficial parameter in the suitability index (see section 4.6.1 “Setting Parameters for the SITES Algorithm”). We assumed that the closures do provide protection, albeit temporary, to rockfish and other nearshore marine species as long as they are in place.

Video Surveys

WDFW provided video survey monitoring data covering the period from 1993 through 1997. Data were provided over the entire Puget Sound region (WDFW). Attributes for each survey were derived from an underwater camera, recording information on total counts of nearshore marine fish species. These data were represented as point locations. The most common species included in the data were copper, brown, quillback, yelloweye and yellowtail rockfish and lingcod. Limited observations occurred for black, china and tiger rockfish.

In British Columbia, the rockfish areas were represented as polygons to indicate temporary closures for hook-and-line fishing and bottom trawling (from the 2001 Annual DFO Fisheries Report for the Strait of Georgia).

We used half square mile grid cells comparable to the actual cells used in the video surveys for aggregating rockfish points. We aggregated points for rockfish over all survey years and summed the count observations in each cell in an attempt to create concentrations of species and numbers of fish seen over time.

Trawl Surveys

We assembled WDFW trawl data that had been collected over a period of 10 to 15 years between the mid 1980s and late 1990s throughout Puget Sound and the southern Strait of Georgia. We took mid-point locations between the start and end of the trawl line as general locations for observed species.

We aggregated mid-trawl points for all target rockfish species by their total count observations over time using the same half square mile grid cells as we used for the marine fish video surveys. These aggregated species observations were classified and ranked in a similar fashion to the video rockfish surveys.

Dive Surveys

REEF data were collected by numerous divers over the last 10 years, and points were digitized to represent the beginning location of each dive. Attribute information included the species, number observed, and experience levels of the divers in accurately identifying species.

Similar to the previous methods for aggregating, classifying, and ranking the total number of observed individuals per species over time, REEF data were only used if the experience of the diver was intermediate to advanced.

4.3.5 Seabirds and Shorebirds

In Washington, we relied on a WDFW seabird colony database, a report on numbers of shorebirds per estuary in Puget Sound (Evenson 1997), and the Puget Sound Ambient Monitoring Program (PSAMP) flight observation data.

In British Columbia, we used the Site Basic Records (SBRs) from the Conservation Data Centre (CDC), which indicated polygon sites containing multiple species. We also used expert review and consulted historic survey records to provide additional locations of seabird colonies.

Seabird Colonies

There were 19 species of seabirds listed as attributes in the colony data in Washington, of which we identified 9 species as targets. These include the fork-tailed storm petrel, Leach's storm petrel, double-crested cormorant, pelagic cormorant, common murre, pigeon guillemot, Cassin's auklet, rhinoceros auklet, and tufted puffin.

In British Columbia, we collected colony data during an experts workshop in Vancouver. Places were identified for pigeon guillemot and various species of cormorant. We were not able to collect digital data on seabird colonies in British Columbia, but relied on a written report to verify expert workshop identification of seabird colonies (Burger et al. 1997).

Colony data were ranked in the following manner. In Washington, we queried the colony catalogue to see how many of the 9 species targets were located at a particular site. For each species per site, we assigned ranks based on the total number of individuals observed over all years surveyed. These values were taken from terrestrial element occurrence viability ranks, though there was no effort to assess the viability for marine species. We then looked across all species for that site and took the highest rank. For example, if site "x" contained three species occurrences with ranks of D, C, and A, then this site was ranked as an A. In British Columbia, data were generated from an experts workshop and all locations were given an EO rank of K, or unknown.

Aerial Surveys

The Puget Sound Ambient Monitoring Program (PSAMP) provided data from aerial surveys over a ten-year period (winters from 1993 to 2000 and summers from 1992 to 1999). Number of birds, survey effort, and all seasons where applicable were calculated per species into density values per one latitude minute cells, using a WDFW computer program density calculation (PSAMP mapping system). Target species in this category include 23 species: black brant, Pacific, red-throated, and common loons, marbled murrelet, red-necked and western grebes, surf and white-winged scoters, and harlequin duck. American wigeon served as a surrogate for 4 species of dabbling ducks: American wigeon, mallard, Northern pintail, and green-winged teal. American wigeons were chosen as a surrogate because of their widespread distribution. Greater and lesser scaups served as a surrogate for 9 species of diving ducks: greater scaup, lesser scaup, merganser, long-tailed duck, ruddy duck, canvasback, bufflehead, common goldeneye, and Barrow's goldeneye. Greater and lesser scaups were chose as surrogates for diving ducks because of their declining numbers and utilization of sandy substrates that support eelgrass beds. It should be noted that mergansers are lumped into this category because they are traditionally thought of as "sea ducks." Technically they are different from the others in this group as they feed on fish and behave more similarly to grebes and loons.

In British Columbia, we used the SBR polygon data set and the historic survey records to attribute them. Target species from the records include 21 species: red-necked and western grebes, brant, harlequin duck, surf and white-winged scoters, marbled murrelet, red-necked and western grebes, and Pacific, red-throated and common loons. Greater and lesser scaups served as a surrogate for 9 species of diving ducks: greater scaup, lesser scaup, merganser, long-tailed duck, ruddy duck, canvasback, bufflehead, common goldeneye, and Barrow's goldeneye.

The aggregated densities in Washington were classified and ranked as element occurrences (A, B, C, D and K values). Values were generalized to cells the size of one-minute latitude; these were then summed within hexagons. In British Columbia the SBRs were intersected with the hexagons, and all hexagons with more than 10 ac of the site were given a K value.

Aerial survey data came to us in two spatial formats. In Washington, point locations derived from density calculations were used for assigning values to seabird targets, and in British Columbia we used point locations derived from hexagon centroids. The British Columbia data were originally in a polygon format that was intersected with hexagons, with values given to their center points. Since the two data sets were based on different calculations (densities versus polygon distributions), the team decided to keep them as two distinct spatial targets in the analysis even though they represent one conservation target.

Shorebirds

In order to identify site locations for shorebird species, we attributed tabular location data from technical reports to the appropriate spatial data delineating estuary/mud flats. These areas then served as surrogates for shorebird concentrations.

Spatial data on estuaries for Washington were taken from a bathymetry data set (WDFW). We then used a WDFW report (Evenson 1997) with total numbers of shorebird species seen at various estuaries throughout Puget Sound to attribute the estuary data. The WDFW report lists 17 different shorebird species and total observations for all species seen in the highest survey years for the winter, spring, and fall seasons. The species include black-bellied plover, semipalmated plover, killdeer, greater yellowlegs, lesser yellowlegs, whimbrel, ruddy turnstone, black turnstone, surfbird, sanderling, western sandpiper, least sandpiper, dunlin, long-billed dowitcher, short-billed dowitcher, snipe, and red-necked phalarope.

In British Columbia, we used polygons generated as part of the ShoreZone mapping system, and attributed them with information from a CDC expert review process based on historic surveys (1935-2001). These records indicated the number of species seen at various areas using the Site Basic Record (SBR) database. The SBRs were mostly estuary systems, but also included areas with rocky shores. The review of historic surveys captured 3 shorebird species: black turnstone, dunlin, and black oystercatcher.

The 17 shorebird species were tagged to a statewide WDFW shallow flats spatial data set. If the total numbers for all shorebirds exceeded 4,000 over the winter, spring and fall seasons, then those shallow flat extents were included in the nearshore hexagon analysis. The marine team only included those intersecting hexagons capturing 10% or more (185.3 ac) of the shallow flat extent per site. In British Columbia we assigned attributes to SBRs if there were more than 2,000 observed individuals from the historic records. We intersected hexagons over the SBRs, taking 10 ac or more of the sites for analysis.

4.3.6 Nearshore Marine Mammals

Most nearshore marine mammal data were general distribution data (e.g., harbor porpoise RI values in British Columbia) or data that represented a known corridor where they occur (e.g., killer whales in Puget Sound). Other data such as minke and gray whale feeding areas were not used because the data were too general. However, these species were attributed to assessment units without set goals. Where we were able to get life stage data within the nearshore, like haul-outs of Steller sealions and harbor seal pupping sites in Washington (WDFW and expert workshops), we used these data to represent primary nearshore marine mammal targets. In British Columbia, data on Steller sealion haul-out and rafting sites (MSRM) were used.

Haul-out data were available as points for Steller sealions throughout Puget Sound and the southern Strait of Georgia; harbor seal pupping sites (Washington only) and Steller sealion rafting sites were available for British Columbia only. The pupping sites were point locations derived from an expert workshop held in Seattle, Washington on April 19-20, 2001; the rafting sites were polygons with RI values. The sealion rafting and haul-out sites were verified at an expert workshop held in Vancouver, BC.

Although we used harbor seal pupping as a life stage target, experts did not think that general haul-out locations for the species were an important conservation target.

4.3.7 Nearshore Marine Invertebrates

Data associated with invertebrate targets were generally not available because they either did not exist or were too general. The marine team used the same WDFW trawl surveys for invertebrates as used for nearshore marine fish, which covered all of Puget Sound and the southern Strait of Georgia. Data from these surveys were used for seawhips, spiny vermilion star, rosy tritonia, orange sea pens, box crab, and basket star.

Other data were derived from a 1992 Puget Sound spatial data atlas (WDFW), which was essentially a survey of experts and fishermen on the general location of species. These data were represented as polygons for pinto abalone and rock scallop.

The third type of data was derived from an expert workshop conducted in Seattle, Washington, which identified point locations on maps for gooseneck barnacles and polyorchis jellyfish in Puget Sound. Analysis of these data was only conducted for locations in the intertidal zone, although some locations were identified in the subtidal area.

The fourth category of data was assembled from the British Columbia Conservation Data Centre (MSRM) for invertebrates and algae species. All locations were in subtidal areas only.

4.3.8 Attributing the Occurrence Data to Standard Assessment Units

In the site selection analysis, the team used different spatial assessment units for the nearshore and shoreline environments. Hexagons of standard size (750 ha) were used for the nearshore environment, following the reasoning and matching the units used in the terrestrial analysis (see section 2.4).

Shoreline ecosystems were analyzed within their native spatial format, i.e., linear segments determined by dominant shoreline type. These units varied widely in length and extended over the entire coastline, thus providing more natural units for analysis (Longley et al. 2001). Two separate analyses were conducted, one with data input into hexagons to determine nearshore species and rocky reef site selection, and another with data input into linear shoreline units to determine a shoreline ecosystem portfolio.

4.4 Data Gaps

4.4.1 Coarse Filter Data Gaps

The greatest limitation to this marine assessment was the lack of data to classify and map ecosystems in water deeper than -20 meters; i.e., beyond the intertidal zone. From -20 to -40m, data was available for only one habitat type, rocky reef. At depths greater than -40m, there were no comprehensive data to classify or map ecosystems. Table 4.5 lists the coarse filter data that were used at different depth ranges. We hope to focus more attention on assembling data and modeling those ecosystems in subsequent iterations of this assessment.

TABLE 4.5 Coarse Filter Data Available/Used at each Depth Range

DEPTH RANGE	DATA AVAILABLE/USED
Riparian zone to mean high water line (top of bluff to supratidal)	Terrestrial ecosystems (Land cover\WDNR)
Intertidal mean high water line to mean lower low water (supratidal to shallow subtidal)	Shoreline ecosystems (ShoreZone\WDNR)
Subtidal zone mean low water to 40 meter depth (shallow to deep subtidal)	Rocky reefs (WDFW)

Although the ShoreZone data set is comprehensive in its representation of shoreline characteristics, we accepted some limitations when adopting this data set to develop our coarse filter targets. Most notably, ShoreZone does not distinguish between differences in the integrity of occurrences of the same ecosystem type. To some extent we compensated for this limitation by using data on shoreline modifications in the suitability index, so that the site selection model favored less altered sites.

Another limitation of this assessment is that it does not distinguish priorities among estuaries, per se. There are two reasons for this; one is methodological, and the other is a data gap. When similar shoreline types were lumped together to create a less detailed set of coarse filter targets, we lost the ability to distinguish estuarine wetlands from other wetlands. Also, alternative data to delineate and prioritize estuaries (e.g., juvenile fish densities, area of estuarine influence, percent historic vegetation) were not available throughout the ecoregion. The National Wetlands Inventory data set, for example, delineates estuarine wetlands differently than ShoreZone, and these data were not available for British Columbia during this assessment. As it stands, this assessment depends largely on delineations of saltmarsh, mud flats, and aggregations of shorebirds to represent the values most associated with estuaries. Many of the major estuaries in the region are identified as high priority sites as a result of expert workshops, where these areas were identified as priority conservation areas by experts (see 4.6.2, "Methods of Analysis").

There are inadequate data to represent the marine counterpart to terrestrial plant communities, i.e., associations of marine algae and sessile invertebrates. Likewise, few algal species can be adequately mapped. We collected information on 11 species of marine algae and plants in the intertidal and subtidal from the CDC in British Columbia. These element occurrences, as defined by the CDC and NatureServe, were mostly located in waters deeper than -40 meters, so were not included in the analysis. In addition, there was no clear indication the Centre had done a comprehensive survey in Georgia Basin for these species or whether they had just sampled in these discrete locations. These species included*: Eugomontia sacculata, Laminaria farlowii, Syringoderma phinneyi, Antithamnion kylinii, Callocolax globosis, Herposiphonia verticillata, Myriogramme pulchira, Myriogramme spectabilis, Ozophora latifolia, Phycodrys riggii, and Polysiphonia macounii.*

4.4.2 Fine Filter Data Gaps

Nearshore marine species data are either very coarse in scale (i.e., depicting a species' distribution over a large area) or collected on a very fine scale of resolution (i.e., detailed survey transects a specific site, but coverage across a wide area is highly discontinuous with varying methods). Data were screened for inclusion in the regional analysis through assessments of spatial data quality, assigning levels of data confidence to each data set. We used this data confidence ranking to decide whether to use the data in the regional analysis, and whether to set different parameters during the site selection analysis (see section 4.6.1). In general, we favored data that included a species' specific life stage (i.e., spawning, feeding areas) over data that represented an observation or a series of observations over a period of time. Observation data are usually attributed with numbers of individuals seen and their behavior, and do not indicate association with habitats. This type of data is biased to places where positive observations were recorded. Without a rigorous evaluation through a process similar to the creation of element occurrences, the inclusion of general polygon distribution or observed point locations may not represent the most persistent populations.

Invertebrates

The biggest data gap in British Columbia was in invertebrate data. We obtained the CDC's element occurrence database for the Strait of Georgia, but most data points were beyond the boundaries of the nearshore zone as defined for this ecoregional assessment. Fine filter data in Washington for invertebrates was collected on trawl ships at discrete locations. Without a comprehensive, continuous survey effort, we were limited by the places where species were found and therefore did not have a sense of abundance across the region. Although this is a systemic problem for all spatial analyses, it is particularly problematic for sessile invertebrates that may utilize large areas of benthic habitat types. These sparse data reflected neither the best nor the only sites where these species occur.

Nearshore Marine Fish

In British Columbia, we had no fishery-independent survey information on rockfish species, lingcod, surf smelt, or sand lance. We used rockfish closure areas as a suitability parameter (a "positive" cost for site selection because those areas are temporarily closed to fishing) in lieu of having explicit data. Only Pacific herring spawning data allowed for a comparison in both ecoregional jurisdictions (British Columbia and Washington).

Fishery-independent data in Puget Sound was collected on multiple rockfish species and lingcod, providing the context for regional analysis down to the 40 meter isobath. As noted above, however, these data were not enough to support selection of priority conservation areas beyond the defined nearshore limit for this assessment.

Rockfish, lingcod, and forage fish information in Washington covered the entire Puget Sound region, comprehensive for known and/or historic rocky reef habitat data where rockfish were both present and absent. Since we had no equivalent data for British Columbia (besides some nearshore marine fish data collected by the WDFW in the Southern Strait of Georgia), the analysis was biased to Puget Sound. Our rule for including data in the analysis was to use data for a conservation target if the target was surveyed over at least half of the ecoregion. Therefore these data, though included in the analysis, tended to over-represent potential priority conservation areas in Washington and under-represent them in British Columbia.

Seabirds

We had good representative data for seabirds on both sides of the border, though their collection methods and spatial data formats differed. Instead of trying to transform them into a single data set, we chose to keep them as two distinct spatial targets that represented one conservation target. In hindsight, this favors site selection where the data are more spatially explicit.

Nearshore Marine Mammals

Nearshore marine mammal data either came to us as general distribution areas depicted as polygons, or site observations with particular times associated with point data. Neither of these data types or formats could be included in the analysis, and therefore were used only for expert review sessions. In those sessions, experts were able to identify concentration areas of gray and minke whale feeding areas, which further refined general observations. However, the marine team did not think that these feeding areas were comprehensively assessed across the ecoregion. The areas were digitized at a coarse scale, and our confidence in them was low.

4.4.3 Other Data Gaps

In building the suitability index, we did not include water quality parameters (e.g., pollution outfalls, toxic dump sites, log transport facilities) or aquaculture areas as impacts to the nearshore. Obviously these are important factors in determining the health of the coastal environment and the suitability of sites for conservation, but we did not emphasize them in the data collection phase. As a result, the site selection algorithm sometimes chose areas of high impact (i.e., Totten Inlet, a site in southern Puget Sound with aquaculture operations) Refinement of this assessment will require the addition of spatial data on a broader set of impact factors to round out site selection parameters.

4.5 Setting Goals

The marine team set goals for each shoreline ecosystem and species target, expressed as percentages of the "amount" of that target known to exist throughout the ecoregion. Guidelines were added to ensure the selection of occurrences from across the natural range of the target throughout the ecoregion.

There was no mechanism to consistently assess viability for fine filter or ecological integrity for coarse filter targets. Since the nearshore marine data sets could not provide reliable data on the relative viability or integrity of individual occurrences, we set conservative (low) goals to help the algorithm assemble an efficient portfolio of sites important to multiple targets. We attempted to answer the question 'where do we start?' in conserving places for nearshore biodiversity, as opposed to 'how much (area) is enough?' to conserve that biodiversity. We used the nearshore and shoreline analyses to order targets into 'tiers' for portfolio assembly, and capture sites where multiple targets co-occur, where suitability for conservation is highest, and where our confidence in individual data sets is sufficiently high.

The team evaluated data quality through the accuracy of spatial and database parameters. Factors in determining the data quality included comprehensiveness across the ecoregion, dates of collection, positional accuracy, and the purpose of the data collected. After considering these factors, the team adjusted site selection algorithm parameters (see section 4.6.1) to ensure data was used correctly, including different data sets at different stages of the analysis (see section 4.6.2).

4.5.1 Coarse Filter Goals

ShoreZone data were the most uniform across the ecoregion and provided the best data for describing a portfolio representative of the ecoregion's nearshore marine biodiversity. Using a different approach than that taken by the terrestrial team, we began by setting a 'portfolio goal' for how much of the total shoreline length should be included in the nearshore marine portfolio. We experimented with a series of scenarios and put them before expert panels. The range of experimental goals was from 20 to 40% of the total shoreline length in the ecoregion. Likewise, we experimented with goal setting for individual shoreline ecosystem targets. The range of target goals tested was from 15 to 50% of that target's current extent.

In this way, we concluded that an overarching goal of including 30% of the entire shoreline ecosystem (not including man made shore units) was appropriate to identify first priorities for conserving the diversity of shoreline ecosystems. We found that 20% omitted some critical sites, while 40% drove the model to over-represent shoreline types.

Goals for coarse filter targets were determined by the relative diversity and complexity of their habitats across the tidal range. Vegetation types were used as a rough surrogate for habitat diversity. Targets with a higher number of vegetation types were assigned relatively higher percentage goals. The biologically simplest targets—unvegetated shorelines—received a goal of 25% of current extent. The biologically richest targets—shoreline ecosystems with saltmarshes, kelps, and seagrasses—received the highest goal of 40% of current extent. The other targets received goals within this range corresponding to their relative richness. In this way, the site selection algorithm will choose more occurrences of the biologically richest sites to ensure representation of the wider range of species that occupy them. These goals are shown in Table 4.6 in terms of shoreline length.

TABLE 4.6 Shoreline Target Goals for the Nearshore Marine portfolio (Non-percent numbers are in km)

SUB-TARGETS	KELP	KELP AND SEA-GRASS	SALT MARSH	SALT MARSH & SUBTIDAL VEG	SEA-GRASS	SUB-TIDAL VEG	UNVEGET-ATED	VEGET-ATED	TOTAL
Mud flat	-	-	618,206	136,656	-	47,821	195,630	-	998,313
Rock cliff	-	-	-	-	-	-	1,027,027	424,614	1,451,641
Rock platform	-	-	-	-	-	-	129,360	155,460	284,820
Rock with sand and/or gravel beach	254,981	109,765	-	18,365	80,514	-	1,042,151	-	1,505,777
Sand and gravel beach	182,046	179,744	37,128	36,695	262,747	-	431,813	-	1,130,172
Sand and gravel flat	74,565	121,036	41,104	56,599	207,792	-	320,206	-	821,301
Sand beach	135,651	63,885	66,841	57,266	194,266	-	162,832	-	680,741
Sand flat	33,337	60,181	67,378	113,689	232,900	-	152,712	-	660,198
Grand Total	680,580	534,611	830,656	419,270	978,219	47,821	3,461,732	580,073	7,532,962
Goal %	30%	40%	30%	40%	30%	40%	25%	30%	**29%**
Goal	204,174	213,845	249,197	167,708	293,466	19,128	865,433	174,022	**2,186,972**

For rocky reef habitats, we set a goal of 30% of known existing occurrences, attempting to capture places with the highest levels of relief and complexity. Although data were not comprehensive across the ecoregion, sites with and without the confirmed co-occurrence of rockfish species were identified.

4.5.2 Fine Filter Goals

In setting goals for fine filter targets, we considered the ecological attributes of the species (relative abundance, distribution, and number of occurrences) and the attributes of our available data sets (comprehensive across the ecoregion, specific as to location and relative importance of the occurrence). The goals ranged from 30 to 60% of known occurrences. Rare or declining species which had data on abundance at specific sites from thorough surveys (i.e., rockfish) were assigned relatively high goals. Widely distributed species for which we had generalized distribution areas, or few occurrences based on spot surveys (i.e., invertebrates), were assigned lower goals.

Like the coarse filter analysis, we used a range of goals to experiment with how the algorithm treated the aggregation of targets. Taxon groups were initially assigned a goal range of 20 to 40% and were analyzed at different stages of portfolio assembly (see section 4.6.2). This was an attempt to build a stepwise analysis and control data biases so that no individual species goal was too high, biasing site selection at those locations. After building these initial seascape sites, we adopted set goals between 30 and 60% for the rest of the analysis. Adjusting levels of ecosystem representation and species assemblages changed site selection results and required output to be carefully evaluated. Changing site selection results could be perceived as a bias, however consultations with multiple experts at different tiers reduced the error associated with such bias. Only after much research and experimentation with the algorithm did the team conclude that a meaningful conservation portfolio result had been attained.

4.6 Nearshore Marine Portfolio Assembly

The purpose of our efforts was to describe a portfolio of sites that, if conserved and properly managed, would protect a representative subset of the existing nearshore marine biodiversity in the Puget Sound and Strait of Georgia. This representative subset encompassed the intertidal zone and shallow subtidal zone.

4.6.1 Setting Parameters for the SITES Algorithm

The team developed a framework for shoreline and nearshore spatial analysis and expert review. Method development included the use of two different assessment units to construct the portfolio, constructing a suitability index, incorporating spatial information into an optimal reserve selection algorithm called SITES, and setting specific SITES parameters to increase efficiency and optimization during site selection (see Appendix 4 for more information about SITES methodology).

Assessment Units

We used two spatial assessment units for the nearshore and shoreline environments: 750-ha hexagons, and linear shoreline units of varying length. Initially, the marine team incorporated all shoreline information into the hexagons, but found that SITES favored those hexagons with more shoreline and not necessarily "more efficient" shoreline when meeting goals. We found that hexagons arbitrarily fragmented and aggregated shoreline units, leaving some hexagons with slivers of shoreline and others with large amounts (i.e., bays, inlets). In addition, the hexagon size lacked ecological justification and often straddled narrow water bodies, further aggregating shoreline units associated with different landmasses. Using linear shoreline assessment units, we found them to be more spatially explicit and easier for experts to review. For this assessment we therefore used both spatial formats for analysis (shoreline segments or lines and hexagons) and combined them during the portfolio assembly and delineation phases. Results of each analysis were evaluated at different stages in portfolio construction.

Suitability Index

To select priority conservation areas for the portfolio we included a suitability index, or "cost index" as it is referred to in SITES literature, in this analysis. This tended to reduce representation in places where human uses or modifications restrict conservation and restoration options. The index was developed in order to calculate both the total cost of choosing a network of sites, and the relative cost of each assessment unit.

Costs are usually referred to as impacts to the environment, making particular places less suitable for conservation. There are also jurisdictional costs where assumptions are made for different lands and waters holding a specific political status. These jurisdictional costs can be seen as more (i.e., lands already in conservation status) or less (i.e., lands devoted to resource extraction) suitable.

The index consisted of nearshore cost parameters and additional modifiers to those values. Each nearshore parameter was given a value and all costs were averaged within each assessment unit. Modifiers were additional values added to the averaged assessment unit costs.

Nearshore costs included public versus private ownership of tidelands, fisheries closures, marine reserves, and other protected areas. We assumed that privately owned tidelands were more difficult to conserve, and therefore given a higher cost relative to public property. However, there are different types of DNR tidelands that would increase or decrease costs. Public tideland does not always carry the lowest cost. Fisheries closures were given a lower cost than public ownership, but a higher cost than marine reserves and other marine protected areas. Descriptors of ownership and jurisdiction were loosely correlated with GAP codes in the terrestrial environment (see Chapter 2).

Modifiers, which unfortunately do not capture a wide variety of biodiversity but were the best available, included ferry and commercial shipping routes, the amount of armoring along the shoreline, the presence of railroad beds in the high intertidal, and the number of public and private boat ramps. We assumed that increased boat traffic was an impact to the nearshore, but was given a lower value than impacts from shoreline structures. The amount of armoring, railroad beds, and boat ramps were calculated within each shoreline unit; if their extent was more than 50% of a particular shoreline length, or at least 10 boat ramps, then those shorelines were identified as modifiers to the nearshore costs.

Nearshore costs and modifiers were calculated within both hexagon and shoreline assessment units (Table 4.7). In hexagons we averaged all nearshore costs and added modifiers to them through raster-based analyses (Map 4.3). A raster is a rectangular array of equally spaced cells, which taken as a whole represent thematic, spectral, or picture data (Zeiler 1999). All nearshore impact data was transformed into raster data. We then took the average of all nearshore cells within each assessment unit before adding the shoreline modifier values. Shoreline costs are displayed for the ecoregion in Map 4.4.

TABLE 4.7 Nearshore Marine Costs

DESCRIPTION	COST
Canadian Ecological Reserve or U.S. Federal Reserve or TNC Preserve	0
Washington Marine Protected Area or Voluntary No-take Area within Fisheries Closure and SJ Bio Reserve	50
Protected Public Tideland or Washington Wildlife or Aquatic Reserve or Voluntary No-take Area within SJ Bio Reserve	50
Public Bedland and Fisheries Closure AND SJ Bio Reserve	100
Public Bedland and Fisheries Closure OR SJ Bio Reserve	100
Public Tideland and Fisheries Closure and SJ Bio Reserve	100
Public Tideland and SJ Bio Reserve	100
Public Bedland	150
Public Tideland	200
Tribal Tideland	300
Private Tideland and Fisheries Closure and SJ Bio Reserve	350
Private Tideland and SJ Bio Reserve	350
Private Tideland	400

TABLE 4.7 (Cont'd.) Nearshore Marine Costs

DESCRIPTION	COST
AQUATIC LANDS	**COST SCORE**
"GAP1"	0– 50
"GAP2"	50– 100
"GAP3"	100– 200
"GAP4"	300– 400
"GAP5" – Open Water	100– 150
SHORELINE COST MODIFIERS	
If shoreline armoring covers greater than 0% and less than 50% of the total shoreline length within a hexagon, add 50 to Cost Score	
If shoreline armoring covers greater than or equal to 50% of the total shoreline length within a hexagon, add 100 to Cost Score	
If railroads in the high intertidal cover greater than 0% and less than 50% of the total shoreline length within a hexagon, add 50 to Cost Score	
If railroads in the high intertidal cover greater than or equal to 50% of the total shoreline length within a hexagon, add 100 to Cost Score	
If there are less than 10 private or public boat launches within a hexagon, add 50 to Cost Score	
If there are 10 or more private or public boat launches within a hexagon, add 100 to Cost Score	

We first chose a focal mean function to assign a cost value to all shoreline cells. Focal functions compute an output cell value from those input cells that are within a "neighborhood" centered on the output cell. The neighborhood is defined as all cells within a given radius; all shoreline cells calculate a mean value from the surrounding nearshore neighborhood. Once each shoreline cell had a mean value, we summarized all values per shoreline assessment unit before adding the modifiers. Using the same factors and values within both hexagons and shoreline assessment units resulted in similar suitability indexes. This provided consistency in running the site selection analysis on both assessment units.

Boundary Modifiers

A boundary modifier determines the amount of clumping between individual assessment units. This is usually done with polygons, but we customized the data inputs here to allow application to the linear spatial format.

We developed a linear boundary modifier that clumped, or attached, adjacent linear segments (arcs) along the shoreline. The algorithm was therefore able to assemble small fragments of shoreline into more continuous stretches (i.e., select an entire islands' shoreline). We also found that this helped us visualize more distinct sites across the shoreline ecosystem representation.

Species Penalty Factors

Setting species penalty factors determines the priority with which the SITES algorithm meets an individual target goal. The species penalty factor was set according to two parameters, the importance of the target and level of data confidence. A high penalty factor is assigned to a high priority target to cause SITES to choose sites in potentially "high cost" areas in order to meet its goals.

A data confidence level was used to drive SITES to favor (i.e., preferentially select for inclusion in the portfolio) habitats or species with high data confidence over those with lower confidence. We looked at the date the data were created, the survey methods used for collection, times of update, scale and positional accuracy, extent of the survey, and overall comprehensiveness in order to assign a confidence level. The penalties were determined by setting them within the range of cost values. The range of cost values was between 1 and 1,000, and the range of species penalty factors was between 1 and 150. Therefore, we set values as follows: 1 represented the default or lowest penalty, 50 represented the medium penalty, 100 the high penalty, and 150 the highest penalty, corresponding with decreasing confidence in the data.

4.6.2 Methods of analysis

The approach for building a nearshore marine portfolio combined spatial analysis and expert review into a 4-tiered system. At each tier we analyzed habitat and species data, then called upon experts to choose irreplaceable sites for that stage. These sites then became the "locked-in" sites for subsequent SITES program runs. This systematic approach was used to test each tier against the other while refining the portfolio.

Tier one involved the experimentation of different goals and expert evaluation to come up with initial seascape sites (nearshore sites important for overall marine biodiversity). Tier two added sites important to nearshore marine fish targets. Tier three added the rest of the target information, and Tier four incorporated select expert-nominated sites. The final stage involved site delineation of individual sites and the integration of nearshore marine with terrestrial sites.

Tier One: Initial Seascape Sites

The purpose of Tier one was to capture those relatively large, most intact seascapes that represent the overall nearshore biodiversity.

SITES analysis was performed on shoreline assessment units to represent the full array of shoreline ecosystems and intertidal habitats. We applied the 30% overall portfolio goal to capture all representative shoreline types, and compared their results against nearshore hexagon analysis.

A step-wise analysis was performed to identify initial seascapes based on various SITES scenarios applied to hexagons. After an evaluation of the importance of the conservation target, data quality, and co-occurrence of species, we grouped species data into four categories. First we input data on the forage fish targets (e.g., herring and sand lance) into SITES. Areas that it chose over a range of goals for each target (20 – 40%) were locked into the model for subsequent data computations. Next, data for lingcod, rockfish, and the rocky reef ecosystems were input into the model and the identified areas were locked in. This procedure was repeated for seabirds and nearshore marine mammals, then for the rest of the species targets. The result was reviewed for shoreline ecosystem target representation (Map 4.5).

In evaluating this analysis, initial seascapes were nominated based on regional importance and stratified throughout the ecoregion. The concept with initial seascape sites was to do a first wave of analysis on nearshore species and match the results with coarse filter habitat representation. Once the data was analyzed, marine technical team members evaluated results and wrote a list of candidate sites. The individual experts were polled to see what order they would assemble the list, using the following three criteria:

1. Large nearshore sites are important for nearshore marine biodiversity
2. Sites must be stratified[2] across the ecoregion

[2] Stratification is a process of creating sections within the ecoregion in order to spread the site selection and review process across the water body. The delineation of sections also serves as a surrogate for oceanographic processes including salinity, current, and temperature.

3. There should be diversity in the types of sites chosen, i.e., good for birds, good for invertebrates

The results of Tier one were the identification of ten seascape sites, five in Puget Trough and five in Georgia Basin (Map 4.6). Once these sites were confirmed by expert review, shoreline units and hexagons representing those sites were established as irreplaceable sites for subsequent analysis.

Tier Two: Nearshore Marine Fish

The purpose of Tier two was to select additional seascapes based on shoreline representation and nearshore marine fish. The marine team selected forage fish, rockfish, and lingcod as primary conservation targets for portfolio assembly based on their regional significance and international recognition as keystones throughout the ecoregion.

With the ten initial seascapes locked-in as irreplaceable sites, both the shoreline and nearshore data were again input into SITES and similar goals were set. With 9% of the shoreline within the initial seascapes, the algorithm computed an additional 21% to represent the variation of ecosystem types. For the nearshore hexagon analysis only the forage fish, nearshore marine fish, and rocky reef habitat information was utilized for site selection at Tier two. These data were among the highest quality for analysis, and were of high importance among conservation targets across the ecoregion. This time SITES computed these selected species and rocky reef ecosystem data once, with goals set between 30-60%, depending on the target.

This approach of computing the shoreline and nearshore data separately provided a means of filtering the representation of shoreline ecosystems, and favored those shore units that co-occur with species information. Shoreline ecosystem representation alone was not sufficient to capture the diversity of coastal communities because the algorithm selected sites based largely on quantity. With the additional nearshore species and REEF data, we were able to incorporate quality into the analysis.

Representative shoreline units were included in the portfolio if they intersected with selected hexagons or were in association with known high quality forage fish and rocky reef locations that fell within 300 meters of shore and were not chosen in the hexagon analysis. The results of Tier two were that 14% more shoreline was captured in the portfolio, bringing the total to 23%.

Tier Three: Seabirds, Nearshore Marine Mammals, and Invertebrates

The purpose of Tier three was to add seascapes to the portfolio based on the remaining conservation targets which included seabirds, nearshore marine mammals, and invertebrates.

With 23% of the shoreline represented in the draft portfolio after Tier two, the linear assessment units were again input so that the remaining 7% could be used as a filter over the selected hexagons or known high quality species occurrences. For the hexagons, all species information, including seabirds, nearshore marine mammals and invertebrates were included, and goals between 30-60% were set depending on the target. With the completion of this analysis, 4% of the shoreline was added to form the Tier three portfolio bringing the total shoreline represented to 27%. All nearshore species goals were met, with many exceeding their goal (Table 4.8).

TABLE 4.8 Fine Filter Data Analysis Targets

CONSERVATION TARGET	SPATIAL TOTAL	DATA TYPE	GOAL %	GOAL AMOUNT	TOTAL AMOUNT CAPTURED	TOTAL % CAPTURED
American wigeon	323,250	EO - DENSITIES	**30%**	96,975	118,700	**37%**
American wigeon BC	106,500	EO	**60%**	63,900	77,000	**72%**
Basket star	4,750	EO	**30%**	1,425	1,500	**32%**
Bird colonies BCWA	29,350	EO	**60%**	17,610	17,800	**61%**
Black brant	60,550	EO - DENSITIES	**30%**	18,165	34,200	**56%**
Black brant BC	111,000	EO	**60%**	66,600	70,000	**63%**
Black rockfish	10,200	EO	**60%**	6,120	5,800	**57%**
Box crab	1,600	EO	**30%**	480	1,050	**66%**
Copper rockfish	103,450	EO	**30%**	31,035	32,700	**32%**
Gooseneck barnacles	3,000	EO	**30%**	900	3,000	**100%**
Harbor seal pups	11,000	EO	**60%**	6,600	7,000	**64%**
Harlequin duck	98,500	EO - DENSITIES	**30%**	29,550	35,500	**36%**
Harlequin duck BC	101,500	EO	**60%**	60,900	67,500	**67%**
Lingcod	55,050	EO	**30%**	16,515	25,400	**46%**
Loons	157,200	EO - DENSITIES	**30%**	47,160	49,400	**31%**
Loons BC	105,000	EO	**60%**	63,000	75,000	**71%**
Marbled murrelet	161,950	EO - DENSITIES	**30%**	48,585	49,550	**31%**
Marbled murrelet BC	136,000	EO	**60%**	81,600	87,500	**64%**
Orange sea pens	13,600	EO	**30%**	4,080	4,800	**35%**
Pacific herring spawn	33,286	Acreage	**60%**	19,972	20,862	**63%**
Pacific herring spawn BC	443,296	Linear meters	**60%**	265,977	276,800	**62%**
Pinto abalone	19,786	Acreage	**30%**	5,936	8,873	**45%**
Polyorchis jellyfish	4,000	EO	**30%**	1,200	2,000	**50%**
Quillback rockfish	110,050	EO	**30%**	33,015	39,450	**36%**
Red necked grebe	176,500	EO - DENSITIES	**30%**	52,950	54,200	**31%**
Red necked grebe BC	103,500	EO	**60%**	62,100	68,000	**66%**
Rock scallop	7,017	Acreage	**30%**	2,105	3,118	**44%**
Rocky reef	308,150	EO	**30%**	92,445	112,100	**36%**
Rosy tritonia	10,300	EO	**30%**	3,090	3,200	**31%**
Sand lance spawn	231,431	Linear meters	**60%**	138,859	146,832	**63%**
Scaups	173,950	EO - DENSITIES	**30%**	52,185	62,750	**36%**
Scaups BC	141,500	EO	**60%**	84,900	86,000	**61%**
Scoters	727,650	EO - DENSITIES	**30%**	218,295	229,200	**31%**
Scoters BC	138,000	EO	**60%**	82,800	86,000	**62%**
Sealion rafts	11,035	Acreage	**60%**	6,621	6,780	**61%**
Seawhip	1,550	EO	**30%**	465	1,550	**100%**
Shorebirds BC	97,100	EO	**60%**	58,260	67,100	**69%**
Shorebirds WA	90,500	EO	**60%**	54,300	55,500	**61%**
Spiny vermillion star	4,450	EO	**30%**	1,335	1,600	**36%**
Steller sealion hauls	8,000	EO	**60%**	4,800	5,000	**63%**
Surf smelt spawn	417,501	Linear meters	**60%**	250,501	260,145	**62%**
Tiger rockfish	2,650	EO	**60%**	1,590	2,650	**100%**
Western grebe	313,050	EO - DENSITIES	**30%**	93,915	90,500	**29%**
Western grebe BC	101,000	EO	**60%**	60,600	70,000	**69%**
Yelloweye rockfish	6,300	EO	**60%**	3,780	5,250	**83%**

We then conducted two quality assessment workshops to review the selected sites with experts from WDNR, MSRM, and the Archipelago Marine Research group who were responsible for creating and mapping the shoreline throughout the ecoregion. They checked to ensure that the portfolio captured the best-quality shoreline habitats in the ecoregion, and that it did not exclude any especially unique, diverse, or pristine sites known from their surveys. Their review added important quality information for many sites, and confirmed the Tier three portfolio without any major changes.

Tier Four: Expert Nominated Seascapes

The purpose of Tier four was to evaluate all expert-nominated sites that were not selected from the analysis up to this point, and incorporate a subset of them into the portfolio. Throughout the ecoregional planning process we conducted workshops to fill data gaps and identify places of diversity. The information we learned from the workshops provided us with a means to compare the spatial analysis with expert-nominated areas and to identify additional places we had not previously selected. However, expert-derived data contains biases depending on the expert's background and familiarity with the geography. Therefore, we had to devise a filtering process for expert nominated sites to confirm those of regional significance.

The filtering process involved interviewing experts after the workshops and showing them the preliminary analyses. Our primary measure of filtering expert-derived sites was to verify whether the site was of regional importance at the scale of the ecoregion. The interview with the experts focused on scale. We asked: “Why was the site originally chosen?” “What was the species or habitat distribution for those selected targets?” and, “Is that site truly irreplaceable across the ecoregion in light of the draft portfolio?”

Most expert-nominated sites reviewed in this way were determined to be insufficiently significant for inclusion in the portfolio, i.e., they were insufficiently important to warrant removing other sites to make room for them. Many of these rejected sites may be of local (rather than ecoregional) significance.

Tier four review added 1% of the shoreline to the Tier three result, bringing the final draft nearshore marine portfolio to 28% toward our goal of 30%. This represents approximately 2,112 km of shoreline out of the total natural (excluding man-made) shoreline of 7,533 km (Map 4.7). We elected not to search for an additional 2% of shoreline to meet our portfolio goal of 30%, anticipating the addition of some shoreline via integration with the terrestrial portfolio.

Integration with Terrestrial Portfolio

After the nearshore marine and terrestrial portfolios were in final draft form, we began a process of integration and site delineation. The draft terrestrial portfolio identified additional shoreline sites for inclusion in the final conservation portfolio based on forest and saltmarsh communities included in the terrestrial coarse filter targets. This final stage is discussed in Chapter 5.

4.6.3 Results

The nearshore marine component of the ecoregional assessment identified 186 shoreline/nearshore sites within the Puget Trough and Georgia Basin (Appendix 19 “Final shoreline sites”). There were 4,732 shoreline units captured in the final portfolio totaling 2,910 km, or 39% of the total shoreline length (excluding man-made shore units). The integration of terrestrial portfolio sites (Chapter 5) added 11% of the shoreline. This resulted in most individual shoreline ecosystem targets exceeding their representation goals (Table 4.9 “Final shoreline results”). See Chapter 5 for a more thorough discussion of portfolio results across terrestrial and nearshore marine ecosystems.

TABLE 4.9 Final Integrated Portfolio Shoreline Results

SHORELINE ECOSYSTEMS	INTERTIDAL HABITATS	TOTAL # SHORE UNITS	TOTAL LENGTH (KM)	GOAL	SHORE UNITS DRAFT NEARSHORE COMPONENT	LENGTH (KM) DRAFT NEARSHORE COMPONENT	% CAPTURED DRAFT NEARSHORE COMPONENT	SHORE UNITS FINAL INTEGRATED PORTFOLIO	LENGTH (KM) FINAL INTEGRATED PORTFOLIO	% CAPTURED FINAL INTEGRATED PORTFOLIO	GOAL MET?
Sand flat	Kelp	74	33.3	**30%**	17	9.6	29%	29	13.7	**41%**	Y
Sand flat	Kelp and seagrass	87	60.2	**40%**	17	17.0	28%		21.6	**36%**	N
Sand flat	Saltmarsh	128	67.4	**30%**	40	24.1	36%	50	29.0	**43%**	Y
Sand flat	Saltmarsh and subtidal veg	183	113.7	**40%**	50	47.4	42%	51	50.1	**44%**	Y
Sand flat	Seagrass	446	232.9	**30%**	114	76.3	33%	137	83.1	**36%**	Y
Sand flat	Unvegetated	355	152.7	**25%**	110	47.2	31%	108	43.9	**29%**	Y
Sand beach	Kelp	230	135.7	**30%**	66	51.8	38%	64	50.1	**37%**	Y
Sand beach	Kelp and seagrass	139	63.9	**40%**	24	12.6	20%	38	15.7	**25%**	N
Sand beach	Saltmarsh	111	66.8	**30%**	26	20.5	31%	29	22.4	**34%**	Y
Sand beach	Saltmarsh and subtidal veg	99	57.3	**40%**	27	17.7	31%	38	23.6	**41%**	Y
Sand beach	Seagrass	370	194.3	**30%**	95	55.2	28%	131	75.7	**39%**	Y
Sand beach	Unvegetated	342	162.8	**25%**	104	54.7	34%	111	58.9	**36%**	Y
Sand and gravel flat	Kelp	118	74.6	**30%**	23	24.6	33%	30	27.8	**37%**	Y
Sand and gravel flat	Kelp and seagrass	177	121.0	**40%**	33	33.6	28%	49	41.1	**34%**	N
Sand and gravel flat	Saltmarsh	55	41.1	**30%**	13	19.7	48%	17	22.7	**55%**	Y
Sand and gravel flat	Saltmarsh and subtidal veg	81	56.6	**40%**	26	23.4	41%	34	29.4	**52%**	Y
Sand and gravel flat	Seagrass	401	207.8	**30%**	118	67.8	33%	134	75.5	**36%**	Y
Sand and gravel flat	Unvegetated	657	320.2	**25%**	142	74.6	23%	206	110.8	**35%**	Y
Sand and gravel beach	Kelp	362	182.0	**30%**	59	37.8	21%	106	58.7	**32%**	Y
Sand and gravel beach	Kelp and seagrass	286	179.7	**40%**	62	51.0	28%	98	75.2	**42%**	Y
Sand and gravel beach	Saltmarsh	63	37.1	**30%**	11	9.8	26%	29	17.6	**47%**	Y
Sand and gravel beach	Saltmarsh and subtidal veg	69	36.7	**40%**	17	13.7	37%	31	19.9	**54%**	Y
Sand and gravel beach	Seagrass	477	262.7	**30%**	100	78.1	30%	109	83.4	**32%**	Y
Sand and gravel beach	Unvegetated	968	431.8	**25%**	193	94.0	22%	300	143.0	**33%**	Y
Rock with sand and/or gravel beach	Kelp	568	255.0	**30%**	62	53.5	21%	197	96.1	**38%**	Y
Rock with sand and/or gravel beach	Kelp and seagrass	258	109.8	**40%**	29	27.3	25%	74	49.2	**45%**	Y
Rock with sand and/or gravel beach	Saltmarsh and subtidal veg	44	18.4	**40%**	27	12.8	70%	32	14.3	**78%**	Y
Rock with sand and/or gravel beach	Seagrass	149	80.5	**30%**	27	24.3	30%	37	28.7	**36%**	Y
Rock with sand and/or gravel beach	Unvegetated	2,223	1,042.2	**25%**	402	215.9	21%	775	385.2	**37%**	Y
Rock platform	Unvegetated	335	129.4	**25%**	33	20.8	16%	95	44.3	**34%**	Y
Rock platform	Vegetated	315	155.5	**30%**	71	43.8	28%	143	68.9	**44%**	Y

SHORE LINE ECO SYSTEMS	INTER TIDAL HABITATS	TOTAL # SHORE UNITS	TOTAL LENGTH (KM)	GOAL	SHORE UNITS DRAFT NEAR SHORE COMPO NENT	LENGTH (KM) DRAFT NEAR SHORE COMPO NENT	% CAPTURED DRAFT NEAR SHORE COMPO NENT	SHORE UNITS FINAL INTE GRATED PORT FOLIO	LENGTH (KM) FINAL INTE GRATED PORT FOLIO	% CAPTURED FINAL INTE GRATED PORT FOLIO	GO AL ME T?
Rock cliff	Unvegetated	2,025	1,027.0	**25%**	371	217.8	21%	683	382.1	**37%**	Y
Rock cliff	Vegetated	1,013	424.6	**30%**	234	126.6	30%	353	160.1	**38%**	Y
Mud flat	Saltmarsh	478	618.2	**30%**	138	251.7	41%	176	300.1	**49%**	Y
Mud flat	Saltmarsh and subtidal veg	161	136.7	**40%**	49	55.9	41%	84	83.3	**61%**	Y
Mud flat	Subtidal veg	72	47.8	**40%**	26	17.1	36%	46	30.5	**64%**	Y
Mud flat	Unvegetated	271	195.6	**25%**	72	65.6	34%	84	75.0	**38%**	Y
Man-made	Unvegetated	551	402.2	**0%**	68	101.7	25%				
Man-made	Vegetated	200	134.3	**0%**	25	16.5	12%				
Totals		**14,941**	**8,069.5**	*** 30%**	**3,121**	**2,213.5**	*** 28%**	**4,732**	**2,910.6**	*** 39%**	

* Total goal is expressed as percentage of the total length of the shoreline in the ecoregion. The goal figures in the remainder of this column are expressed as percentage of the current extent of the referenced ecosystem target.

4.6.4 Discussion

The nearshore marine conservation portfolio identified 122 sites in Washington and 64 in British Columbia. The larger number of sites in Washington reflected state efforts to identify saltmarshes, seagrasses, and kelps in its ShoreZone Inventory. Georgia Basin was one of the first regions mapped using the ShoreZone system, and biological surveys were not as thorough, particularly along the eastern shore. Consequently, a large number of vegetated shoreline units were identified in the survey as "unvegetated" and therefore not valued as highly in the SITES algorithm.

There were other cases where the strength of Washington data sets – the scale of resolution, number of occurrences, or measured abundances – drove the portfolio to under-represent British Columbia. We tried to normalize this effect by only including data sets that spanned most of the waters of the ecoregion, generalizing Washington data to better match data resolution in British Columbia, and setting goals lower in Washington for the same target species. For example, data on seabird observations in Washington had a finer scale of resolution and resulted in more data points, so the algorithm had more qualifying sites to choose from in Washington. To compensate for this, the team set Washington goals for seabird observations at half those in British Columbia to attempt to capture equal area for those targets in each country.

We conducted a preliminary comparison of the draft nearshore marine portfolio to existing conservation areas in the ecoregion. The draft nearshore marine portfolio (before integration with terrestrial conservation opportunity areas) included approximately 2,214 km of shoreline, or 28% of the ecoregion's shoreline. Our comparison illustrated that approximately 433 km (or 20%) of shoreline ecosystems were within existing conservation areas. The draft portfolio did not include 417 km of shoreline associated with existing conservation areas. The comparison also pointed out the limits of existing data on conservation areas. For example, in most cases the administering agency does not have jurisdiction over the protection of nearshore marine species (e.g., Washington State Parks), although it does have jurisdiction over the property. A thorough comparison of the final portfolio to existing conservation areas would have required additional, labor-intensive effort to acquire and map more information.

Resource managers in Washington were interested in identifying the value of the portfolio to Washington "species of concern," so we included the related data in the analysis. We set the goals for these local targets at zero so data did not skew the site selection, but the portfolio can be assessed for its contribution to the conservation of those species.

Marine ecosystems are open and dynamic, and are not as easily defined or prioritized as terrestrial systems. Through this effort we have learned what it means to plan in the dynamic nearshore system. ShoreZone data provided an excellent baseline of data on coastal characteristics, representing a complete picture of the shoreline over thousands of kilometers. Through this lens, nearshore sites with high concentrations of biodiversity have been located and assessed. This has established a basis for prioritizing sites and describing a representative portfolio at the ecosystem level. However, this is a starting point for conservation, not a complete vision. Data are sparse, reducing the reliability of any target list or portfolio selection process. One particular challenge was not having ecosystem or habitat level data for subtidal areas. Methods are needed to accommodate ecological processes more fully in assembling a portfolio. Although the interaction of marine species and habitats has been evaluated through the data development and analytical stages of the process, we cannot describe the level of connectivity among sites in the current portfolio. In consideration of this, there are significant steps we can take to develop more robust conservation portfolios in the coastal zone.

Looking ahead, it would be useful to add ecosystem processes to the portfolio assembly model by including information on littoral cells. Like watersheds, which define the boundaries of a stream system, littoral cells delineate the boundary of a beach-sediment system. Understanding how waves interact with sediment over time is central in evaluating how coastal processes affect the biota of the nearshore.

The process of integrating terrestrial, freshwater and nearshore marine assessments needs to be improved. Methods we are interested in exploring include building databases that combine stream reach information with stretches of shoreline, and analyzing watershed parameters in association with estuarine and other coastal systems. Concepts of integration and the delineation of terrestrial-nearshore marine portfolio sites are still in their infancy. As our understanding of these systems increases, more effort should be put into planning across these diverse ecosystems.

This assessment incorporated ideas about threats to nearshore biodiversity only via the suitability index. A spatially explicit threats analysis would further inform portfolio assembly. This might include the compilation of regional information on point and nonpoint source pollution, invasive species distributions, aquaculture, coastal development and other threats, and developing analytical techniques that explore cumulative affects. The inclusion of this information is critical to understanding how the nearshore continually changes in the face of these threats. It is also essential in evaluating how these threats can be abated.

In future iterations of this assessment we hope to run site selection algorithms for all marine ecosystems in Puget Sound and the Strait of Georgia. Data on substrates and bathymetry, salinity, currents, sea surface temperature and productivity might be combined to create a model for offshore ecosystems. More biological data are needed to test such a model. Future work in this area will assist planning for conservation in deeper waters.

4.7 Expert Review

The marine technical team utilized a wide circle of experts to fill data gaps and conduct reviews of the nearshore marine portfolio. New relationships were established with state, provincial, and national agencies, members of academia, and other environmental nonprofit organizations. Please see Appendix 2 for the complete list of participating experts.

Experts reviewed various draft portfolios, first while the team was experimenting with multiple target goals, and second when developing the 4 tiers of analysis. Given that goal setting did not reflect a viability analysis among the targets, experts initially reviewed a series of draft portfolios from a range of goals (20 to 40% of the shoreline captured). These initial analyses were reviewed to determine if the site selection was capturing places that experts knew had a strong presence of targeted biodiversity or captured targets in their area of expertise. Experts reviewed the portfolio to determine if sites were being selected in highly degraded places (which the suitability index did not adequately represent). Experts also reviewed draft portfolios with higher goals to test the balance between selecting too many places and the degree of algorithm optimization.

During the workshops and review sessions, experts identified places of known importance according to their expertise. The team documented and tracked these places in association with the site selection analysis. Expert-nominated places and those selected by the algorithm were combined in the four-tier approach. After each tier of analysis, experts reviewed the site selection and verified their results. At Tier four, experts reviewed the remaining expert-nominated sites outside the draft portfolio. At this point they were deciding whether these expert-nominated sites contributed to meeting nearshore marine target goals and should be added to the portfolio.

Expert knowledge and review at different stages of the analysis was valuable to both verify output from the site selection algorithm and fill gaps in our understanding of important places for nearshore marine biodiversity in the ecoregion. It was useful to create a framework for including expert input to be used as a verification process and to prevent expert-nominated sites from controlling site selection. This combined approach served to reinforce the analysis and strategically direct the use of undocumented expertise.

Chapter 5 – Assembly and Summary of the Final Portfolio

This chapter describes how the terrestrial, nearshore marine, and freshwater analyses were combined to create a single, final portfolio. The chapter ends with a description of the resulting portfolio.

Topics described in this chapter include the following:

5.1 Introduction

The preceding chapters described separate analytical processes for terrestrial, nearshore marine, and freshwater biodiversity. Each process used the best available data, expert knowledge, and a GIS-based, optimal site selection algorithm, SITES, to identify ecoregionally significant places for the conservation of their respective segments of biodiversity. The terrestrial, freshwater, and marine portfolios were then compared, integrated, and adjusted to maximize the efficiency (in terms of biodiversity conserved per unit area) of the combined portfolio, and site boundaries were further approximated based on natural features and/or land use patterns.

5.2 Assembling the Portfolio

The process of integrating and delineating the final Willamette Valley-Puget Trough-Georgia Basin portfolio included four major steps listed below:

1. **Expert review** of the terrestrial portfolio and initial integration with draft nearshore marine portfolio.

2. **Integration** of freshwater attributes into sites already selected for the nearshore marine/terrestrial portfolio.

3. **Delineation** of approximate boundaries for all sites in the integrated portfolio.

4. **Addition** of special occurrences to form the final portfolio.

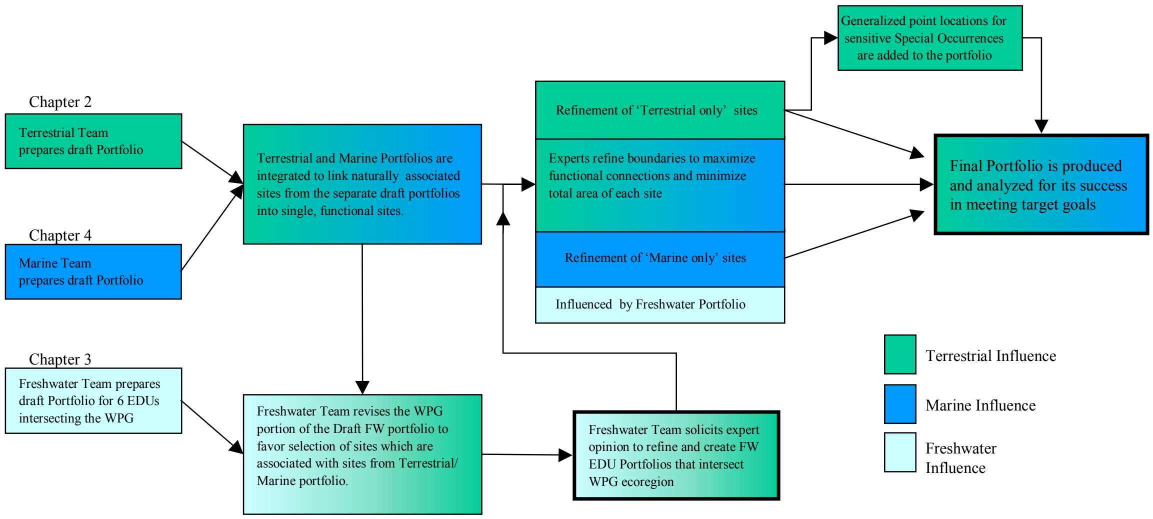


FIGURE 5.1 Willamette Valley-Puget Trough-Georgia Basin Portfolio Assembly

5.2.1 Nearshore Marine Portfolio Integration

Because all 489 assessment units (including hexagons and linear shoreline units) selected in the nearshore marine portfolio were of 'high confidence,' these were locked in with the terrestrial portfolio lock-ins (Map 5.1) and run together in SITES to create the integrated portfolio. This revealed an overlap of 132 units where marine and terrestrial targets co-occur. We ran SITES again with these 1687 [(357 marine, 1198 terrestrial, and 132 marine/terrestrial) assessment units] locked in. The hexagons added by SITES to meet terrestrial goals brought this first integrated portfolio up to a total of 3178 hexagons, or about 40% of the ecoregion (Map 5.2). In several cases the algorithm was able to capture additional terrestrial targets in the locked in marine (shoreline) areas that were not a part of the original terrestrial portfolio. Review by the core team confirmed this approach as an effective way to efficiently select places where terrestrial and marine targets coexist.

5.2.2 Integration of a Subset of Freshwater Portfolio with the Nearshore Marine/Terrestrial Portfolio

As described in Chapter 3, the freshwater team devised a method to favor the integration of assessment units selected for freshwater targets with those already selected for terrestrial or nearshore marine values. The final step in the development of the suitability index for each freshwater system occurrence was to note whether that occurrence overlapped with the terrestrial or nearshore marine portfolios. If overlap occurred, the unweighted average of the four suitability index factors used in the freshwater SITES run was reduced by 50% (and therefore the suitability index was increased) to preferentially select areas closer to terrestrial or nearshore marine areas. While this may ultimately enable a more efficient integrated portfolio, this process biases the freshwater portfolio towards EDU occurrences that fall within the Willamette Valley-Puget Trough-Georgia Basin ecoregion. A more complete integration of freshwater and terrestrial portfolios will require further consideration in light of subsequent ecoregional assessments intersecting the same EDUs, and in light of further assessment of habitat suitability within the EDUs. In addition, the freshwater portfolio was used during the site delineation process (section 5.2.3) as another source of information to help guide delineation of sites to capture known freshwater attributes of importance.

5.2.3 Delineation of Site Boundaries

Using the hexagons selected in the draft integrated portfolio, core team members and other experts delineated site boundaries (at a scale of 1:100,000) based on natural features and land-use patterns using available maps, aerial photos, remote imagery, target data, expert knowledge, and other information assembled during this project to facilitate site delineation.

We delineated sites to efficiently capture all of the biodiversity for which the area was selected and to address connectivity needs. We excluded portions of those units that did not contribute to the site's conservation values or integrity.

These boundary refinements greatly improved the accuracy of the portfolio. However, each of these priority conservation areas is complex, and the boundaries delineated here are a first, rough approximation. The boundaries should be regarded as a starting point to be further refined with local information.

Each delineated site was named based on dominant natural features, nearby towns or communities, local custom, or established protected area names. We asked agency, tribal and private-sector biologists to complete one final review of the delineated portfolio. A total of 372 polygonal sites were delineated in this process, representing approximately 1,264,000 ha, or 23% of the ecoregion (Maps 5.3a and 5.3b). The final portfolio also includes 39 marine shoreline segments that we were unable to combine with the terrestrial or marine polygonal sites. These 39 segments represent stand-alone marine portfolio sites. They are linear sites without calculated areas and do not contribute to the total area figure of 1,264,000 ha.

5.2.4 Addition of Special Occurrences to the Final Portfolio

A number of hexagons selected by SITES to conserve target species and rare plant community occurrences were not included in delineated portfolio areas. The target occurrences contained within these hexagons were either too small to be reliably delineated, have lower viability/integrity ranks, were based on data that is restricted from publication due to the sensitivity of the species, or represented data in which we had lower confidence regarding accuracy. Because of the likely importance of these isolated occurrences to the survival of the imperiled species or rare community types they represent, these hexagons were added back into the portfolio as special occurrences.

Special occurrences are displayed as a point symbol on Maps 5.4a and 5.4b. The components of each occurrence are listed in Appendix 20. Their locations are generalized to the center of the hexagon and tracked by using the hexagon's unique identification number. (Point symbols for special occurrences in Oregon were located in the general location of the referenced target(s) rather than the center of the hexagon.) Our general method for creating special occurrences was as follows:

1. We created special occurrence points for hexagons that contained target species or plant communities with at least one A, B, or C ranked occurrence. If a hexagon was selected based on this criterion, D and K occurrences in that selected hexagon were also included in the portfolio.

2. In the Washington and British Columbia portions of the ecoregion, we created a center-point (centroid) for the portion of any qualifying hexagon outside of existing delineated areas. For each centroid defined, we documented the target species and plant community occurrences it represents. In Oregon, we used expert review to generalize the location of special occurrences.

The total area of these special occurrences was neither calculated nor included in the total area of the final portfolio. Of the 534 special occurrences in the portfolio, 116 are in the

Georgia Basin, 144 in the Puget Trough, 77 in the Lower Columbia and 197 in the Willamette Valley. There are 107 in British Columbia, 191 in Washington, and 236 in Oregon. The large number of special occurrences in the Willamette Valley may reflect the greater fragmentation of the landscape in that section.

5.3 The Result: A Portfolio of Priority Conservation Areas for the Willamette Valley-Puget Trough-Georgia Basin Ecoregion

The completed portfolio for the Willamette Valley-Puget Trough-Georgia Basin is a first approximation of the high priority places for terrestrial and nearshore marine conservation across the ecoregion. Many of these sites are also important for conservation of the ecoregion's freshwater biodiversity, but the assessment is not as complete for freshwater targets in all EDUs as it is for terrestrial and nearshore marine targets.

As displayed in Table 5.1, the total area of this portfolio is approximately 1.2 million ha (3,122,080 ac), or 23% of the total area of the ecoregion, including 372 delineated sites (Appendix 21a). The portfolio also includes 39 shoreline segments (Appendix 21b) and 534 special occurrences (Appendix 20) for which polygonal boundaries and areas were not calculated.

TABLE 5.1 Final Portfolio Assembly

PORTFOLIO COMPONENTS	NUMBER OF UNITS	PORTFOLIO AREA OR SHORE LENGTH	PERCENT OF ECOREGION
Delineated Portfolio (sites)	372	1,263,972 ha	22.77%
Special Occurrences	534	N/A	N/A
Nearshore Marine Shoreline Segments	39	89 km	N/A

Target Goals and the Portfolio

Goal performance is presented separately for terrestrial, freshwater and marine targets due to differences in goal-setting processes, as described below. Table 5.2 summarizes the success of the final portfolio in meeting goals for terrestrial targets. Table 5.3 summarizes portfolio success in meeting marine target goals. The target/goal success of the preliminary freshwater portfolios developed for the six ecological drainage units that overlap the ecoregion is described in Chapter 3. The number of sites that include freshwater targets in the integrated, final portfolio is shown in Table 5.8.

Recall that goals were primarily a device for assembling an efficient conservation portfolio, and that they should not be interpreted as guaranteeing the necessary and sufficient conditions for long-term survival of species, plant communities, or ecological systems. Our goals may also be used as benchmarks for gauging the progress of biodiversity conservation in the ecoregion over time.

TABLE 5.2 Terrestrial Target Goal Results of the Final Portfolio

TARGET	TOTAL NUMBER OF TARGETS	NUMBER OF TARGETS WITH GOALS	NUMBER OF TARGETS THAT MET GOALS	PERCENT OF TARGETS THAT MET GOALS
Terrestrial Systems	19	19	13	68%
Plant Communities	90	90	8	9%
Terrestrial Species Targets	422	320	42	13%
Birds	45	28	11	39%
Herpetofauna	24	20	5	25%
Invertebrates	38	26	6	23%
Mammals	20	13	2	15%
Non-vascular plants	56	0	n/a	n/a
Vascular plants	239	233	18	8%
Total	**531**	**429**	**63**	**15%**

The goal statistics should be used as a check on the assessment process, keeping in mind the different goal-setting processes used in terrestrial, nearshore marine, and freshwater efforts. Terrestrial target goals were set to capture 30% of the historic extent of terrestrial large-scale system types, or a number and distribution of occurrences of species, small-scale system types and rare community targets that would capture the genetic, ecologic and floristic diversity of those targets across all sections of the ecoregion, reducing the chance of local extirpation. For 32% of terrestrial systems targets, this goal could not be met because the target has already been reduced to less than 30% of its historic extent. The team was forced to include large expanses of altered habitat (e.g., logged forests that are in active production forestry) to meet goals because a limited amount of higher-quality habitat currently exists in the ecoregion. Likewise, goals could not be met for most terrestrial species and rare community targets despite including all known occurrences; enough known occurrences to meet goals simply do not exist.

Marine target goals (Table 5.3), however, were set to capture a percentage of the current extent of each system type, bringing known areas of exceptional importance to nearshore biodiversity into the portfolio while avoiding redundant or lower-integrity sites. These target goals were nested within an overall marine portfolio goal of no more than 30% of the entire shoreline length in the ecoregion. The marine team described their goal-setting guideline as a device to find ‘where to start’ in conserving a representative sample of nearshore biodiversity.

TABLE 5.3 Nearshore Marine Target Goals Results of the Final Portfolio

TARGET	TOTAL NUMBER OF TARGETS	NUMBER OF TARGETS WITH GOALS	NUMBER OF TARGETS THAT MET GOALS	PERCENT OF TARGETS THAT MET GOALS
Nearshore Marine Systems	40	40	37	93%
Nearshore Marine Species Targets	68	33	33	100%
Birds	12	11	11	100%
Fish	11	9	9	100%
Invertebrates	26	10	10	100%
Mammals	8	3	3	100%
Non-vascular plants	11	0	n/a	n/a
Total	**108**	**73**	**70**	**96%**

Freshwater goals, meanwhile, cannot be compared to marine or terrestrial goals as they were set for entirely different geographic regions (ecological drainage units rather than the ecoregion). The freshwater system occurrences included in the freshwater portfolio informed the terrestrial and marine analysis to ensure that the final portfolio included sites where important freshwater attributes co-occur with terrestrial or marine sites. The freshwater portfolios developed here for the six overlapping EDUs provide a starting point for a more complete, parallel assessment and portfolio design for freshwater biodiversity.

These goal statistics tell us that the terrestrial sites selected in this assessment are essentially all that remains of many already-depleted terrestrial systems, species, and rare communities. Because the assembled portfolio was forced to include impacted habitats in order to approach meeting the systems goals, and because of the shortage of fine filter target occurrences, these statistics also suggest a need for restoration to improve the quality and extent of occurrences for many targets within and outside the portfolio.

In the nearshore marine environment, these goal statistics tell us simply that the team fulfilled its objectives of selecting roughly 30% of the total shoreline in a way that represents the full range of targets.

Imperiled Terrestrial Species and Rare Communities in the Portfolio

Forty-five percent of the 311 delineated terrestrial sites in the portfolio contain G1(globally critically imperiled) or G2 (globally imperiled) targets (Table 5.4).

Approximately 26% of the 829 known occurrences of G1 or G2 targets in the ecoregion fall outside delineated portfolio sites and are captured only in the special occurrences. Of the 97 G1 or G2 targets, six are only known to occur in special occurrences (Table 5.5) and one, the plant community Sitka spruce/red-osier dogwood-Hooker's willow, was not included in the polygonal sites or the special occurrences due to poor viability.

TABLE 5.4 Count and Percent of Terrestrial Sites with G1 or G2 Targets

SECTION	# OF CONSERVATION AREAS WITH G1 OR G2 TARGETS	TOTAL TERRESTRIAL SITES	% OF SITES WITH G1 OR G2
Georgia Basin	46	94	49%
Puget Trough	31	92	34%
Lower Columbia	20	44	45%
Willamette Valley	42	81	52%
WPG	139	311	45%

TABLE 5.5 G1 or G2 Targets Represented Only in Special Occurrences

Black cottonwood-red alder/slough sedge plant community
Black cottonwood-white alder plant community
Coyote-thistle-smooth lasthenia plant community
Fragrant popcorn-flower
Paper birch-red alder/swordfern plant community
Van dyke's salamander

Site Distribution in the Portfolio

Portfolio sites are distributed across all sections of the ecoregion. British Columbia, Washington, and Oregon are each represented in the portfolio (Table 5.6). Although marine areas of the portfolio are represented in Table 5.6, shoreline segments are excluded, because segments are only measured linearly.

TABLE 5.6 Portfolio Area by Ecoregional Section and State/Province for the Willamette Valley-Puget Trough-Georgia Basin (shown in hectares)

	Section Name				
PROVINCE/STATE	GEORGIA BASIN	LOWER COLUMBIA	PUGET TROUGH	WILLAMETTE VALLEY	TOTAL
British Columbia	236,712		77,262		313,973
Oregon		107,380		242,799	350,179
Washington	70,674	93,212	435,935		599,821
Total	307,385	200,592	513,197	242,799	1,263,973

Figure 5.2 shows the range of sizes for the priority conservation areas. Most of the 372 sites in the ecoregion fall into the 200 to 8400 ha range with approximately equal numbers of smaller and larger sites (54 sites are smaller and 53 sites are larger). The Puget Trough section contains the greatest number of large sites, while the Georgia Basin has most of the small sites. The Lower Columbia section has the fewest sites and these are distributed more evenly among size classes.

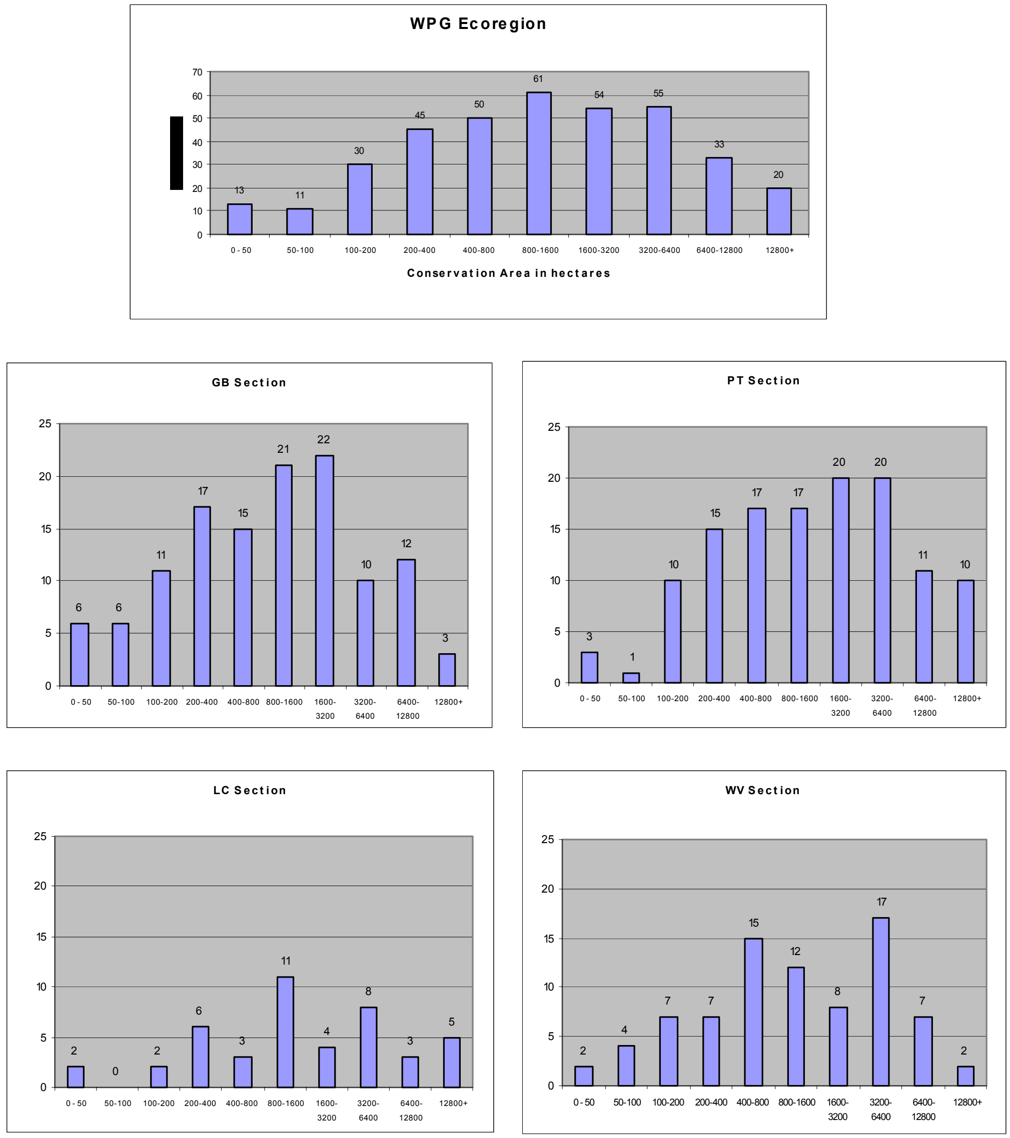


FIGURE 5.2 Priority Conservation Area Size Classes for the Ecoregion and Ecoregion Sections. X-axes numbers are size classes in hectares. Y-axes show the number of sites in each size class.

Conservation areas range in size from 18 ha at Trial Island in British Columbia, to Western Kitsap Peninsula, at 36,779 ha.

Of the 372 delineated conservation areas, 123 are in the Georgia Basin section (representing 16% of the sectional area), 44 in the Lower Columbia section (31% of the area), 124 in the Puget Trough section (27% of the area) and 81 in the Willamette Valley section (23% of the area) (Table 5.7). The larger total number of sites in the Georgia Basin and Puget Trough may be due in part to relatively more detailed terrestrial systems and GIS (for example, digital orthophotos) information available during site delineation. This allowed some large individual hexagon groupings to be split into multiple conservation areas.

TABLE 5.7 Number of Delineated Sites by Section and Province/State in the Willamette Valley-Puget Trough-Georgia Basin

	SECTION NAME				
PROVINCE/STATE	GEORGIA BASIN	LOWER COLUMBIA	PUGET TROUGH	WILLAMETTE VALLEY	TOTAL
British Columbia	66	-	15	-	81
Oregon	-	19	-	81	100
Washington	57	25	109	-	191
Total	123	44	124	81	372

Table 5.8 shows conservation areas by type and province/state. The total number includes the 372 polygonal sites and 39 shoreline conservation areas counted within the nearshore marine only category. These linear sites are excluded from the area analyses because their polygonal boundaries have not been delineated.

TABLE 5.8 Number of Sites by Type for State/Province and Sites with Freshwater Portfolio Elements

CONSERVATION AREA TYPE	SITES WITH FRESHWATER	BRITISH COLUMBIA	OREGON	WASHINGTON	PROVINCE/ STATE TOTAL
Nearshore Marine only	0	25	-	75	100
Terrestrial only	157	25	100	100	225
Terrestrial/Nearshore marine	41	41		45	86
Total	198	91	100	220	411

Existing Protected or Natural Resource Management Areas and the Portfolio

Only 24 (6%) of the 372 delineated priority conservation areas in the portfolio are within existing protected areas, with at least 50% of their area "protected" under the GAP Protected Status Classification detailed in Appendix 3 (Table 5.9).

TABLE 5.9 Number of Conservation Areas by Section and Province/State that are > 50% Protected*

	SECTION NAME				
PROVINCE/STATE	GEORGIA BASIN	LOWER COLUMBIA	PUGET TROUGH	WILLAMETTE VALLEY	TOTAL
British Columbia	6	-	-	-	6
Oregon	-	1	-	2	3
Washington	10	-	5	-	15
Total	16	1	5	2	24

*Protected here means GAP code 1 or 2

Twenty percent of the portfolio lies within public lands owned and/or managed by the Washington Department of Natural Resources, the US Department of Defense, the US Bureau of Land Management, British Columbia Parks, and other government entities (Table 5.10).

Table 5.10. Overlap of Portfolio with Major Land Ownership Categories (areas in hectares)

PROVINCIAL/FEDERAL GOVERNMENT		BRITISH COLUMBIA	OREGON	WASHINGTON	TOTAL
BC Federal Government	Fisheries and Oceans Canada	360			360
US Federal Government	Corps of Engineers		4,830		4,830
	National Park Service			850	850
	US Bureau of Land Management		20,370	270	20,640
	US Dept. of Defense			34,490	34,490
	US Fish and Wildlife Service		4,070	2,410	6,480
	US Forest Service		2,930	8,400	11,330
	Federal Government Total	**360**	**32,190**	**46,410**	**78,970**
TRIBAL LANDS	Tribal			**9,530**	**9,530**
STATE OR PROVINCIAL GOVERNMENT					
BC Provincial Government	BC Parks	16,390			16,390
	Parks Canada	2,070			2,070
	Provincial Park Ecological Reserve	1,340			1,340
State of Oregon	Oregon Department of Fish and Wildlife		7,370		7,370
	Oregon Parks and Recreation		1,630		1,630
	Oregon State		1,440		1,440
	Oregon State University		4,470		4,470
	State Scenic Waterway		10		10
State of Washington	Department of Natural Resources			75,510	75,510
	Other			340	340
	University of Washington			410	410
	Washington Department of Fish and Wildlife			5,680	5,680
	Washington Parks and Recreation Commission			9,850	9,850
	Washington State Department of Corrections			260	260
	Western Washington University			40	40
	State or Provincial Government Total	**19,790**	**14,910**	**92,090**	**126,800**
LOCAL GOVERNMENT					
City or Municipal Government	City		1,980	10,190	12,170
County Government	County Government		1,200	3,200	4,400
Regional District	Regional District Nature Appreciation Area	5,280			5,280
	Regional District Park	2,590			2,590
	Local Government Total	**7,880**	**3,180**	**13,390**	**24,450**
ENVIRONMENTAL NGO					
Nature Trust of BC	Canadian Wildlife Service	20			20
	Fisheries and Oceans Canada	250			250
	Nature Appreciation Area	410			410
	Provincial Park Ecological Reserve	10			10
The Nature Conservancy	Preserve	0	440	1,330	1,770
Trust Lands/NCC	Trust	8,210			8,210
	Environmental NGO Total	**8,900**	**440**	**1,330**	**10,670**
	Managed Lands Grand Total	*277,040*	*299,460*	*437,060*	*1,013,550*
6. PRIVATE/OTHER					
	Portfolio Total	**313,970**	**350,180**	**599,820**	**1,263,970**

The heavy reliance of the portfolio on public, private, and tribal lands currently in revenue-generating uses leads to the presumption that conservation of many of these larger sites will require innovative blending of management actions to sustain both biodiversity and other economic activities.

Chapter 6 – Exploring Prioritization

This chapter explores potential prioritization schemes for the terrestrial conservation areas and assessment units in the Willamette Valley-Puget Trough-Georgia Basin ecoregion. Prioritization matrices are presented for the conservation areas combining scores for biological values and vulnerability and, in a separate exercise, hexagon assessment units' relative values are displayed under varying goal assumptions both with and without the suitability index. Data limitations and differences in assessment units precluded addressing the freshwater and nearshore marine systems in the prioritization analyses.

The following topics are discussed in this chapter:

6.1 Part I: Exploring Portfolio Prioritization

The Willamette Valley-Puget Trough-Georgia Basin conservation portfolio identifies 372 separate polygonal portfolio areas as important for biodiversity conservation. Given the uneven geographic distribution of species, habitats, and impacts to biodiversity across the ecoregion, we know intuitively that these conservation areas vary in their biological importance and vulnerability. Meanwhile, many users of the assessment will need to know all they can to guide their own decisions about which sites to focus on first within this vast portfolio.

When deciding how to order priorities within the portfolio, a number of important factors could be considered, such as each site's total number of targets, number of extremely imperiled targets, the extent of an ecological system, and/or the immediacy of the threats to the persistence of native biodiversity. Here we explore methods for prioritizing conservation areas within the portfolio. This exploratory prioritization is limited to the terrestrial portions of the portfolio, i.e., those 311 priority conservation areas that include terrestrial targets.

6.2 Portfolio Prioritization Methods

A number of schemes have been proposed for prioritizing conservation areas (Winston and Angermeier 1995, Poiani et al. 2001, see Justus and Sarkar 2002 for a review). We adopted a scheme similar to those used by Noss et al. (2001) and Rumsey et al. (2003) (Figure 6.1).

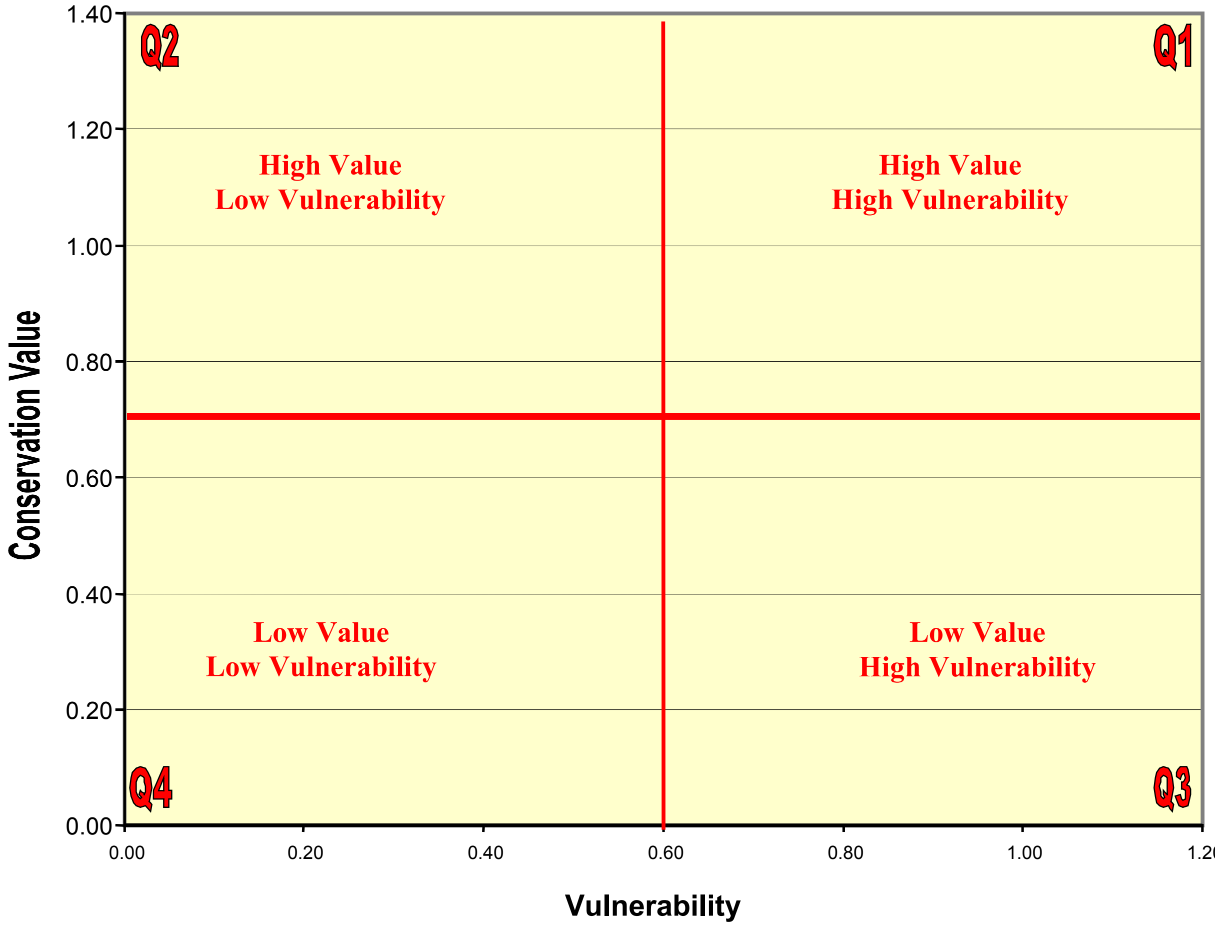


FIGURE 6.1 Quadrants of the Conservation Value/Vulnerability Scatter Plot

They plotted conservation value versus vulnerability for a large number of conservation areas. The resulting scatterplot sorts conservation areas into 4 general categories: more vulnerable, higher value areas in the upper right-hand quadrant (Q1); less vulnerable, higher value areas in the upper left quadrant (Q2); more vulnerable, lower value, areas in the lower right quadrant (Q3); and less vulnerable, lower value areas in the lower left quadrant (Q4). More vulnerable, higher value sites in Q1 are often thought of as the highest priority for conservation action. Less vulnerable, lower value areas are usually the lowest priority. Conservation areas in the other two quadrants frequently receive intermediate priority. Quadrants were defined by the median values for conversation value and vulnerability. The use of median values to define the quadrants causes each quadrant to contain the same number of conservation areas.

6.2.1 Conservation Value

Pressey et al. (1994), Margules and Pressey (2000), and Pressey and Cowling (2001) have discussed quantitative measures of conservation value that rate the relative contributions made by different conservation areas toward biodiversity goals. For this analysis, our measure of conservation value had to be a function of readily available GIS data. We based conservation value on six factors:

1. ***Species Rarity****:* The number of imperiled (G1 and G2) elements within a conservation area;

2. ***Target Richness****:* The total number of A, B, C and D targets. K targets were included only for species (modeled K community occurrences were not included due to data uncertainties);

3. ***Coarse Filter Targets****:* The percent of area-based coarse-filter target captured by a priority conservation area. The only coarse filter system types represented in this measure are:

    - Riparian Forests and Shrubland
    - Willamette Oak Woodland
    - Douglas-fir–Western Hemlock–Western Redcedar Forest
    - Dry Evergreen Forest–Woodland

4. ***Irreplaceability:*** The SITES algorithm was used to measure the irreplaceability of a conservation area. We ran 25 replicates of SITES without the suitability index. The number of times a hexagon was selected corresponded to its relative importance or irreplaceability. The irreplaceability value for a conservation area was the mean of all the hexagons intersecting the conservation area. Without the suitability index, SITES will preferentially select hexagons that have imperiled species and/or many targets over hexagons with common species and fewer targets.

5. *Target Density:* The number of imperiled (G1 and G2) elements within a conservation area;

6. ***Target Quality****:* The average Element Occurrence (EO) rank score. The score was computed for each target as follows in the table below. This measure includes A, B, C occurrences as well as D occurrences for species.

EO-RANK	SCORE
A	10
B	8
C	4
D	1

These six factors were combined as follows:

$$\text{conservation value} = A_1 B_1 SR + A_2 B_2 TR + A_3 B_3 CF + A_4 B_4 IR + A_2 B_2 TD + A_3 B_3 TQ \quad (6\text{-}1)$$

where A_i is a subjective weight that expresses certainty or confidence in GIS data, B_i is a subjective weight that expresses the importance of the factor, SR is normalized species rarity, TR is normalized target richness, CF is the normalized proportion of coarse filter captured, IR is the normalized mean relative importance, TD is the target density and TQ is the mean target quality. When determining the subjective weights, the factor considered the most important was given a weight of 1 for B_i, and the factor with the highest quality GIS data was given a weight of 1 for A_i. The other weights are values relative to 1.

We created two sets of weights to explore different ways of estimating the conservation value of conservation areas (Table 6.1). Although the GIS data used in both the species and landscape analyses were the same, different certainty or confidence weights were given to each analysis based on the different perceptions of core team members.

TABLE 6.1 Potential Relative Weightings for Value Certainty and Importance

	WEIGHTING FACTOR	SPECIES RARITY	TARGET RICH-NESS	COARSE FILTER REPRE-SENTATION	IRRE-PLACE ABILITY	TARGET DENSITY	TAR-GET QUA-LITY
Set 1 Species	CERTAINTY	1	0.4	0.8	0.5	0.5	0.6
	IMPORTANCE	1	0.7	0.5	0.3	0.4	0.6
Set 2 Land-scape	CERTAINTY	0.7	0.4	1	0.5	0.5	0.6
	IMPORTANCE	0.4	0.4	1	0.5	0.3	0.3

Weight Set 1 reflects a belief that species are the most important consideration when determining conservation value. Species rarity is given the highest importance. The proportion of a coarse filter target captured in a particular unit or area (relative to the total area of that target captured in the entire portfolio) is the second highest weight because of the species-area relationship – a larger area should support a greater number of species. Irreplaceability, or the mean value of all hexagons selected in a conservation area, was third. Weight Set 2 reflects a belief that large blocks of habitat are the most valued characteristic of a conservation area. The proportion of coarse filter captured was given the greatest importance. In both sets of weights, irreplaceability receives a medium weight because it is somewhat redundant. That is, without the suitability index, hexagons with imperiled species and/or many targets have higher irreplaceability. Target richness was given low confidence because differences in sampling effort between areas can bias results.

The conservation value distribution for all conservation areas was subdivided into quartiles to observe how the relative value of each area shifted in response to changes in weights (See 6.3.1).

6.2.2 Vulnerability

Vulnerability of a conservation area is the likelihood that targets will be lost from that area given its condition and landscape context. Vulnerability is based on impacts at each area, the status quo, and plausible extrapolations of status quo management and policies. Suitability indicates the relative likelihood of successful conservation at a conservation area (see Chapter 2). Suitability reflects assumptions about efficient and practical conservation. For the purposes of prioritization, we assumed that vulnerability was approximately the opposite of the suitability. They are not exact opposites, but terms in the suitability index correspond quite well to vulnerability factors. The suitability index included terms for current condition (i.e., land use), and for near-term impacts (i.e., proximity to urban growth areas). Therefore, one component of the vulnerability of a conservation area was the mean suitability of all hexagons intersecting the conservation area.

We did not fully explore alternate ways of estimating the vulnerability of conservation areas. However, we took advantage of opportunities with local and regional experts to gather cursory information about the impacts within each priority conservation area, together with an estimate of the severity and urgency of each of those impacts at each priority conservation area. The result is a checklist of generalized impacts for each assessment unit. Table 6.2 shows the list of impacts to conservation areas in the ecoregion.

TABLE 6.2 Impacts to Priority Conservation Areas (in alphabetical order)

	IMPACT CATEGORY
1	Channelization of rivers or streams
2	Commercial/industrial development
3	Conversion to agriculture or silviculture
4	Crop production practices
5	Ditches, dikes, drainages and diversions
6	Fire management
7	Forestry practices
8	Grazing practices
9	Industrial discharge
10	Invasive species
11	Landfill construction or operation
12	Military activities
13	Mining practices
14	Non point source water pollution
15	Operation of drainage or diversion systems
16	Point source water pollution
17	Recreational infrastructure development
18	Recreational use
19	Recreational vehicles
20	Residential development
21	Roads and/or utilities
22	Shoreline stabilization

Along with suitability index values, the total number of impacts and the number of high urgency and high severity impacts at each site were included in vulnerability ratings (Table 6.3). These three factors were combined as follows:

$$\text{vulnerability} = A_1\ B_1\ SV + A_2\ B_2\ TI + A_3\ B_3\ MI \quad (6\text{-}2)$$

where Ai is a subjective weight that expresses certainty or confidence in GIS data, Bi is a subjective weight that expresses the importance of the factor, SV is the normalized suitability index value for each site, TI is normalized total number of impacts and MI is normalized magnitude of impacts (number of impacts given both high severity and urgency ratings). We used the same weightings for all factors in both the Set 1 (Species) and Set 2 (Landscape) analyses.

TABLE 6.3 Potential Relative Weightings for Vulnerability Certainty and Importance

	WEIGHTING FACTOR	SUITABILITY	NUMBER OF IMPACTS	MAGNITUDE OF IMPACTS
Set 1 Species	CERTAINTY	1	0.7	0.4
	IMPORTANCE	0.9	1	0.4
Set 2 Landscape	CERTAINTY	1	0.7	0.4
	IMPORTANCE	0.9	1	0.4

6.3 Portfolio Prioritization Results

6.3.1 Distribution of Value and Vulnerability among Sites

The relative values of the conservation areas were more widely distributed for the species weighted values (Figure 6.2) than for the landscape values (Figure 6.3). Keep in mind that differences between these results are based entirely on the confidence and importance weightings and that the underlying data is identical.

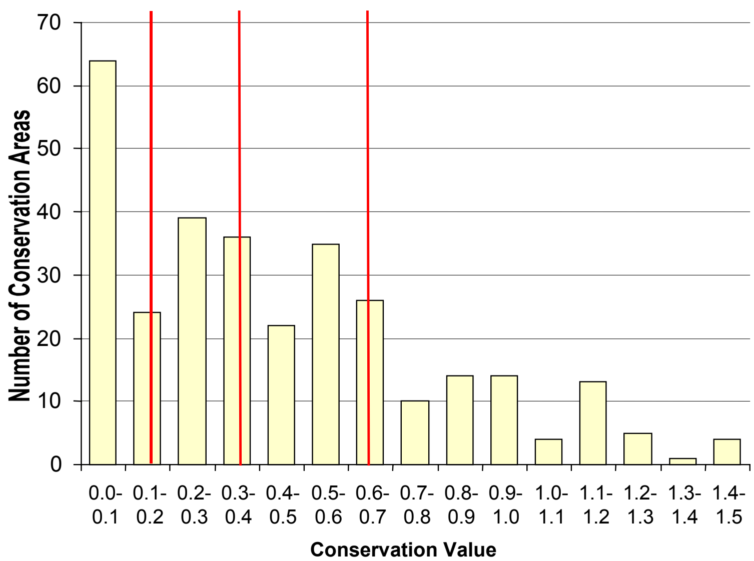


FIGURE 6.2 Distribution of species-weighted conservation value for all terrestrial conservation areas. Red lines are approximate locations of first quartile, median, and third quartile.

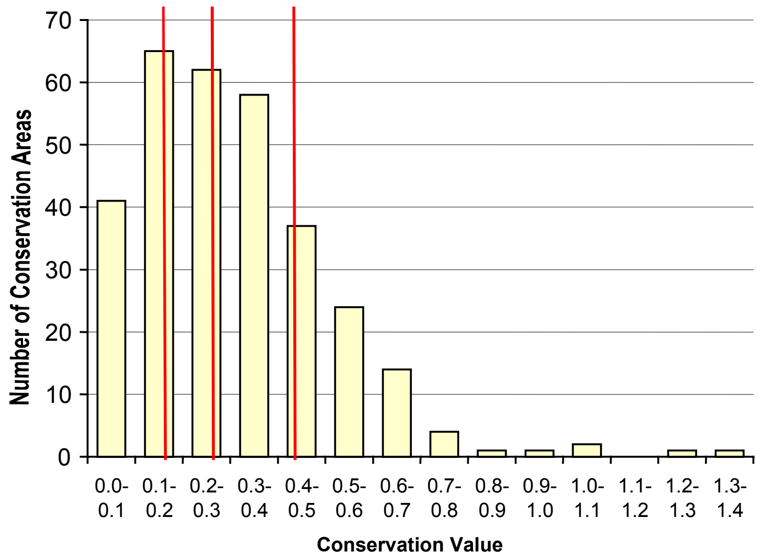


FIGURE 6.3 Distribution of landscape-weighted conservation value for all terrestrial conservation areas**.** Red lines are approximate locations of first quartile, median, and third quartile.

The relative vulnerabilities of conservation areas were normally distributed (Figure 6.4); the mean, median, and mode values were approximately equal. In effect, most areas are subject to medium vulnerability but a small number of sites have very low vulnerability and a small number have very high vulnerability.

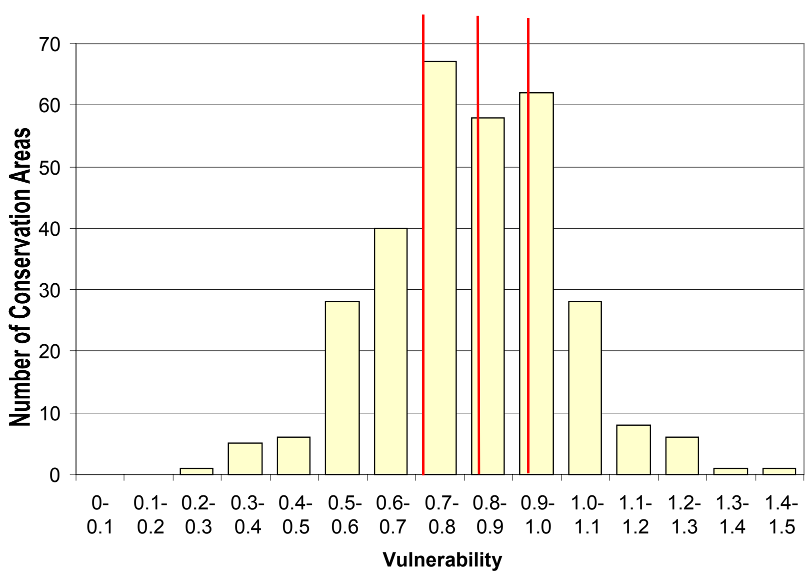


FIGURE 6.4 Distribution of vulnerability values for all terrestrial conservation areas. Red lines are approximate locations of first quartile, median, and third quartile.

6.3.2 Prioritization Matrices

The interaction of the two dimensions of value and vulnerability sorts the terrestrial conservation areas into the four quadrants that correspond to the four priority categories. Figure 6.5 shows this sorting using the Set 1 (Species) weightings.

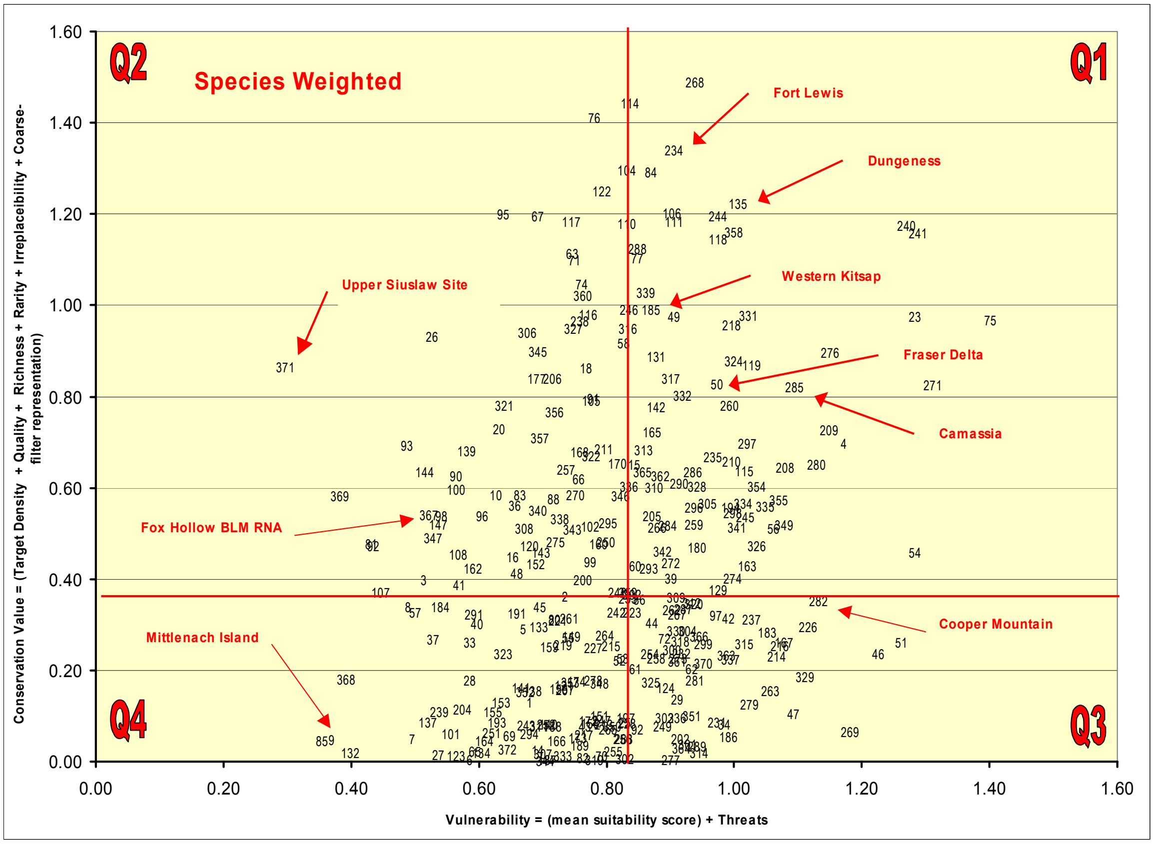


FIGURE 6.5 Species-Weighted Terrestrial Conservation Area Prioritization

The absolute x and y values for any area are not meaningful, but the relative position of sites to each other within the scatterplot does convey useful information. Conservation areas in the upper right of the scatterplot are frequently thought to be the highest priority for conservation because they are the most valuable and the most vulnerable. Conservation areas in the lower left of the scatterplot would logically be the lowest priority because they are the least valuable and the least vulnerable.

A second scatterplot (Figure 6.6) shows the shift in relative position of conservation areas if the coarse filter conservation value weight is increased (i.e., Set 2 weightings from Table 6.1).

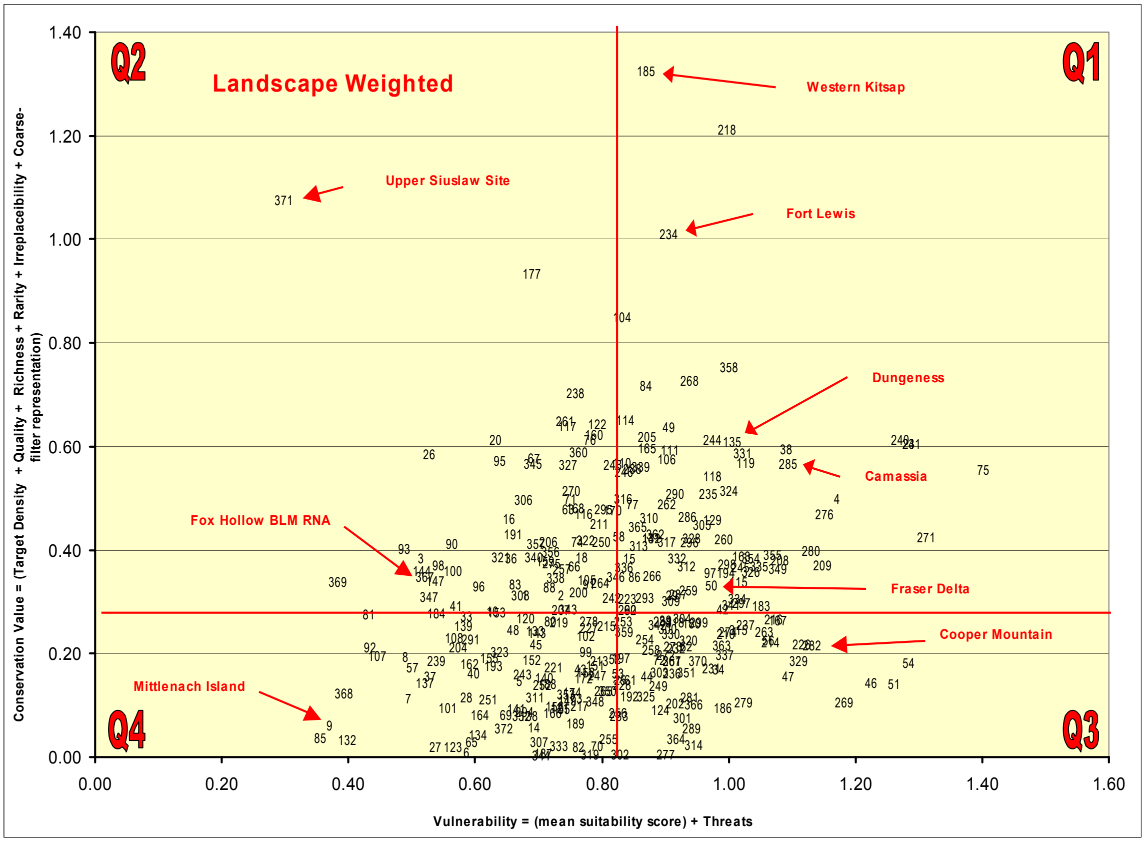


FIGURE 6.6 Landscape-Weighted Terrestrial Conservation Area Prioritization

One can see the change in the relative value of sites between Figures 6.5 and 6.6 by examining example sites, indicated in each figure. Sites with large areal contributions to coarse filter target goals, such as Western Kitsap, climb substantially along the conservation value axis from Figure 6.5 to 6.6 relative to other sites. However, areas like Cooper Mountain, which are relatively low in coarse filter targets and more likely selected for fine filter species, decrease in relative value from Figures 6.5 to 6.6. For approximately 1/3 of the sites (105), this shift in the balance of coarse and fine filter targets caused nearly equal numbers of targets to increase or decrease by a least one quartile in value (55 vs. 50, respectively).

Maps 6.1a, 6.1b, 6.2a, and 6.2b show how prioritization among the terrestrial sites appears spatially across the ecoregion for species-weighted and landscape-weighted prioritizations, respectively. The Index to Maps 6.1a and b in the Map Book shows for the species-weighted scheme how each of the 311 named terrestrial sites is represented within 16 sections of the matrix, referred to as quartiles. Site names are indexed by color for comparison with Maps 6.1a and b. Each quartile subdivision is represented by one of the 16 colored sectors in the map showing 16 new prioritization categories, based on the original four quadrants. Maps 6.2a and b used the same method. The sectors show which conservation areas are especially high value/high vulnerability and especially low value/low vulnerability.

6.4 Portfolio Prioritization Discussion

The prioritization methods just demonstrated can be used by decision-makers who are thinking about conservation at ecoregional scales. The rough priorities established make sense at the ecoregional scale, but are not fine enough to support prioritization of sites that occur within a smaller part of the ecoregion. At these smaller scales, such as a single county, the job of prioritizing among portfolio sites must and can be informed by a more complete understanding of value, vulnerability, cost, and opportunity.

Interpretation of the scatterplot can lead to different conclusions and strategies for conservation action. Some decision-makers, who favor action at more highly threatened and higher value sites (often referred to as “biodiversity hotspots”), would look to quadrant 1 for action priorities. Others may see a more efficient conservation strategy in concentrating resources in quadrant 2, which shows sites that are of higher value but with lower threat and presumably a better chance of successful conservation.

This prioritization method provides useful information. However, it should be used with caution. Vulnerability values are based in part on a very cursory evaluation of impacts. This cursory approach did not account for the interaction among impacts (e.g., forestry practices may impact a site, but are often an important economic buffer against the impact of urbanization), or consider the programs underway to abate each impact and their likelihood of success, or break complex impacts (e.g., invasive species) into finer components that can differ dramatically in their importance and tractability. In addition, relative biological values are shaped by differences in survey effort. Poorly surveyed areas with high biodiversity may not be accurately represented in this analysis.

Therefore, one should resist interpreting minor differences between conservation areas on the scatterplot as significant. It is more significant to note in what quadrant a site lies in the matrix rather than to look at differences between sites within a quadrant. Users should take this prioritization as a beginning, and be prepared to adjust it as they look more closely at a particular area’s biodiversity, vulnerability, and the practical issues of conservation opportunity.

We were unable to include the marine and freshwater portions of the portfolio in this analysis. We did not have G1/G2 rankings for our marine targets in order to give us species rarity values at sites, which is one of the key components of our conservation value measure. The relative value of sites to freshwater biodiversity must be assessed within the context of ecological drainage units rather than terrestrial ecoregions as described in Chapter 3.

6.5 Part II: Exploring Assessment Unit Prioritization Using a Sensitivity Analysis

The purpose of the sensitivity analysis is twofold: (1) to demonstrate how changing our assumptions with regard to goals and the suitability index influences the selection and prioritization of assessment units and (2) to generate additional information to help prioritize among assessment units and the areas selected for the portfolio.

The sensitivity analysis was done only for the terrestrial portion of the portfolio because: (1) the terrestrial results have a greater influence on the portfolio than the marine or freshwater results and (2) terrestrial environments and species have been more thoroughly studied, and therefore, the terrestrial results are more robust than the marine or freshwater results.

6.6 Sensitivity Analysis Methods

For the purposes of the sensitivity analysis, we defined 5 alternative goals: 100, 80, 60, 40, and 20% of the goals used in the analysis of section 2.5 of Chapter 2. We ran the SITES optimal site selection algorithm ten times: each of the five alternative goals with the cost index (see Map 6.3) and without the cost index (see Map 6.4). We knew beforehand one obvious result: reducing the goals would reduce the number of selected hexagons. We sought to determine how changes in goals effect the number of hexagons selected, the spatial distribution of selected hexagons, and variation in replicate optimal solutions.

To explore the effect of the suitability index we conducted the analysis with the index (see Map 6.5) and without the index (see Map 6.6). The index used was that described (see Map 2.4: “Suitability Index”) in Section 2.4. To remove the suitability index, we set the “cost” of all hexagons to 1, the lowest value allowed by SITES. Without a suitability index the optimization algorithm attempts to meet the goal with the smallest number of hexagons. As a result, the position of hexagons relative to public lands or urban growth areas did not affect the optimization.

SITES has a number of other parameters that affect the optimization. For almost every type of scientific analysis, as the number of parameters increases, the ability to interpret results decreases. Therefore, to better understand the results of our analyses, these other parameters were assigned values that would minimize their confounding influences. For instance, the boundary modifier parameter was set to zero. Parameter values for all analyses are given in Table 6.4.

TABLE 6.4 Values for SITES parameters used in all sensitivity analyses

PARAMETER	FUNCTION	VALUE
Replications	Number of times to repeat full optimization	25
Iterations	Number of times to test new combination of hexagons	2,000,000
Boundary modifier	Weighting factor for “cost” of nonadjacent hexagons	0
Species penalty factor	“cost” of not meeting a species’ ecological goal	1 for all species (minimum allowed value)
Hexagon status	Initial state of each hexagon	0 for all hexagons (no “lock-ins”)

The output known as the “sum solution” seemed most appropriate for our analysis. The sum solution is the number of times a hexagon was selected by multiple individual replicates. We performed 25 replicates for each combination of alternate goals and suitability index. Hence, a hexagon selected 25 times was considered irreplaceable and hexagons selected 20 to 24 times were considered to have high relative importance.

Information conveyed in separate sum solutions (i.e., one for each goal) can be integrated into a single map referred to as the “sum-sum solution.” Relative to a single sum solution, the sum-sum solution enhances the contrast in relative importance among hexagons and more fully depicts the spatial extent of biodiversity across the ecoregion. The sum-sum solution is produced by adding the five separate sum solutions. Hence, a hexagon with high irreplaceability would be selected close to 125 times (5 runs x 25 replicates/run) and hexagons selected 100 to 124 times have high relative importance. The sum-sum solution was calculated separately for runs with and without the suitability index.

6.7 Sensitivity Analysis Results

As expected, as the goals increased, the number of hexagons included in the sum solution (i.e., selected in at least one of the replicates) increased (Figure 6.6, Maps 6.3 and 6.4). The rate of increase declined as the goal increased. The number of hexagons included in the sum solution was always smaller for analyses run with the suitability index than those run without the index (compare Maps 6.5 and 6.6). For the 20% alternative goal, 21% of all hexagons were included in the sum solution without the suitability index but only 14% with the index. For the 100% alternative goal, 43% of all hexagons were included in the sum solution without the suitability index but 40% with it. This demonstrates that when suitability is not considered the range of potential solutions increases but also that the suitability index results in a more “efficient” solution.

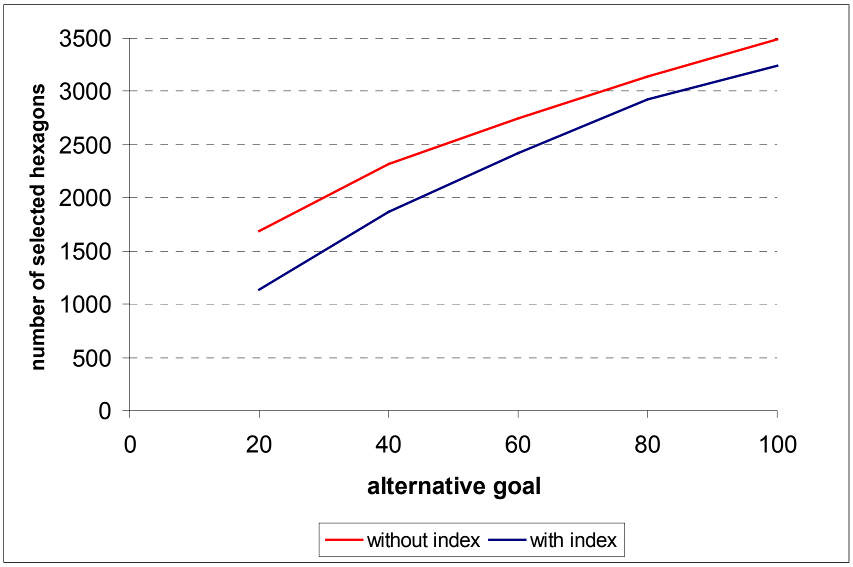


FIGURE 6.7 Number of hexagons selected in the terrestrial sum solutions (i.e, included in at least one of the 25 replicate solutions) with and without the suitability index as a function of alternative goals. The alternative goal is expressed as percent of the goal used in the SITES analysis of section 2.5. Total terrestrial hexagons in the ecoregion equals 6048.

As the goal increased, the number of irreplaceable (high relative importance) hexagons also increased (Figure 6.7, green hexagons in Maps 6.3 and 6.4). This occurs because the algorithm must include more hexagons in the solution and, consequently, has fewer options for optimal solutions. At the 100% goal with the suitability index, 51% of all selected hexagons were irreplaceable (i.e., included in 25 of 25 replicates). Without the index, 41% of all selected hexagons were irreplaceable. The number of irreplaceable hexagons was always larger for analyses run with the suitability index than those run without the index. In other words, without the suitability index there is more variability across the set of replicate solutions.

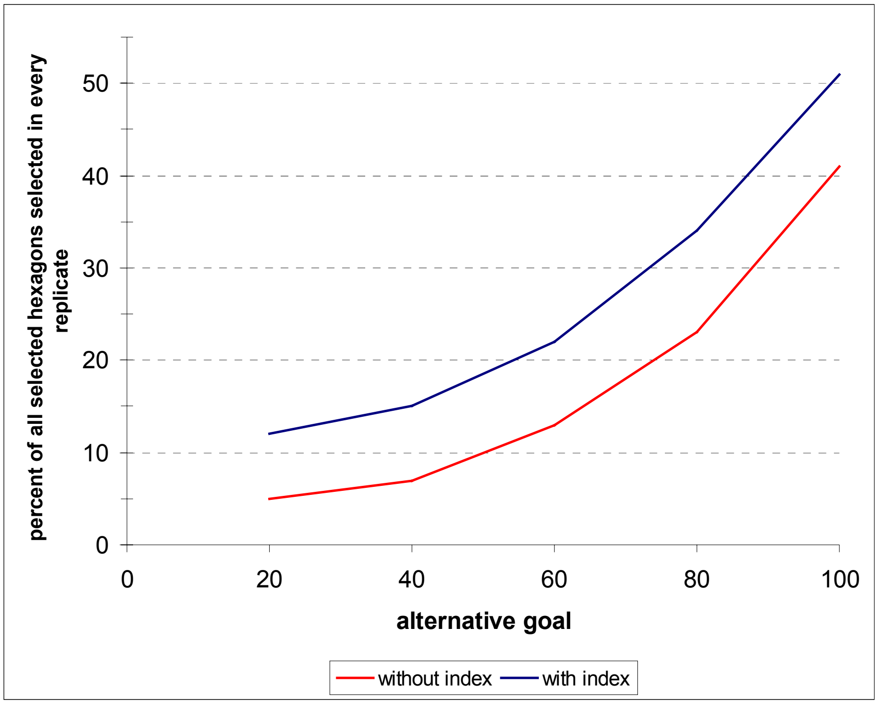


FIGURE 6.8 Number of irreplaceable hexagons (selection frequency equals 25) with and without the suitability index as a function of alternative goals. The alternative goal is expressed as percent of the goal used in the SITES analysis of section 2.5. This is a measure of variability across each set of 25 replicate solutions which indicates the potential for alternative optimal solutions.

As expected, as the alternative goal increases, the spatial extent of selected hexagons expands. The suitability index causes this expansion to occur in a directed pattern (Map 6.3). That is, at the lowest goal, selected hexagons concentrate in or near to public lands and far from urban areas. As the goals increase, the selected hexagons expand farther into private lands and toward urban areas. In contrast, without the suitability index at the lowest goal, selected hexagons are more dispersed (Map 6.4). However, as the goal increases the sum solution maps generated with and without the suitability index become more similar. The mean absolute difference in hexagon relative importance decreases as the goal increases (Figure 6.8). In other words, there is greater agreement about which hexagons have moderate to high importance.

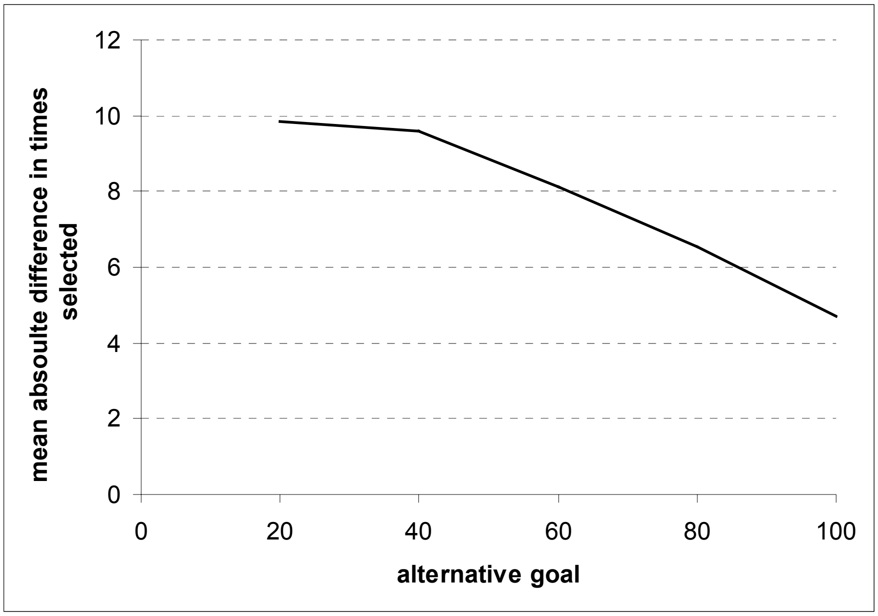


FIGURE 6.9 Mean absolute difference in hexagon relative importance between sum solutions with and without the suitability index. Calculation done only for hexagons of moderate to high relative importance (i.e., selection frequency greater than 12). The alternative goal is expressed as percent of the goal used in the SITES analysis of section 2.5

The sum-sum solutions (Maps 6.5 and 6.6), which combine results for the 20, 40, 60, 80, and 100 % alternative goals, show conservation priorities with or without a suitability index. Certain hexagons stand out as high priorities (dark green) in both cases. These hexagons correspond to places with imperiled targets or high target richness or both, and these hexagons are high priorities for conservation regardless of suitability assumptions. Two differences between the maps are readily discernable. First, the sum-sum solution without the suitability index includes more hexagons (3670 out of 6048 terrestrial hexagons), and the majority of these additional hexagons have low relative importance. This demonstrates that many places across the ecoregion support some element of biodiversity but these places probably support more common targets such as conifer forest. Second, when the suitability index is applied, the relative importance of some hexagons is amplified. Some hexagons that were moderately important become highly important. Those green hexagons (i.e., the hexagons of high relative importance) that appear in the sum-sum solution generated with the suitability index show an attractive combination of biodiversity value and a better potential of conservation success.

6.8 Sensitivity Analysis Discussion

An important purpose of the sensitivity analysis was to generate additional information to help prioritize among the assessment units and areas selected for the portfolio. The sum-sum solution maps fulfill that purpose. The sensitivity analysis helps to highlight the most important assessment units, and with the addition of the suitability index, the number of selected hexagons is reduced still further. The analysis also shows that some places are high priorities regardless of the assumptions about goals or suitability.

The large spatial extent of the hexagonal solutions portrays a vexing situation in fragmented ecoregions with expanding habitat conversion; conservation planners must make hard choices about which areas are most important. The sum-sum solutions provide some guidance. Many hexagons contain targets, i.e., a patch of habitat or a species occurrence, but the sum-sum solution with the suitability index versus the sum-sum solution without the index indicates that some places are relatively better suited to successful conservation. While most hexagons contained some element of biodiversity, as shown in the sum-sum solution maps, the suitability index leads to a mapping of important places that might more effectively and efficiently maintain the ecoregion's biodiversity.

Comparison of the Sensitivity Analysis with the Automated Terrestrial Portfolio

In contrast with the multiple solutions represented by results of the sensitivity analysis (see Maps 6.3 and 6.4), the automated terrestrial portfolio (see Map 2.5) represents a single solution that comes the closest to meeting our goals in the most efficient manner. This efficiency relates not only to creating a solution using the least area but also tends to choose adjacent assessment units to promote larger, more functional landscapes and networks of conservation opportunity areas. The single best solution shown in the automated terrestrial portfolio can be largely seen within the summed solution by comparing the automated portfolio with the darkest green assessment units of the summed solution. These dark green summed solution hexagons show the assessment units that were picked in every SITES run because they have high biodiversity or irreplaceable element occurrences. This exercise lends support to the use of the automated portfolio as the appropriate terrestrial portfolio to carry forward to assembly with the other portfolios (see Chapter 5 for assembly of the overall portfolio).

The large spatial extent of the selected hexagons in the sum-sum solution maps and the automated portfolio can be misleading. Because of the coarse resolution of these units (750 ha), and inaccuracies in the available land cover map for the ecoregion, a large portion of the area within some selected hexagons is not, in fact, high-quality native habitat. Consequently, an accurate mapping of the actual habitat area encompassed by selected hexagons required the refinement of the portfolio by experts guided by their own field knowledge, additional GIS data, and other data sources. This refinement for the terrestrial portfolio is described in section 2.5.3 and in Chapter 5.

Chapter 7 – Major Findings, Data Gaps, and Uses of this Assessment

The following topics are discussed in this chapter:

7.1 Summary of Major Findings
7.2 Data Gaps and Future Iterations of this Assessment
7.3 Using this Assessment

7.1 Summary of Major Findings

1. Relative to its size, the Willamette Valley-Puget Trough-Georgia Basin ecoregion has a large number of species (526 species targets) that are imperiled, declining, or endemic to the ecoregion and of conservation concern. It is highly likely that many more species for which we lack distribution and abundance data (especially invertebrates, fungi and non-vascular plants) are of concern. The ecoregion also has an exceptional diversity of habitats including 217 nearshore, terrestrial, and freshwater ecological systems, and 90 imperiled terrestrial plant communities.

2. Three hundred and seventy-two conservation areas covering 23% of the ecoregion (1,264,000 ha or 3,122,080 ac), 534 special point occurrences, and 39 marine shoreline segments were identified as being important for the conservation of the ecoregion's biological diversity.

   The conservation areas identified in the assessment are important for a number reasons. First, some are the last places where one or more species or ecological community targets occur. Short of restoration to expand habitat, there were no other options for capturing these targets. This is particularly true for prairies and most of their associated species.

   Second, some conservation areas are the last large, relatively intact landscapes in the ecoregion. Nearly all these places are second-growth managed forests. Large areas are especially important to wide-ranging species such as black bear, bobcat, and goshawks. While the quality of habitats in these large landscapes has been impacted by timber management or agriculture, they exhibit little fragmentation due to residential development. Hence, they make irreplaceable contributions to ecoregional biodiversity and possess significant potential for the maintenance or restoration of landscape-scale ecological processes.

   Third, wherever possible, the assessment selected places that are the most promising sites for successful conservation. This assessment used a suitability index to map the relative likelihood of successful conservation across the ecoregion. The suitability index was a quantitative expression of several well-accepted principles of conservation biology: (1) large areas of habitat are better than small areas; (2) habitat areas close together are better than areas far apart; and (3) areas with low habitat fragmentation area better than areas with high fragmentation. The suitability index was also based on two reasonable assumptions: (1) existing public land is more suitable for conservation than private land; and (2) rural areas are more suitable for conservation than urban areas. Application of these principles and assumptions guided site selection toward existing public lands and away from private land, and toward rural areas and away from urbanized or urbanizing areas.

3. Only 6% of the lands and waters identified in the portfolio occur in dedicated natural area reserves, national parks or other designations primarily focused on biodiversity conservation (i.e., GAP codes 1 and 2). Eighty percent of the land

identified in the terrestrial portfolio is privately owned. A wide range of federal, tribal, state, provincial, and local government lands make up the remainder. The state of Washington is the largest landowner among these, with 92,000 ha (227,240 ac). Less than one percent is owned by non-profit conservation groups such as The Nature Conservancy. We did not evaluate ownership in the nearshore environment.

4. We were not able to meet portfolio assembly goals for 422 terrestrial species and 90 plant community targets, despite the inclusion of every known, reliable occurrence in the ecoregion. In some cases, this reflects the lack of sufficient survey effort. But for the vast majority, it reflects the widespread loss of historic habitat as well as altered condition of that which remains.

5. The scientific literature suggests that the loss of species lags in time behind the loss of habitat (see Chapter 2). In the Willamette Valley-Puget Trough-Georgia Basin, for example, where prairie habitats have been reduced to less than 10% of their historic extent, many of the species that still survive in these prairie remnants will be lost over time if the species-area relationships described earlier are correct. The same applies to other habitat types that have been dramatically reduced in the ecoregion.

6. The broad conclusion for conservation planners is that in ecoregions such as the Willamette Valley-Puget Trough-Georgia Basin where the majority of native habitat has been lost or severely degraded, the extent of future local extirpations will depend on how quickly the loss of remaining habitat is abated and degraded or lost habitat is restored.

Chapter 5 provides more detailed statistics about the portfolio.

7.2 Data Gaps and Future Editions of this Assessment

In the process of completing this assessment for the Willamette Valley-Puget Trough-Georgia Basin, there were a number of times when the desired data or analytical tools were unavailable. For example, location and status have been documented for very few freshwater and marine species in enough detail across the ecoregion for use in the selection of conservation areas. The same is true for many terrestrial species. As a result, most of the ecoregion's biodiversity must be represented through the 'surrogate' of coarse-filter habitat or system targets. Similarly, biodiversity information in some portions of the ecoregion is less well developed than in others. In the marine environment information for the assessment is almost entirely restricted to the nearshore region.

As part of this project, we developed or improved data to address some of these shortcomings. We crosswalked the classification of terrestrial ecological systems across jurisdictions to create an ecoregional classification (Chapter 2). We developed a classification system for freshwater macrohabitats and ecological systems and mapped them for six ecological drainage units intersecting the ecoregion (Chapter 3). We crosswalked classification systems and mapped shoreline and nearshore habitat types (Chapter 4). And we collected and organized a great deal of expert interview information and analyzed existing imagery to fill in details or correct weaknesses in existing data sets.

Of the remaining gaps detailed in earlier chapters, the following emerge as the highest priorities to improve the next edition of this assessment:

- This assessment did **not** make a full accounting of **existing conservation efforts**. While most state and federal lands designated for conservation and some private nature reserves were included here, future assessments should assemble complete spatial information for land trust properties, wetland reserve conservation easements, and perhaps area-explicit conservation programs such as fisheries management areas.

- The **freshwater assessment** described here includes preliminary portfolios for six ecological drainage units (regional watersheds) that intersect the ecoregion. While this is a useful beginning for freshwater conservation planning, this first analysis varied considerably among ecological drainage units in depth of expert input on such matters as site condition and importance. The most pressing need is a comprehensive and coordinated approach to bringing much more species-specific (including salmon) data into the analysis to develop usable conservation portfolios for freshwater biodiversity.

- We constructed a **vegetation map** that was used as a surrogate for terrestrial ecological systems and some plant communities by piecing together landcover data from a number of sources. The accuracy of the landcover data was variable, and the accuracy of the resulting vegetation map was not tested rigorously across the ecoregion. We performed additional analyses to compensate for the poor accuracy of the conifer forest mapping as described in Chapter 2. For future assessments, we propose two alternative approaches to improving the vegetation data layer. First, weaknesses in the layer developed for this assessment could be improved upon by: 1) quantitative verification of map accuracy for all system types to prioritize types or geographic areas for improvement, 2) remapping of top priority weak areas/types and 3) distinguishing coniferous forests younger than 40-45 years from older forests to identify stands where old-growth characteristics may be developing. Two obvious priority improvements are the development of a British Columbia land cover map at the same finer resolution as the current Washington-Oregon coverage, and field evaluation of depressional wetlands occurrences derived from the National Wetlands Inventory in Oregon and Washington to determine which should be mapped as Riparian Forests and Shrublands. The second alternative is to start over and produce an improved vegetation map using Landsat imagery or existing landcover data (e.g., National Land Cover Database), and to plot data and other sources to develop a consistent vegetation data layer across the entire ecoregion. The latter is likely to be the more expensive option.

- We lack reliable data on the location and status of many **imperiled and declining species and plant communities** in the ecoregion. Some of these species and habitats are naturally rare (i.e., they were rare before European settlement). Others were formerly much more common, but have become rare as a result of human activities since European settlement. Others are still common but are rapidly declining. As a broad strategy for filling this data gap, new survey efforts should focus on finding additional occurrences of these 'newly rare' targets and documenting the status of known occurrences to inform conservation strategies, and on defining habitat needs of currently common but rapidly declining species in an effort to prevent them from becoming rare.

- The **marine** portion of this assessment provides an important starting point for marine conservation but is not a complete vision. Looking ahead, the largest need is to extend the assessment to deep water habitats throughout the Puget Sound and Strait of Georgia. Data on substrates and bathymetry, salinity, currents, sea surface temperature and productivity might be combined to create a model for offshore ecosystems. More biological data are needed to test such a model. Second, it would be useful to add ecosystem processes to the portfolio assembly model by including information on littoral cells. Like watersheds, which define the boundaries of a stream system, littoral cells delineate the boundary of a beach-sediment system. Third, survey effort is needed to verify the condition and biodiversity value of nearshore marine portfolio sites.

- The process of **integrating terrestrial, freshwater and nearshore marine assessments** needs to be improved. The next step in this regard for this ecoregion is the completion of freshwater portfolios for the six intersecting ecological drainage units. This will allow a more balanced integration that represents freshwater priority conservation areas. Additional needs include building databases that combine information on stream reaches, contributing watersheds and associated estuaries and shoreline to allow better integration of ecological processes in these multi-ecosystem sites.

- The portfolio of conservation areas presented here should **not** be used as the sole guide for siting **restoration projects**. These priority sites include high-quality habitat that must be maintained as well as lower-quality habitat that will require restoration. But they are not the only sites in the ecoregion that merit restoration, whether for rebuilding habitat for imperiled species, increasing salmon or game productivity, improving water quality, or other community objectives.

- A deeper, more site-specific **analysis of the key impacts** to biodiversity is needed to inform impact-abatement strategies. The impact analyses conducted in this assessment (i.e., the use of suitability indices to gauge some of the impacts that may determine the success of biodiversity conservation at each site, and the cataloging of a checklist of impacts believed to operate at each site) allowed for crude estimates of the relative prevalence, severity, and urgency of impacts, but did not address the complex interactions among impacts or break complex impacts (e.g., invasive species) down sufficiently. This deeper impact analysis and strategy-development work may be inappropriate for inclusion in ecoregional assessments, and more suited to planning conducted by users of the assessment.

- **Climate change** was not considered in this assessment. In future editions, the portfolio should be examined to determine its vulnerability to sea-level rise, temperature and moisture gradient shifts, and other predicted changes that may require adjustments in site selection, prioritization, and boundaries.

7.3 Using this Assessment

The Willamette Valley-Puget Trough-Georgia Basin assessment was prepared to support focused and effective long-term conservation of the ecoregion's extraordinary biodiversity. It is a first approximation of priority conservation areas, and we know that the only way to test and improve its utility is to put it to work in the real world.

The conservation portfolio presented here has two main applications. First, the portfolio is most useful as a guide for habitat protection. We encourage government agencies, donors, and NGOs that fund conservation projects or provide financial incentives for habitat protection to use the portfolio as they consider priorities. Conservation projects inside the conservation portfolio should receive special consideration, and projects that can have a range of siting options should be sited to benefit priority conservation areas wherever possible. Biodiversity conservation in the ecoregion will attain its fullest potential if all conservation organizations coordinate their land acquisition, conservation easement, and habitat restoration efforts according to the priorities identified by the portfolio. In the process of using this new portfolio tool, the users themselves will discover improvements that should be incorporated in future updates.

The partners in the preparation of this assessment will use the assessment to establish their own organizational priorities. The Nature Conservancy and Nature Conservancy of Canada have committed to using ecoregional assessments to drive their priorities for site-based work and for identifying priority investments in 'multi-site' strategies to conserve portfolio sites through policy, education, research, and other approaches. The Washington Department of Fish and Wildlife will use the results of the assessment to guide their development of a State Comprehensive Wildlife Conservation Strategy in coordination with other governmental and non-governmental organizations, to be completed by 2006. Similar assessments are being prepared for all northwest ecoregions in support of this strategy.

Second, the data and analyses behind this assessment will be available to a wide range of users. With a clear understanding of its strengths and weaknesses, all planners are encouraged to use this assessment together with other resources to address specific projects. For example, local governments preparing long-term land use plans should find the portfolio and associated data useful for identifying places that should be given special consideration for their biodiversity value. Likewise, local land trusts can use the assessment to gain an ecoregional perspective on local biological resource values and to quickly obtain detailed information on the biological value and suitability parameters of local portfolio sites.

Users must be mindful of the large scale at which this assessment was prepared. The portfolio does not include some sites that are locally significant for biodiversity conservation, such as small wetlands and small, high-quality patches of common habitat types. Mapped site boundaries are approximate and may include areas unsuited for conservation mixed in with highly suitable areas. We expect that local planners equipped with more complete information and higher resolution data will develop refined boundaries for these sites. We encourage users to treat the assessment as a 'first approximation,' and to share any refinements of portfolio site boundaries or improved target information with us to help make a second edition better. Several of the author organizations—including The Nature Conservancy, Nature Conservancy of Canada, and Washington Department of Fish and Wildlife—are eager to work directly with local planners in a few test cases to explore the use of the assessment and make progress toward practical conservation strategies for portfolio sites.

This assessment has no regulatory authority. It is simply a guide to help inform conservation decision-making across the ecoregion. The sites described are approximate, and often large and complex enough to allow (or require) a wide range of resource management approaches. Ultimately, the establishment, siting and management of any priority conservation area will be based on the policies, values, and decisions of the affected landowners, governments, and other community members.

The assessment report and the final product data behind it are available to all interested parties. A PDF version of the report will be available on the Websites of the primary partner organizations (see Appendix 2 for contact information). By May 2004, a GIS data product, developed using the ESRI ArcGIS 8.x application, will be available via the Web that will allow the display, symbolization, query, summarization, and analysis of the portfolio and associated data, and all assessment units that are the building blocks of the portfolio. These queries and summaries can operate on individual portfolio sites and/or assessment units, or across sets of these units. The biodiversity content of these areas can be placed in context within the overall biodiversity of the ecoregion or subset of the ecoregion (e.g., Section, or a particular ownership or jurisdiction).

The authors will conduct annual reviews of the use of the assessment and feedback received from users to determine the timing and focus of future editions.

Appendix 1. Glossary

Aquaculture: the cultivation or farming of aquatic organisms such as fish and shellfish under captive conditions for purposes of human consumption.

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

Assessment unit: the area-based polygon units used in the optimal site selection algorithm and attributed with the amount and quality of all targets located within them. These units are non-overlapping and cover the entire ecoregion. The assessment unit chosen for the WPG was a 750-hectare hexagon.

Automated portfolio: in the WPG, a data-driven portfolio created by the SITES algorithm operating on hexagonal assessment units (terrestrial and marine) or linear assessment units (marine only).

Base layer: a data layer in a GIS that all other layers are referenced to geometrically.

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

Cadastral: relating to landed property, usually including the dimensions and value of land parcels, used to record ownership.

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

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

Conservation target: (see target)

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

Cost: a component of the SITES algorithm that encourages SITES to minimize the area of the portfolio by assigning a penalty to factors that negatively affect biodiversity, such as proximity to roads and development. In the WPG assessment, a cost was assigned to each assessment unit in the ecoregion.

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

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

Disjunct: disjunct species have populations that are geographically isolated from each other.

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

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

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

Ecological system (see terrestrial ecological systems or aquatic ecological system)

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

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

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

Endemic: species or communities that are largely restricted to an ecoregion (or small geographic area within an ecoregion), and depend entirely on this area for survival.

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

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

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

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

Functional landscapes: large areas (usually greater than 1,000 acres [405 hectares]) where the natural ecological processes needed to conserve biodiversity can be maintained or potentially restored.

Functional network: a well-connected set of functional landscapes within an ecoregion or across multiple ecoregions.

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

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

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

Global rank: an assessment of a biological element's relative imperilment and conservation status across its geographic distribution, ranging from G1 (critically imperiled) to G5 (secure). Assigned by the Natural Heritage Network, global ranks for species and communities are determined by the number of occurrences or total area of coverage (communities only), modified by other factors such as condition, historic trend in distribution or condition, vulnerability, and impacts (see Appendix 6 for more information).

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

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

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

Impact: the combined concept of ecological stresses to a target and the sources of that stress to the target. Impacts are described in terms of severity and urgency.

Impacts assessment: for each conservation area in the portfolio, the overall impact to the area is ranked as High, Medium, or Low. The overall impact ranking is a gestalt ranking by the project team, taking into account the conservation targets in the area and the varied impacts to the targets.

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

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

Limited target: a geographically restricted species or community that occurs in the ecoregion and within a few other adjacent ecoregions.

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

*Littoral cell: a g*eographic region of the coast, such as between two headlands, that is self-contained with respect to all sources and losses of beach sand.

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

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

Minimum dynamic area: the smallest area necessary for a reserve or managed area to have a complete, natural disturbance regime in which discrete habitat patches may be colonized from other patches within the reserve.

Nearshore marine zone: the area of the marine environment extending from the supratidal area above the ordinary or mean high water line to the subtidal area. In the Willamette Valley-Puget Trough-Georgia Basin ecoregional assessment, the nearshore marine area extends below to -40 meters, because beyond that depth data were less available. This also approximates the photic zone, or depth of macrophytes. The WPG consists of 1,509,733 ha of nearshore marine zone.

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

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

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

Peripheral: a species or community that only occurs near the edges of an ecoregion and is primarily located in other ecoregions.

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

Portfolio: (see portfolio of sites)

Portfolio of sites: in the WPG assessment, the identified and delineated suite of priority conservation areas that are considered the highest priorities for conservation in the ecoregion.

Priority Conservation Area: areas of biodiversity concentration that contain target species, communities and ecological systems. Boundaries need to be refined during site conservation planning for adequate protection and to ensure supporting ecological processes are maintained for the targets within.

Quartile: any one of the four equal groups into which a statistical sample can be divided.

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

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

Shoreline segments: nearshore marine elements of the integrated portfolio that are measured as linear features representing coarse filter targets.

SITES: software consisting of computerized algorithms specifically designed for The Nature Conservancy. SITES is an optimal site selection algorithm that selects conservation sites based on their biological value and suitability for conservation.

SITES goal: the goal adjusted for input to the SITES optimal site selection algorithm. SITES goals differed from goals (see "goal" definition) where there were not enough occurrences of a target in the ecoregion to meet the goal. In this case, the SITES goal was set to take all available occurrences in the ecoregion.

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

Special occurrences: in the WPG, all occurrences that were chosen in the final integrated portfolio that were not contained within a delineated conservation area or a marine shoreline segment.

Species aggregate: where multiple species are represented by a single target, as in the case of a multi-species shorebird colony target or a single species such as the American widgeon used, for example, in representing multiple species of dabbling ducks. Species aggregates were used most extensively in the marine analysis.

Subtidal area: the subtidal begins at approximately the mean lower low water line (zero feet elevation) to the –20 meter isobath. In the Willamette Valley-Puget Trough-Georgia Basin Ecoregional Assessment, the subtidal area extends into the deeper subtidal of –40 meters.

Suitability: the likelihood of successful conservation at a particular place relative to other places in the ecoregion. For the terrestrial portion of the WPG assessment, four GIS layers were used to construct the suitability index: GAP status, urban growth areas, landcover/land use, and roads.

Supratidal area: area above the mean high water line, such as the top of a bluff or the extent of a saltmarsh in the upper intertidal; the upper limit of the nearshore marine zone.

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

Terrestrial ecological systems: dynamic spatial assemblages of ecological communities that 1) occur together on the landscape; 2) are tied together by similar ecological processes (e.g. fire, hydrology), underlying environmental features (e.g., soils, geology) or environmental gradients (e.g., elevation, hydrologically-related zones); and 3) form a robust, cohesive, and distinguishable unit on the ground. Ecological systems are characterized by both biotic and abiotic (environmental) components and can be terrestrial, aquatic, marine, or a combination of these.

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

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

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

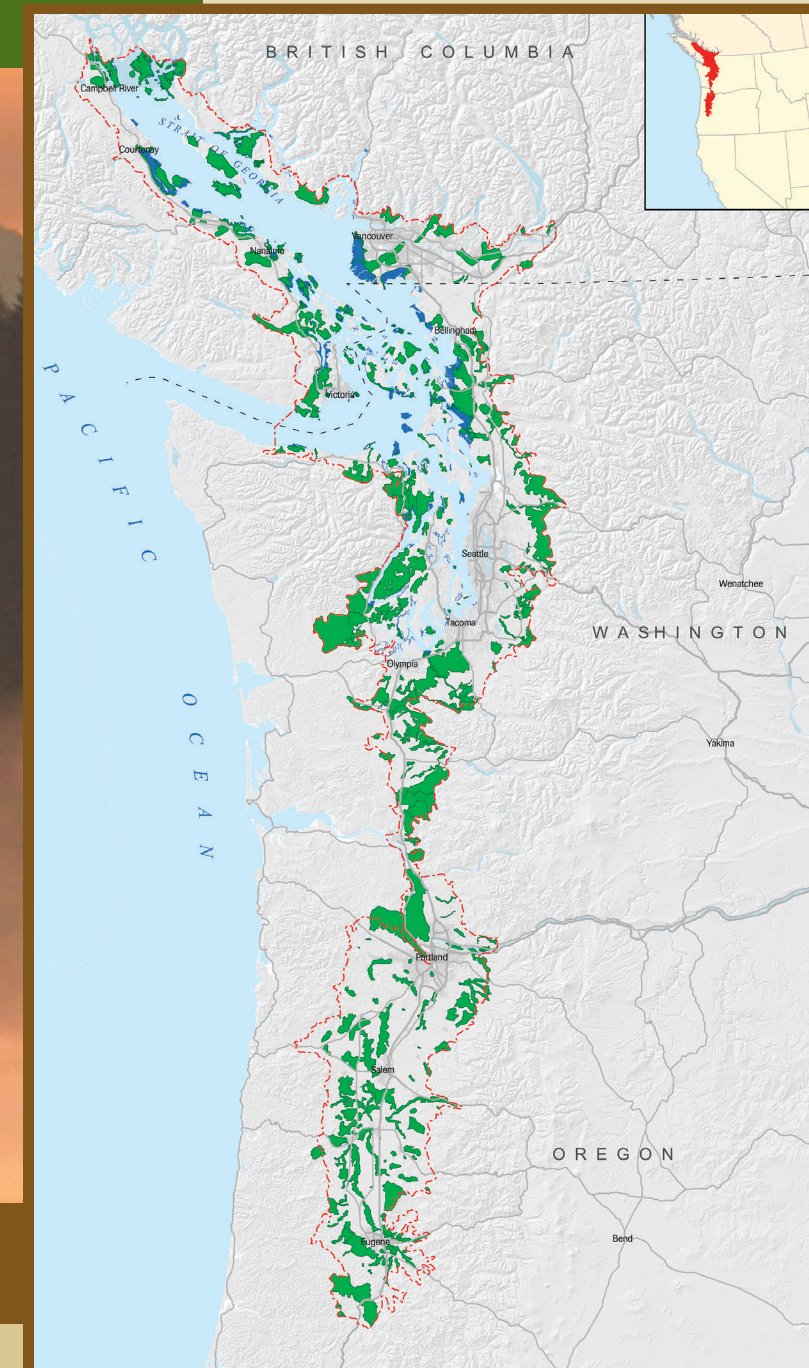
Viability: the ability of a species to persist for many generations or an ecological community or system to persist over some time period. Primarily used to refer to species in this document.

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

Widespread: a species or community typically found in the ecoregion, but common in several other ecoregions; the bulk of its distribution is elsewhere (or, the majority of the target occurrences exist in other ecoregions).

Willamette Valley–Puget Trough–Georgia Basin

ECOREGIONAL ASSESSMENT



MAPS

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Nature Conservancy Canada

Conservation de la Nature Canada

Washington Department of Fish and Wildlife

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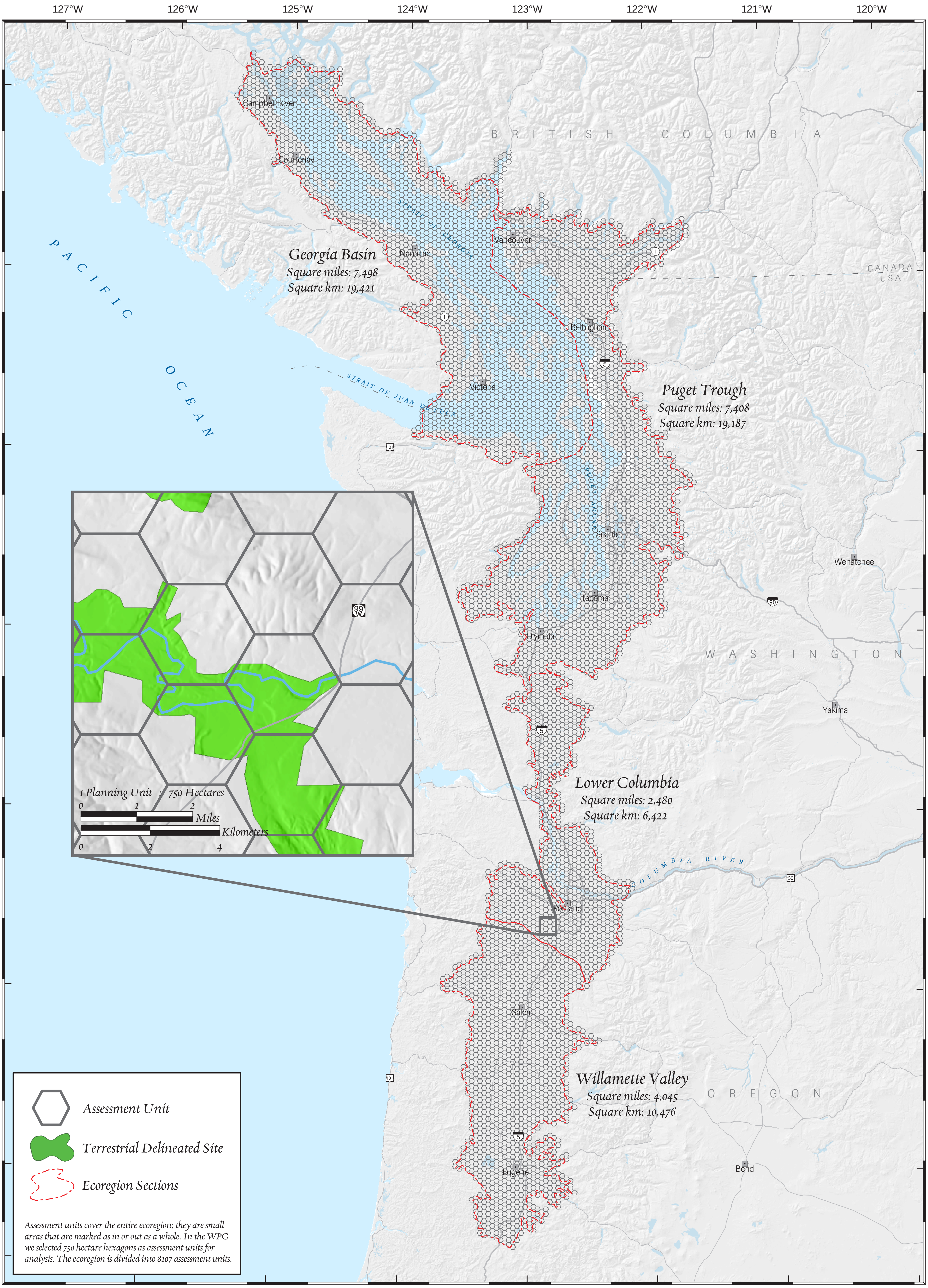
MAPS **Page**



Willamette Valley - Puget Trough - Georgia Basin Ecoregion

Map 1.1: Assessment Units

1 inch equals 35 miles

0 5 10 15 20 25 30 35 Miles

0 10 20 30 40 50 60 Kilometers

Sources: TNC, WDFW, WDNR, USGS

March 2004

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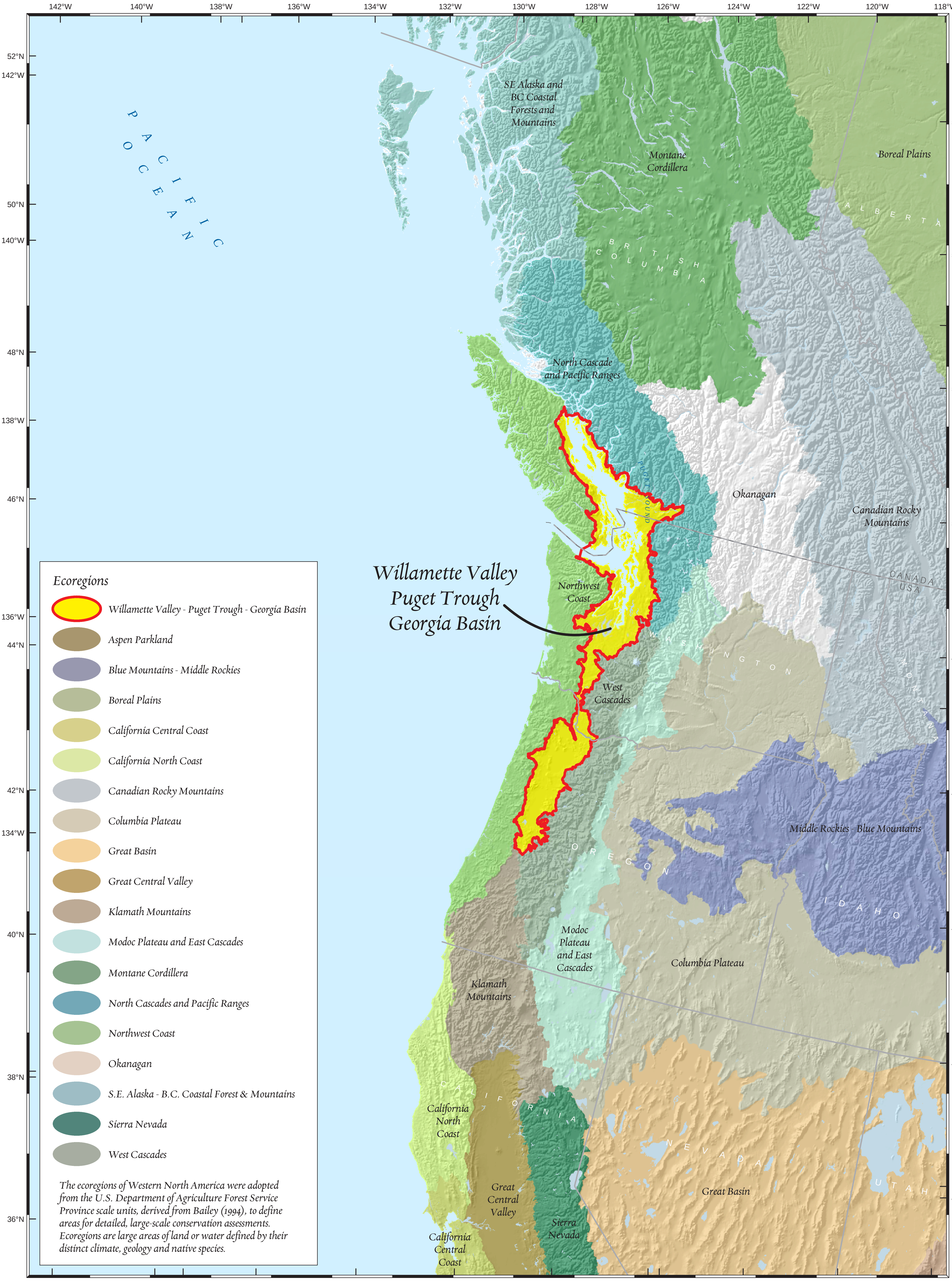

Willamette Valley - Puget Trough - Georgia Basin Ecoregion

Map 1.2: Ecoregions of Western North America

1 inch equals 100 miles

0 20 40 60 80 100 Miles

0 50 100 150 200 Kilometers

Sources: MSRM, TNC, WDFW, WDNR

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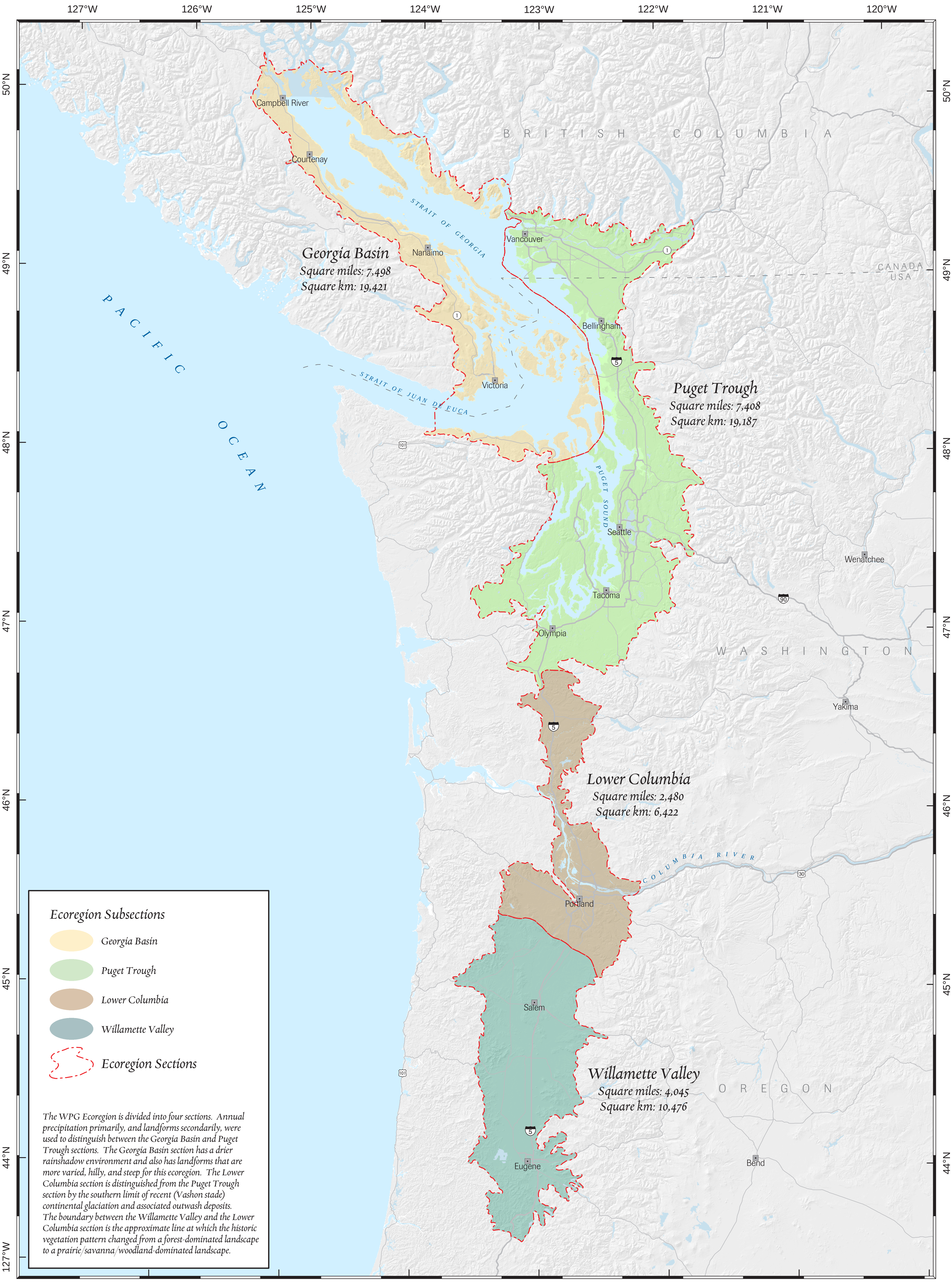
Nature Conservancy Canada — Conservation de la Nature Canada

Washington Department of Fish and Wildlife



Willamette Valley - Puget Trough - Georgia Basin Ecoregion

Map 1.3: Ecoregion with Sections

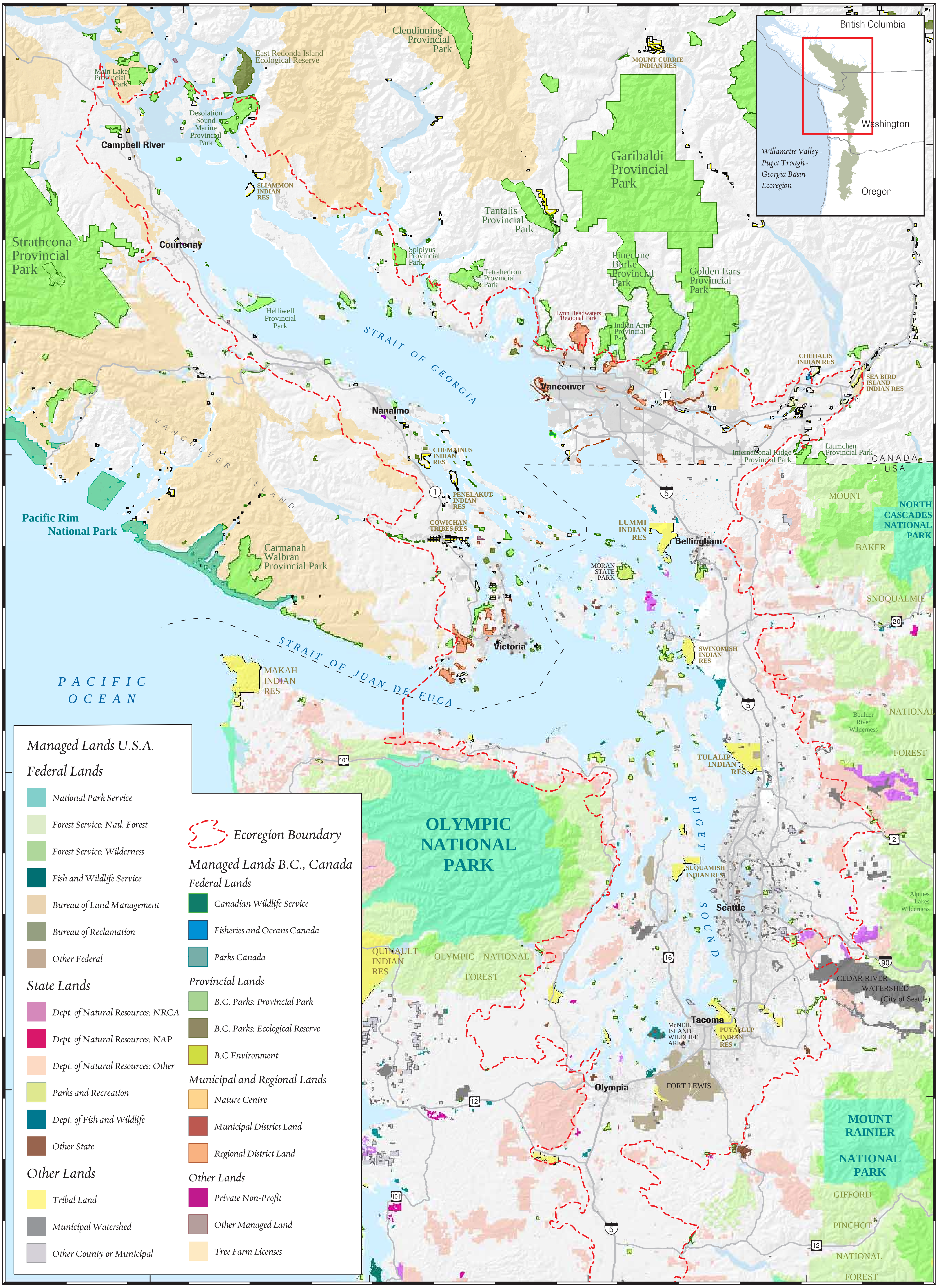
1 inch equals 35 miles

0 5 10 15 20 25 30 35 Miles

0 10 20 30 40 50 60 Kilometers

Sources:
TNC, WDFW,
WDNR, USGS

March, 2003



Georgia Basin and Puget Trough

Map 1.4a: Managed Land

1 inch equals 20 miles

0 5 10 15 20 Miles

0 10 20 30 40 Kilometers

Sources: BLM, MSRM, TNC, WDFW, WDNR

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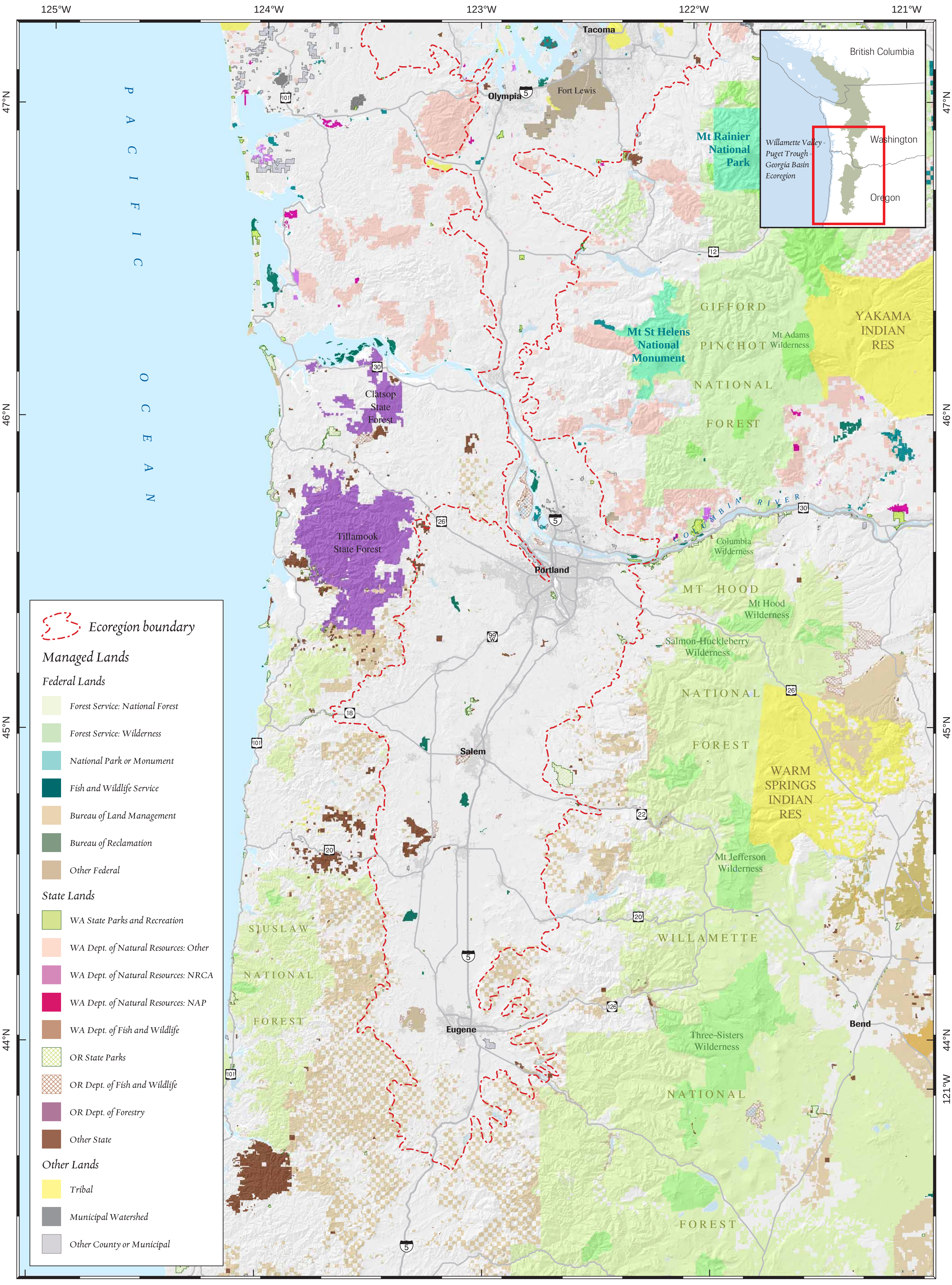

Lower Columbia and Willamette Valley

Map 1.4b: Managed Land

1 inch equals 20 miles

0 5 10 15 20 Miles

0 10 20 30 40 Kilometers

Sources: BLM, TNC, WDFW, WDNR

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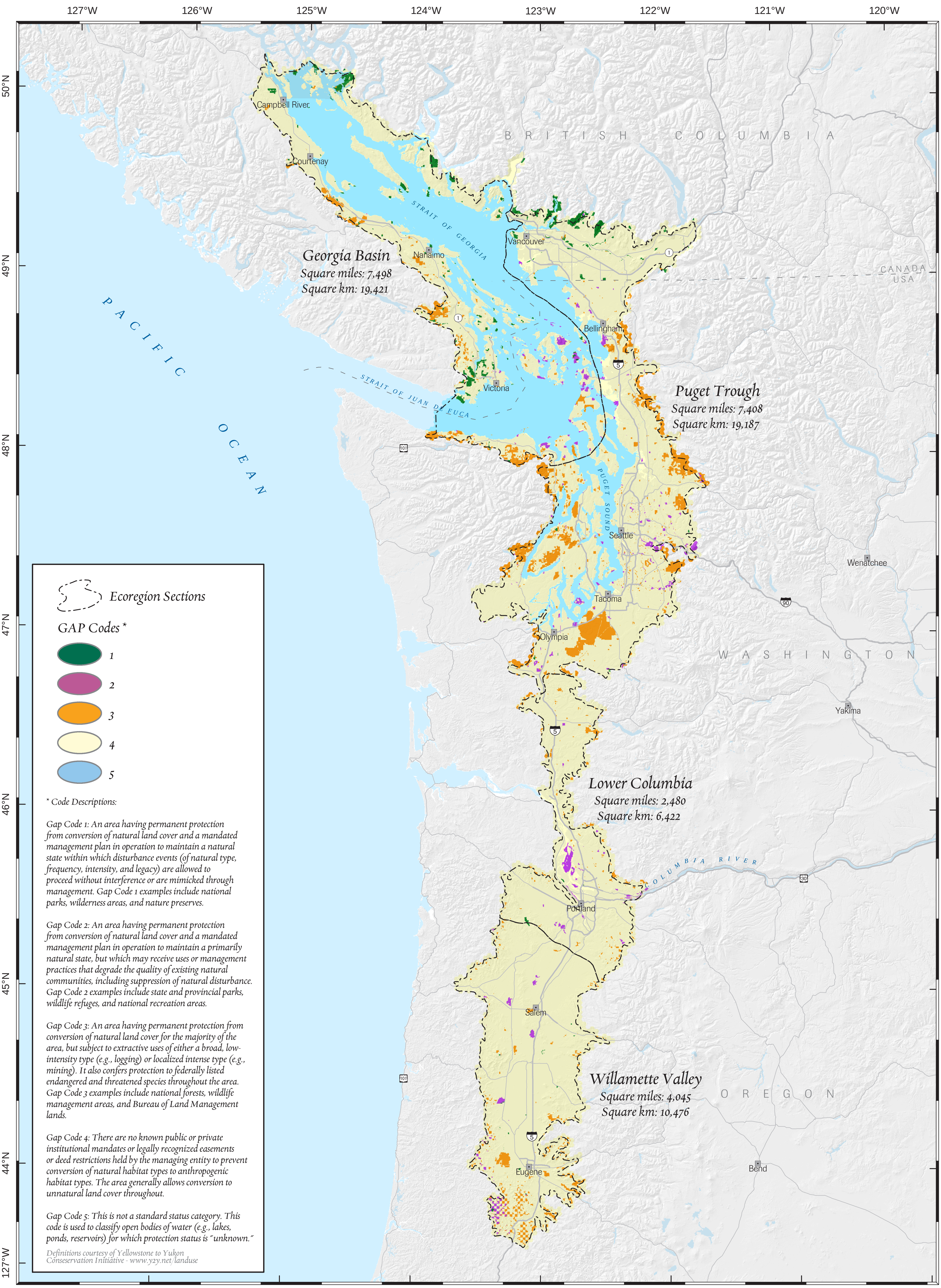

Willamette Valley - Puget Trough - Georgia Basin Ecoregion

Map 1.5: Managed Land Status

1 inch equals 35 miles

0 5 10 15 20 25 30 35 Miles

0 10 20 30 40 50 60 Kilometers

Sources:
TNC, WDFW,
WDNR, USGS

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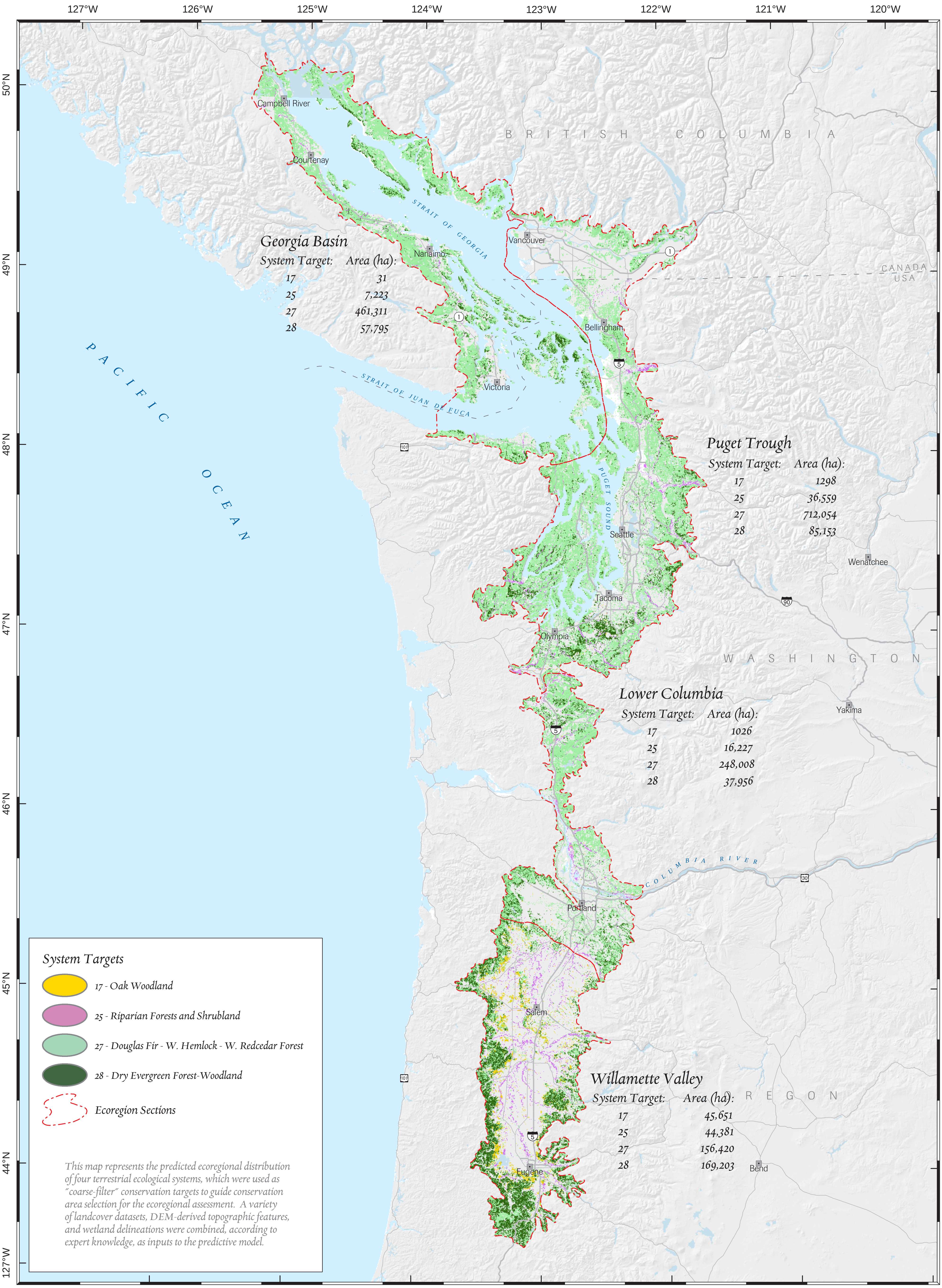

Willamette Valley - Puget Trough - Georgia Basin Ecoregion

Map 2.1: Terrestrial Ecological System Targets

1 inch equals 35 miles

0 5 10 15 20 25 30 35 Miles

0 10 20 30 40 50 60 Kilometers

Sources: MSRM, TNC, WDFW, WDNR

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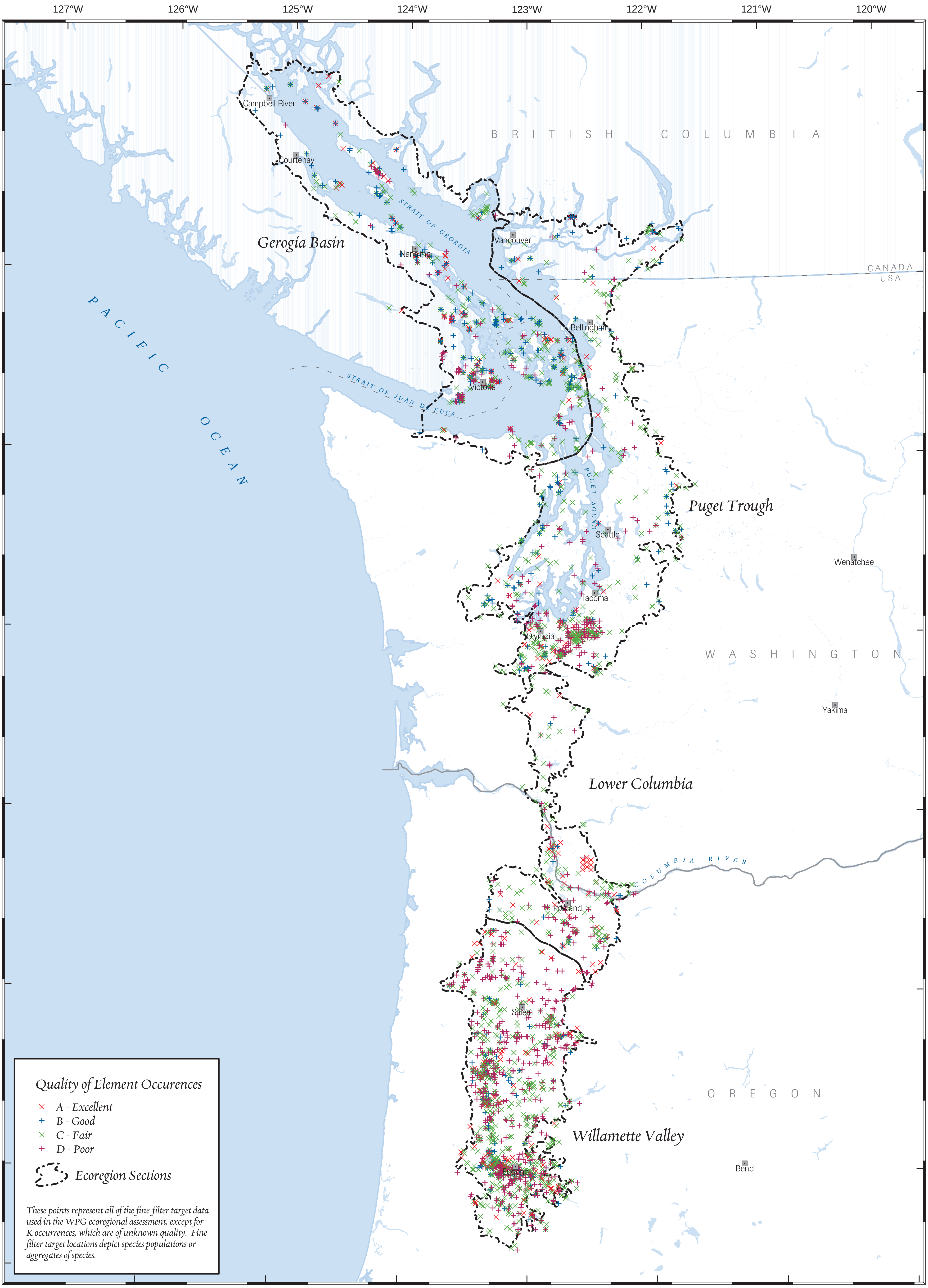

Willamette Valley - Puget Trough - Georgia Basin Ecoregion

Map 2.2: EO Rank for Fine Filter Occurrences

1 inch equals 35 miles

0 5 10 15 20 25 30 35 Miles

0 10 20 30 40 50 60 Kilometers

Sources:
TNC, WDFW

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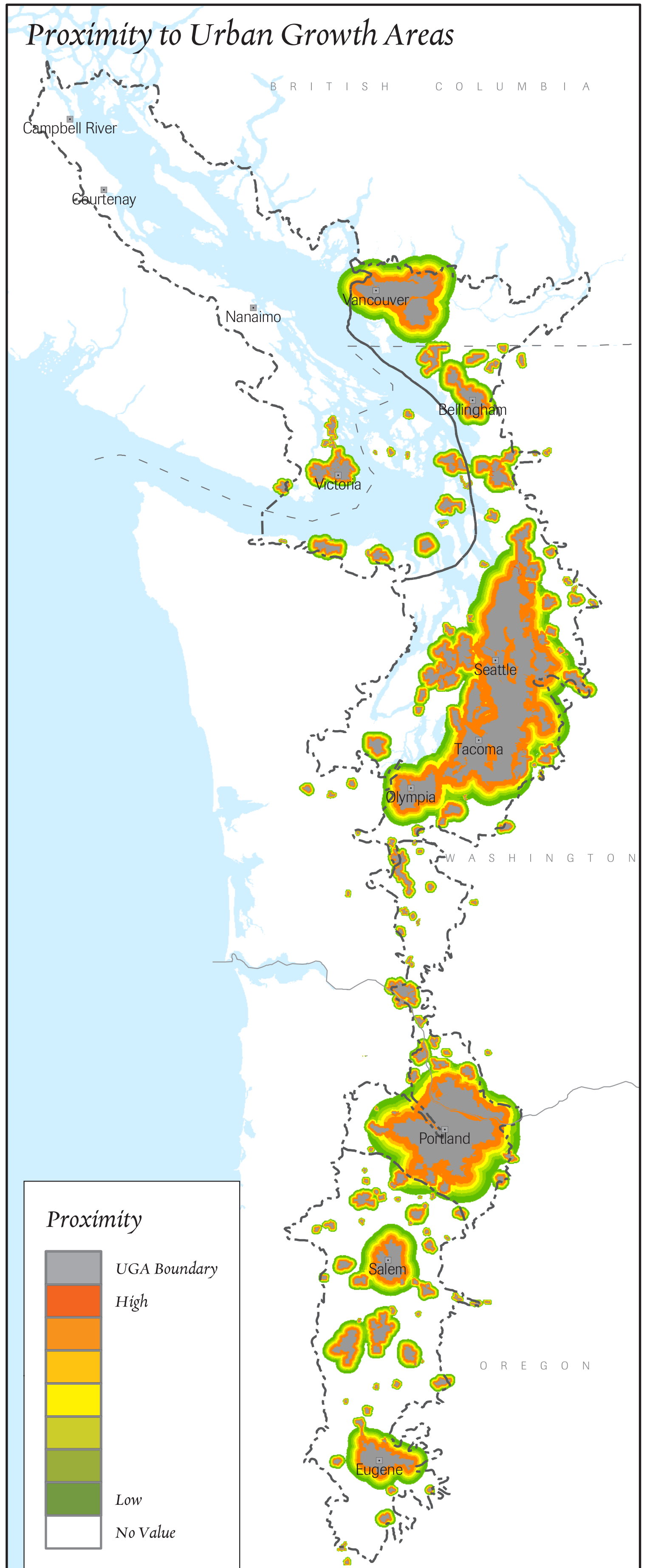

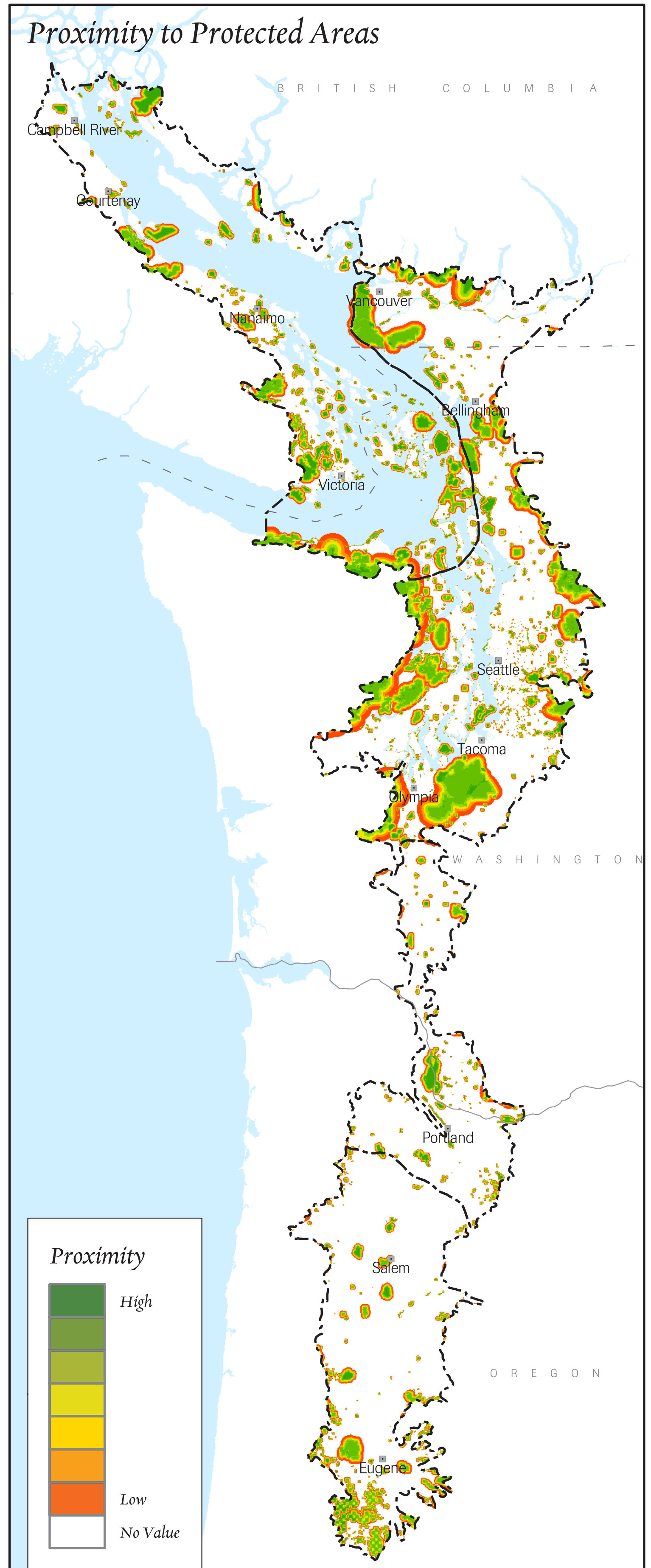

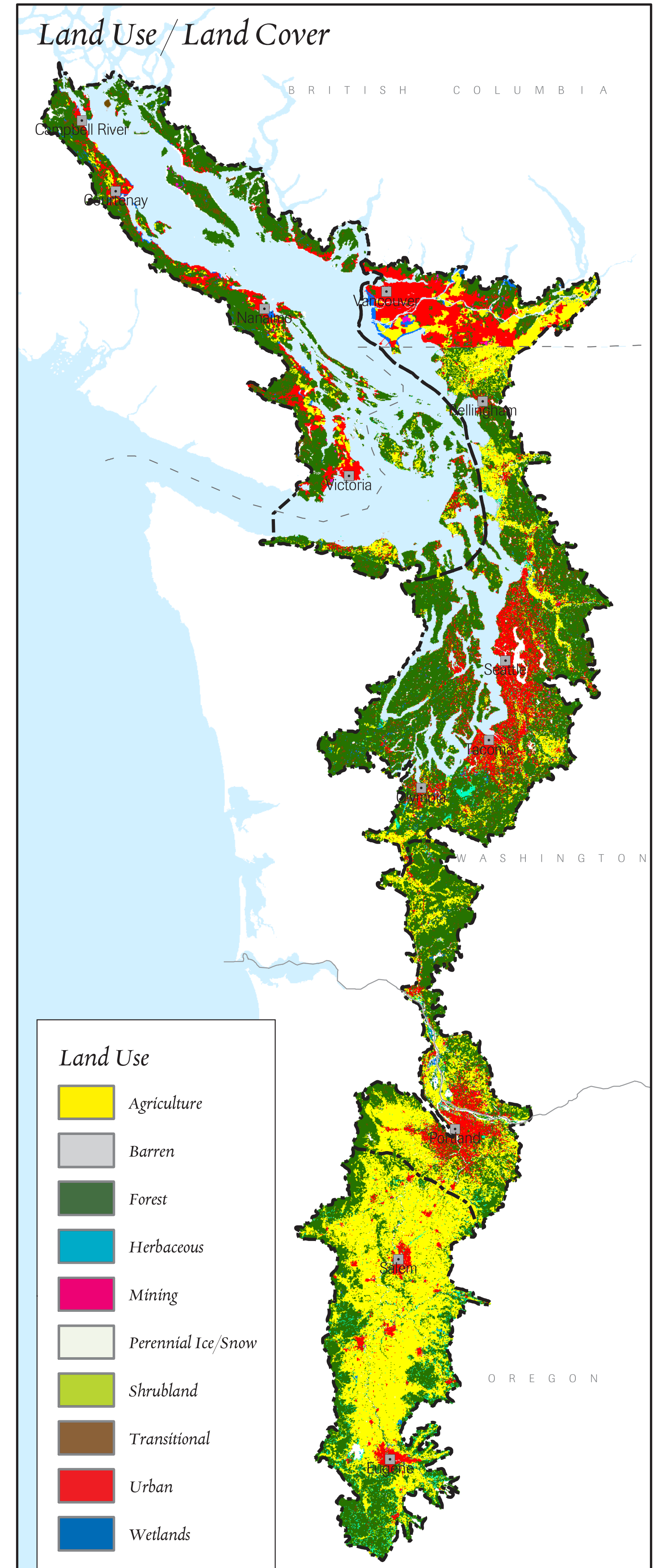

Willamette Valley - Puget Trough - Georgia Basin Ecoregion

Map 2.3: Building the Suitability Index

GIS data used in the suitability index. Urban growth areas (UGAs) were assumed to be highly unsuitable for biodiversity conservation (left panel). Zones around UGAs represent increasing suitability for conservation as distance from UGA increases. Existing protected areas were assumed to be the best places upon which to build larger landscapes for biodiversity conservation (center panel). Zones around protected lands indicate where private lands could contribute toward an ecologically functional landscape. Current land use / land cover also affected the index (right panel). We assumed that lands closer to their original native state are more suitable for conservation than lands that have been developed. This assumption does not preclude the possibility of restoration. In the land use/land cover map, the forest category corresponds to lands with a close conifer forest canopy. This includes parks, forests managed for timber, and low density residential areas.

N W E S

1 inch equals 50 miles

0 10 20 30 40 50 Miles

0 20 40 60 80 100 Kilometers

Sources: TNC, WDFW

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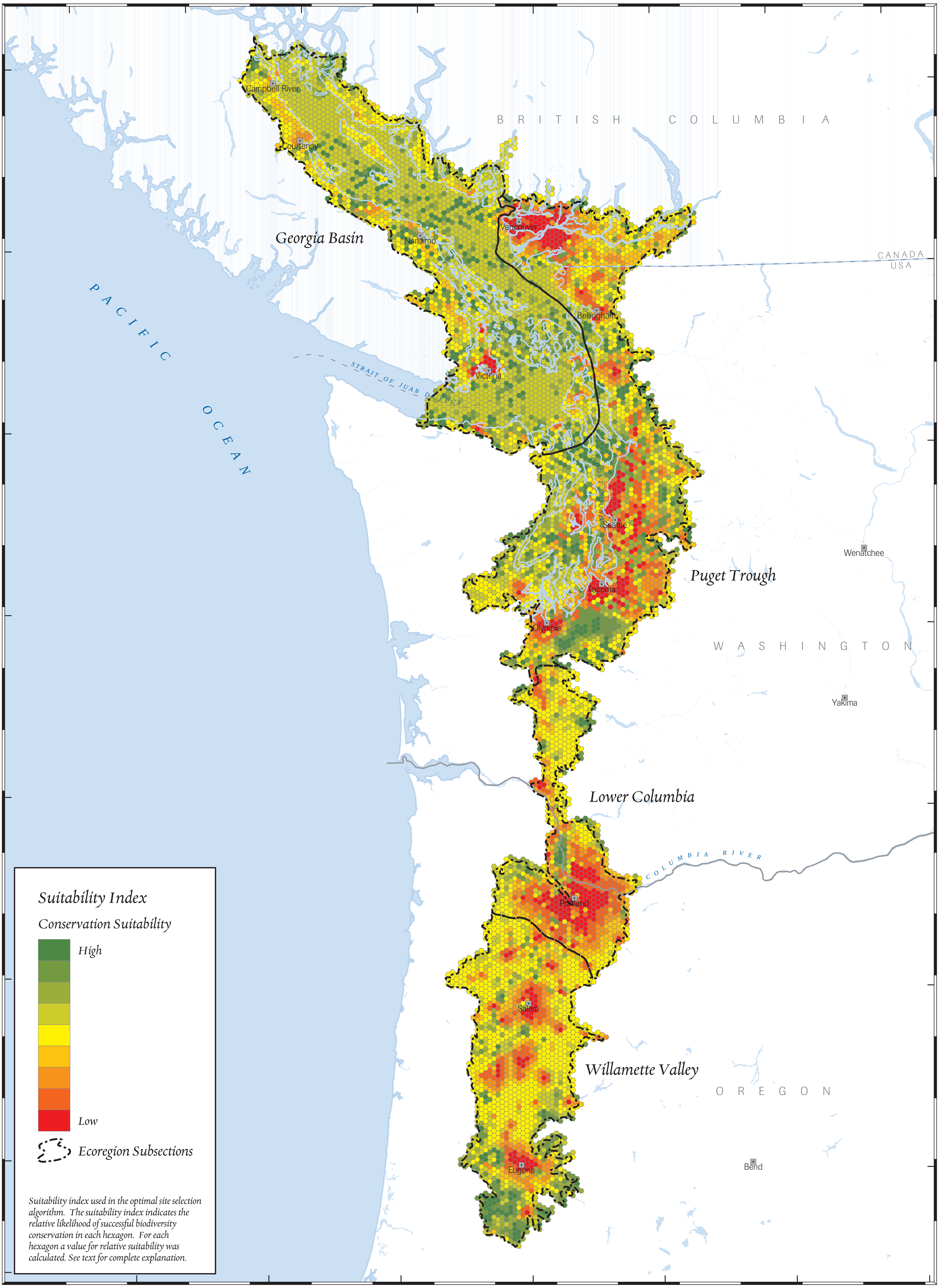

Willamette Valley - Puget Trough - Georgia Basin Ecoregion

Map 2.4: Suitability Index

1 inch equals 35 miles

0 5 10 15 20 25 30 35 Miles

0 10 20 30 40 50 60 Kilometers

N W E S

Sources: TNC, WDFW

Map revised August 4, 2003

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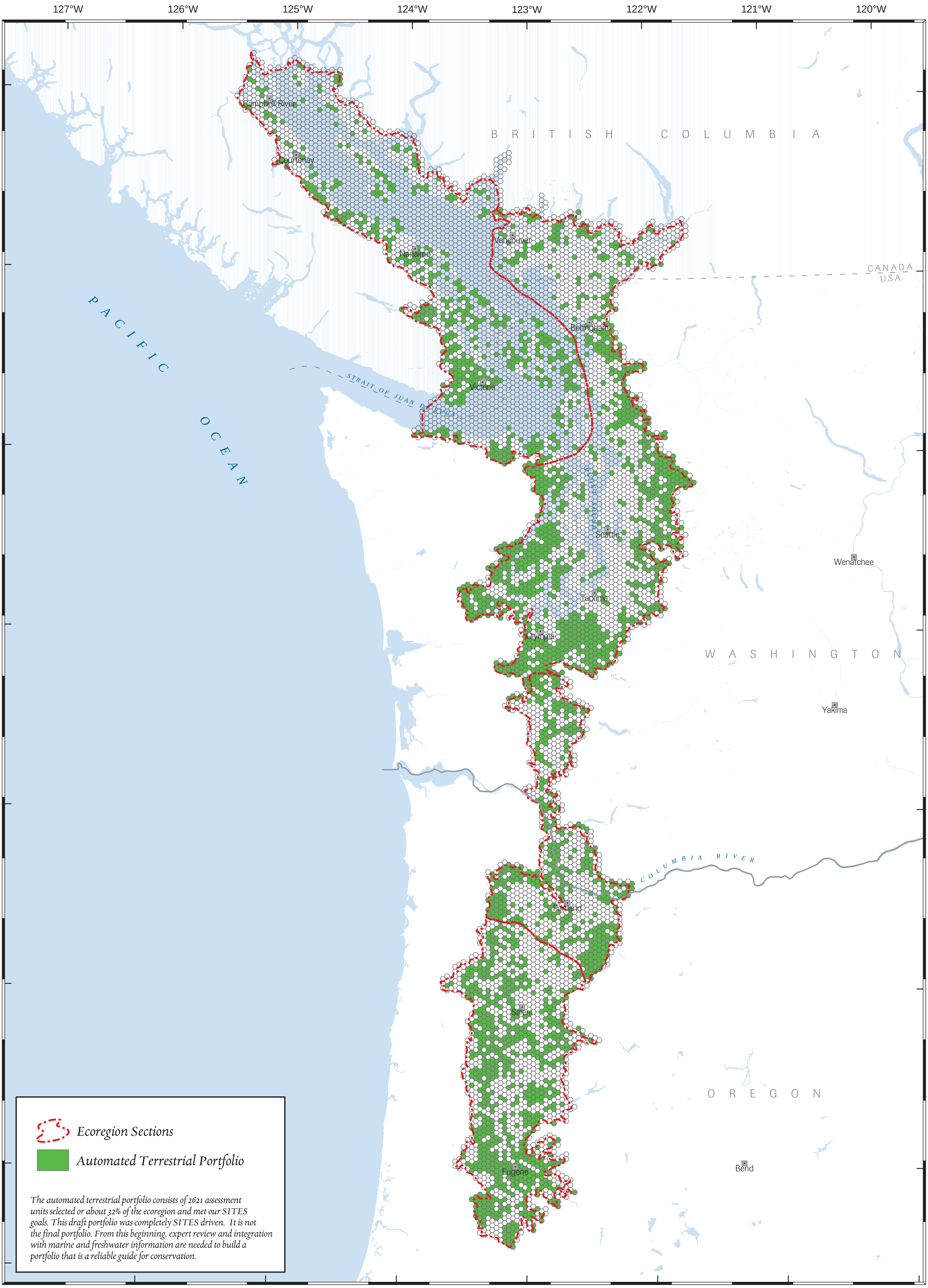

Willamette Valley - Puget Trough - Georgia Basin Ecoregion

Map 2.5: Automated Terrestrial Portfolio, Full Goals, No Lock-ins

1 inch equals 35 miles

0 5 10 15 20 25 30 35 Miles

0 10 20 30 40 50 60 Kilometers

N W E S

Sources:
TNC, WDFW, WDNR

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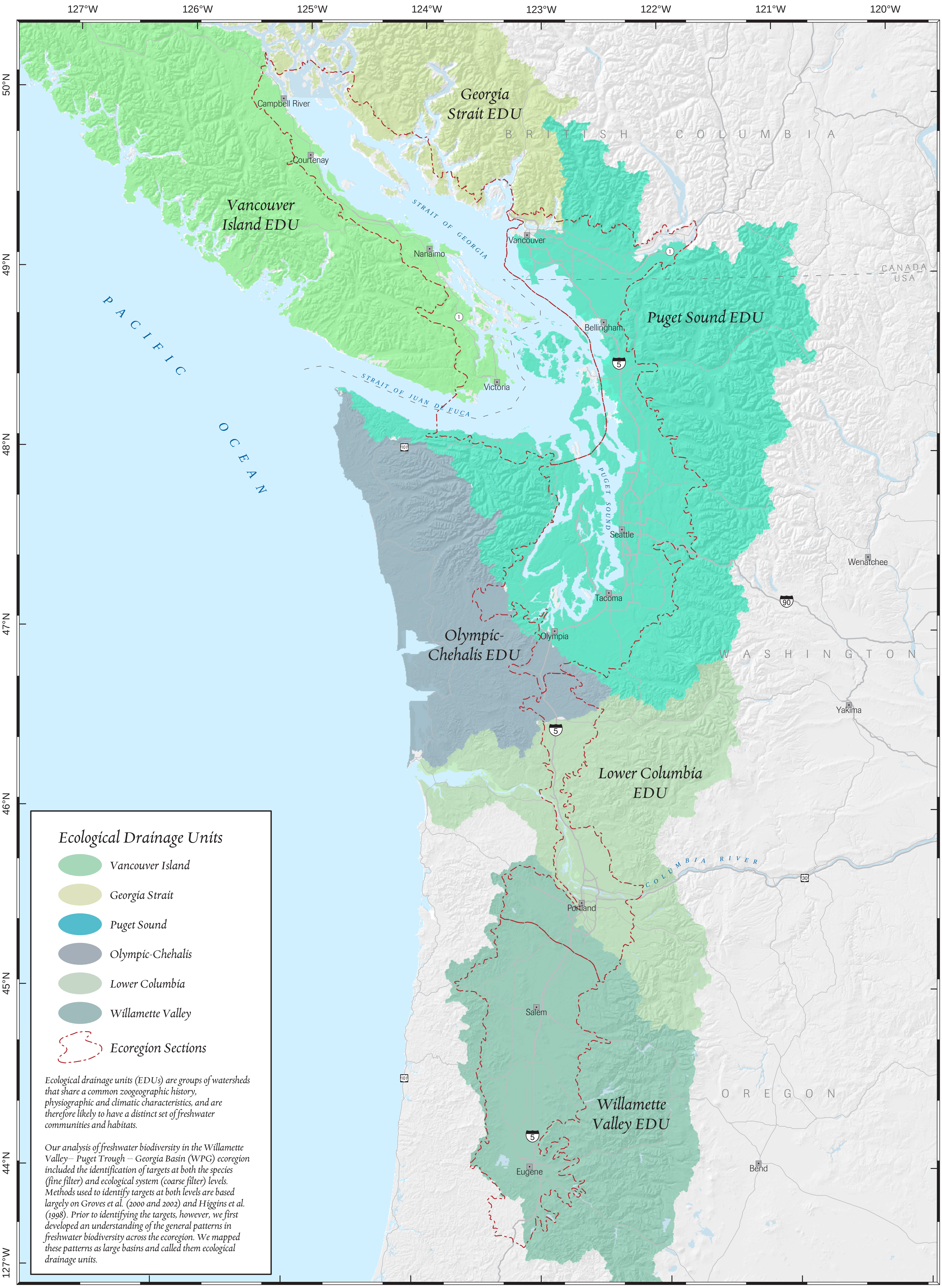

Ecological drainage units (EDUs) are groups of watersheds that share a common zoogeographic history, physiographic and climatic characteristics, and are therefore likely to have a distinct set of freshwater communities and habitats.

Our analysis of freshwater biodiversity in the Willamette Valley – Puget Trough – Georgia Basin (WPG) ecoregion included the identification of targets at both the species (fine filter) and ecological system (coarse filter) levels. Methods used to identify targets at both levels are based largely on Groves et al. (2000 and 2002) and Higgins et al. (1998). Prior to identifying the targets, however, we first developed an understanding of the general patterns in freshwater biodiversity across the ecoregion. We mapped these patterns as large basins and called them ecological drainage units.

Willamette Valley - Puget Trough - Georgia Basin Ecoregion

Map 3.1: Ecological Drainage Units

1 inch equals 35 miles

0 5 10 15 20 25 30 35 Miles

0 10 20 30 40 50 60 Kilometers

Sources:
MSRM, TNC, WDFW,
WDNR, USGS

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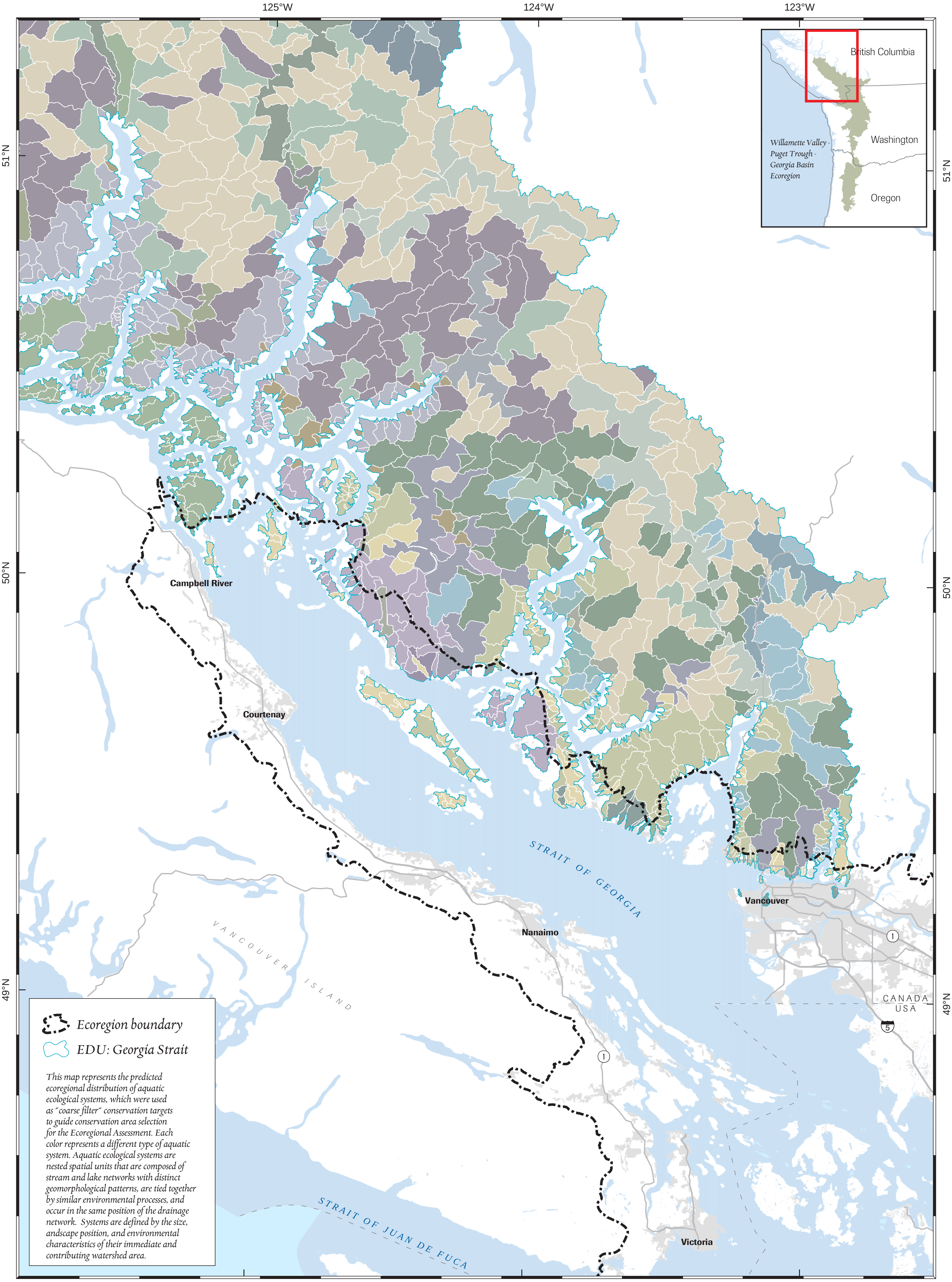


Georgia Basin EDU

Map 3.2a: Aquatic Ecological Systems

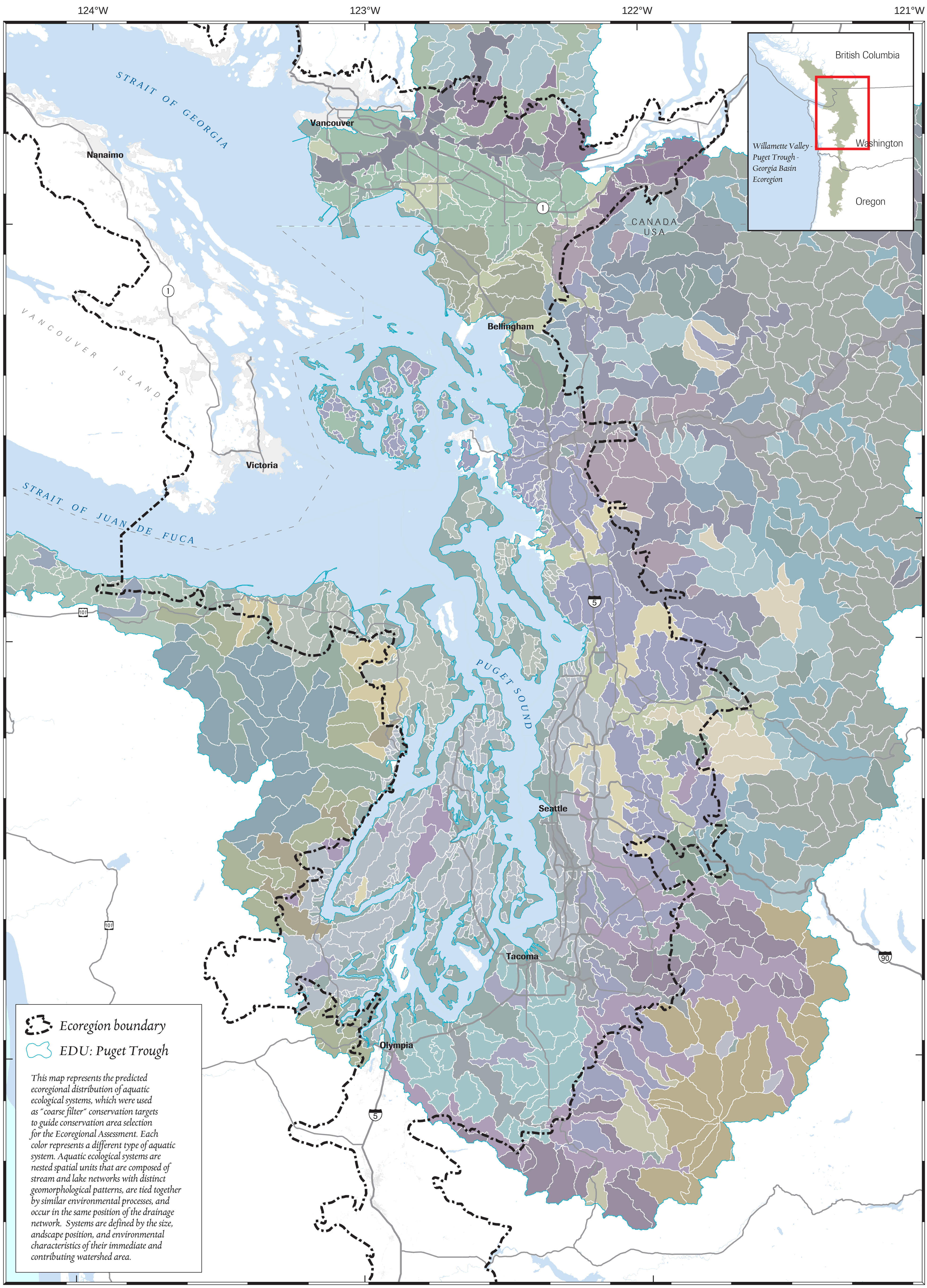
1 inch equals 15 miles

0 5 10 15 Miles

0 10 20 30 Kilometers

Sources:
TNC, USGS

March, 2004



Puget Trough EDU

Map 3.2b: Aquatic Ecological Systems

1 inch equals 15 miles

0 5 10 15 Miles

0 10 20 30 Kilometers

N W E S

Sources: TNC, USGS

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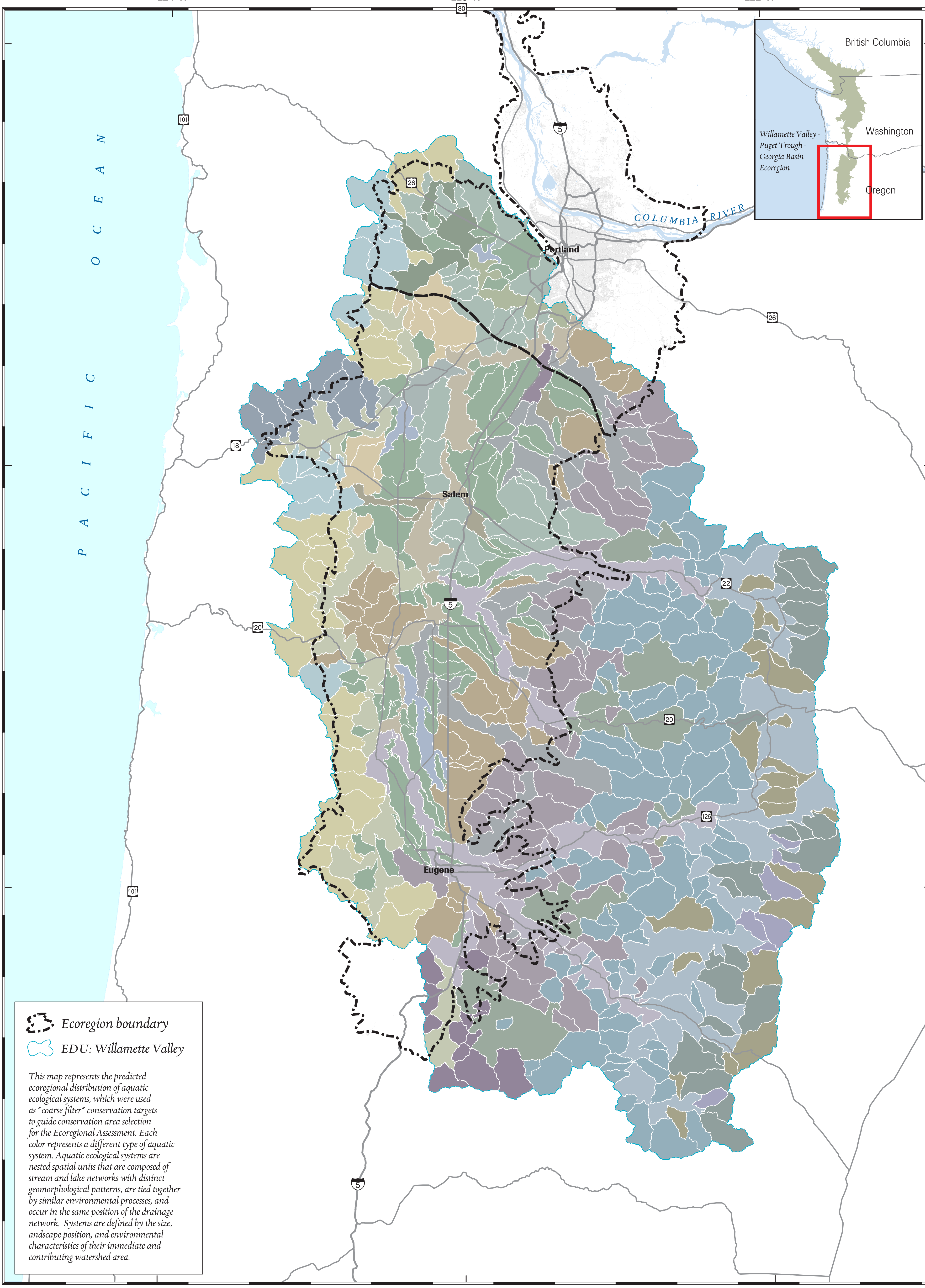

Willamette Valley EDU

Map 3.2c: Aquatic Ecological Systems

1 inch equals 15 miles

0 5 10 15 Miles

0 10 20 30 Kilometers

Sources: TNC, USGS

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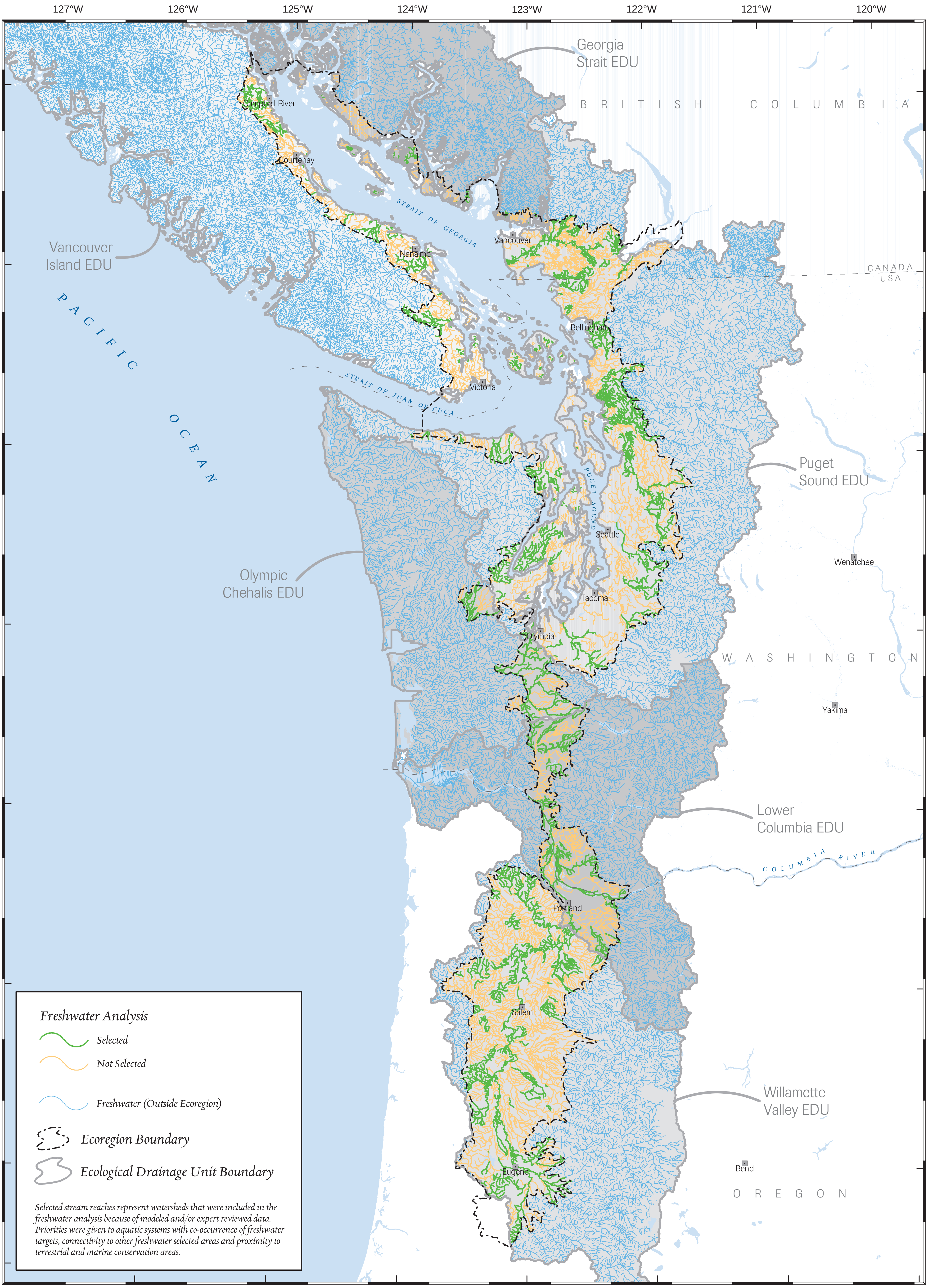

Willamette Valley - Puget Trough - Georgia Basin Ecoregion

Map 3.3: Results of Freshwater Analysis

1 inch equals 35 miles

0 5 10 15 20 25 30 35 Miles

0 10 20 30 40 50 60 Kilometers

N W E S

Sources: TNC, WDFW, WDNR, USGS

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Georgia Basin and Puget Trough

Map 4.1: Nearshore Waters in the Ecoregion

1 inch equals 17 miles

0 8.5 17 Miles

0 10 20 30 Kilometers

N W E S

Sources:
MRSM, TNC, WDFW, WDNR, USGS

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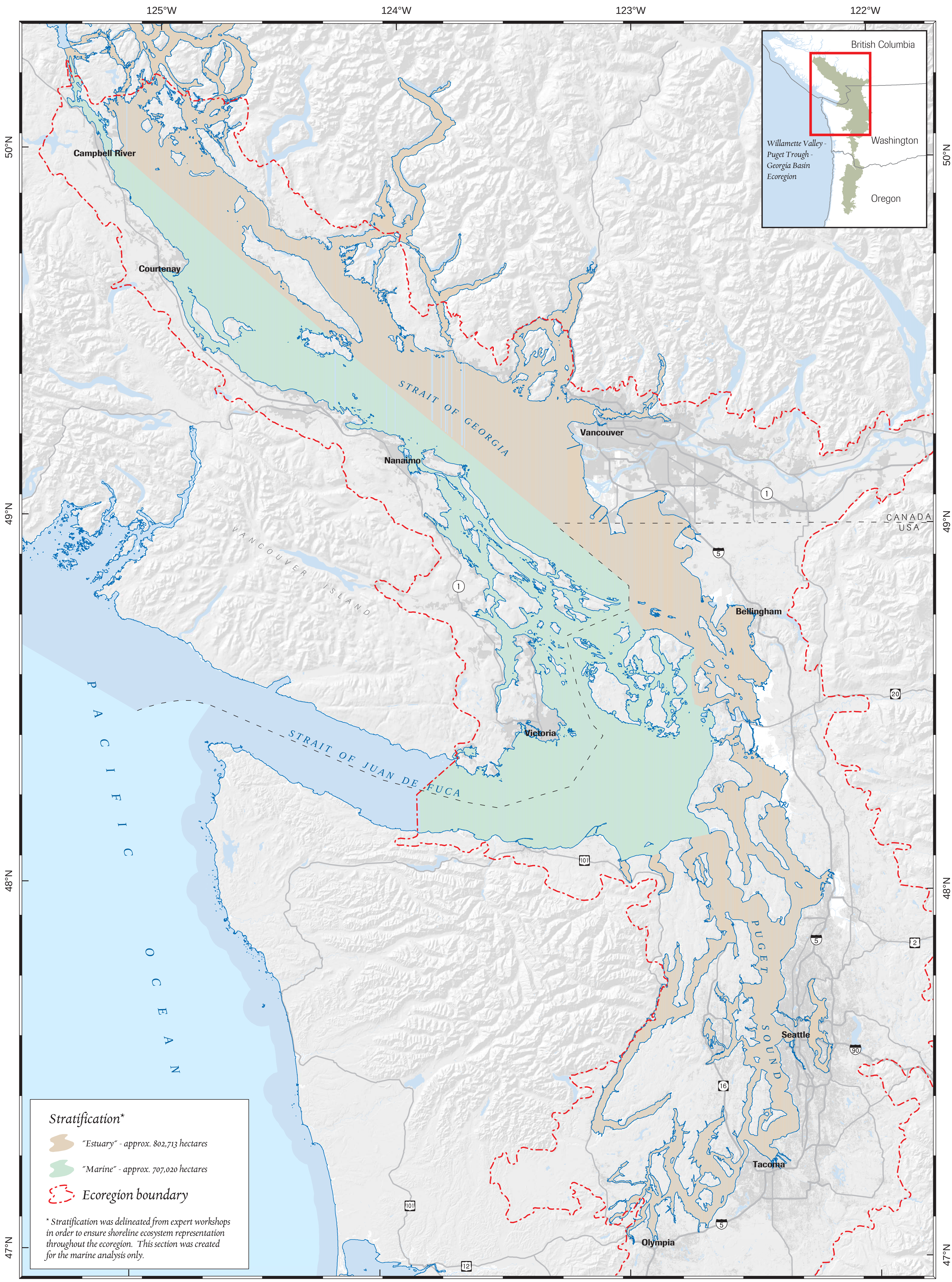

Georgia Basin and Puget Trough

Map 4.2: Water Subsections within the Ecoregion

1 inch equals 17 miles

0 8.5 17 Miles

0 10 20 30 Kilometers

N W E S

Sources: MRSM, TNC, WDFW, WDNR, USGS

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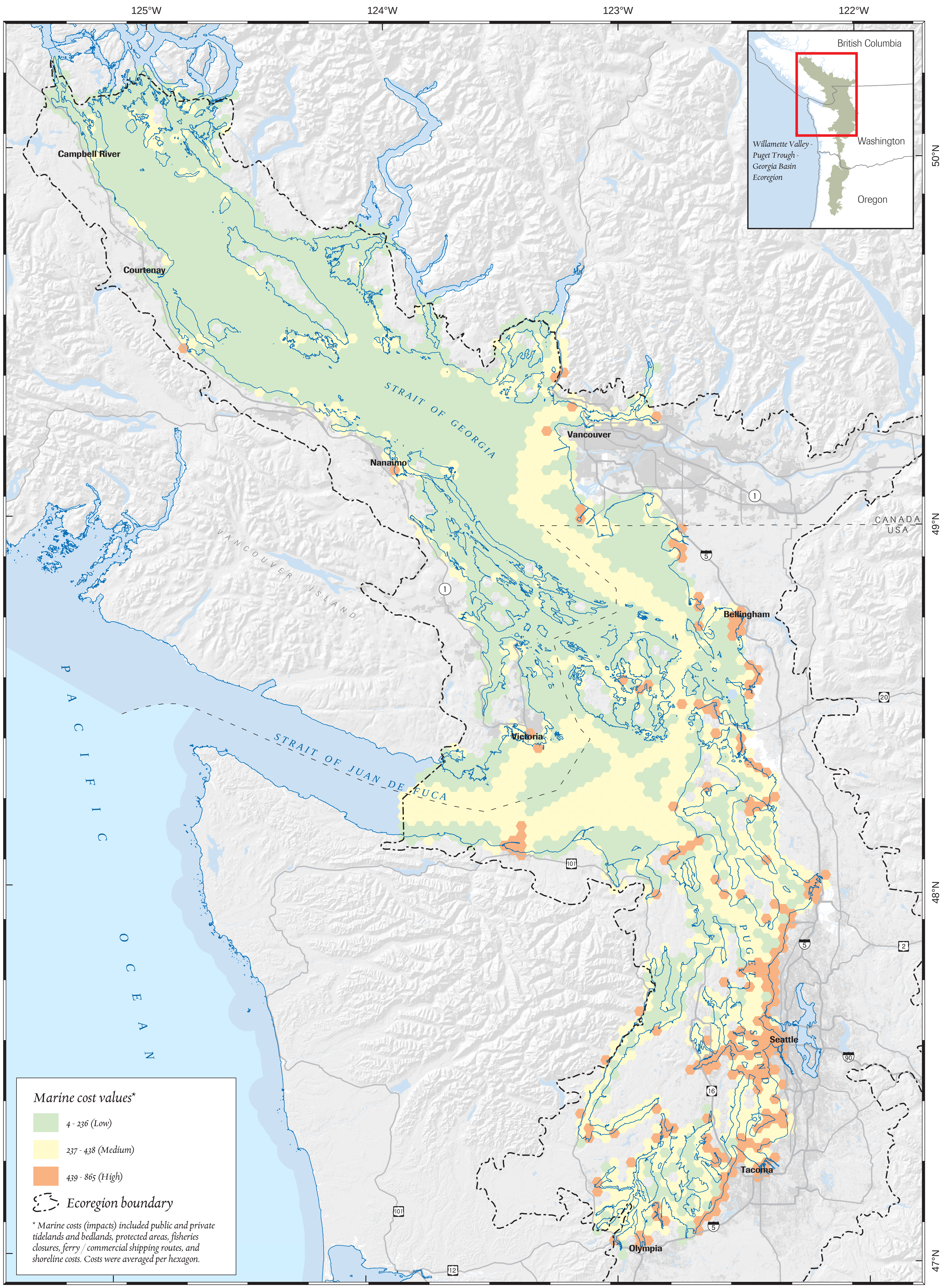

Georgia Basin and Puget Trough

Map 4.3: Marine Cost Parameters and Values

1 inch equals 17 miles

0 8.5 17 Miles

0 10 20 30 Kilometers

Sources: MRSM, TNC, WDFW, WDNR, USGS

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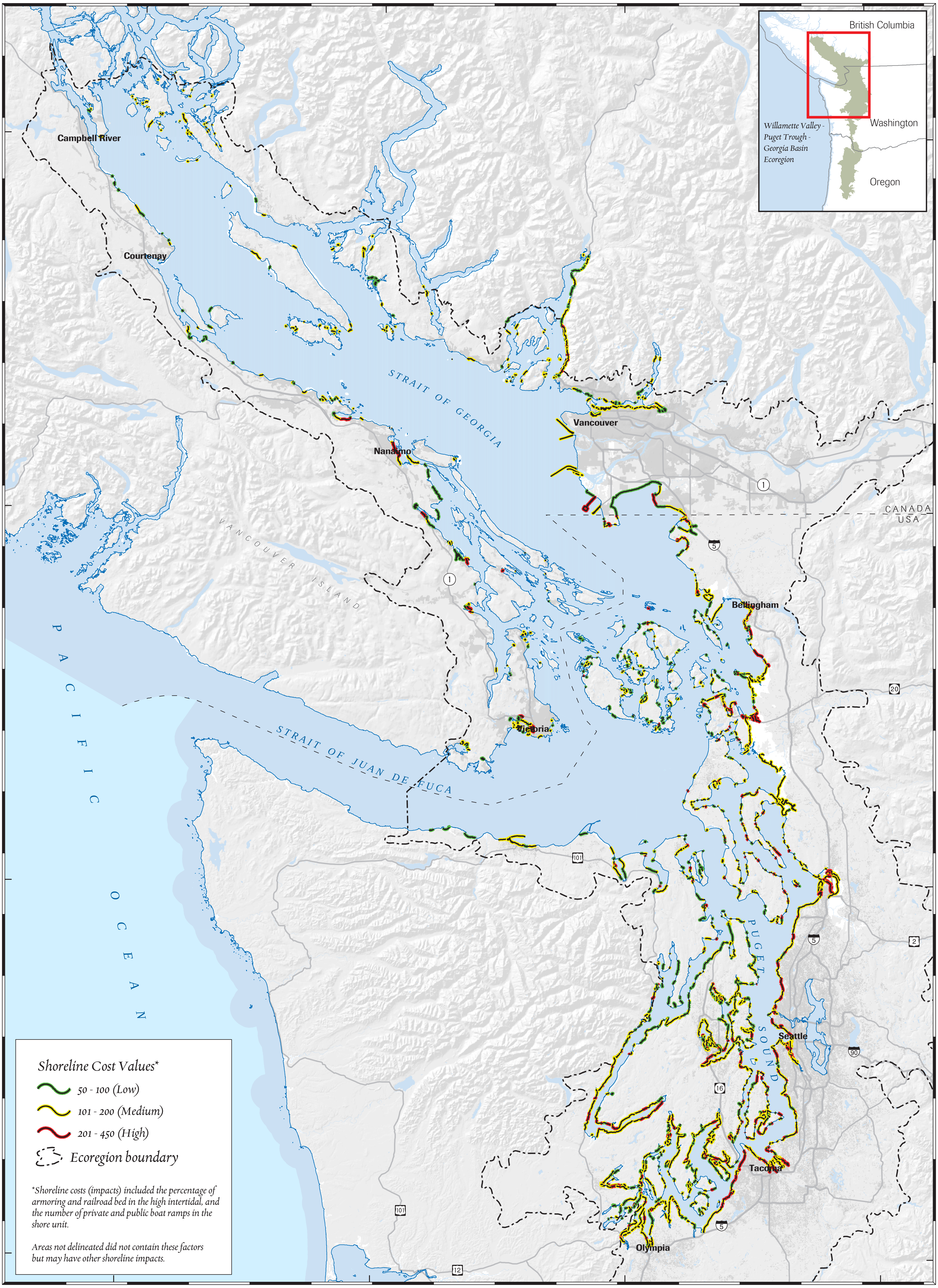

Georgia Basin and Puget Trough

Map 4.4: Shoreline Cost Parameters and Values

1 inch equals 17 miles

0 8.5 17 Miles

0 10 20 30 Kilometers

Sources: MRSM, TNC, WDFW, WDNR, USGS

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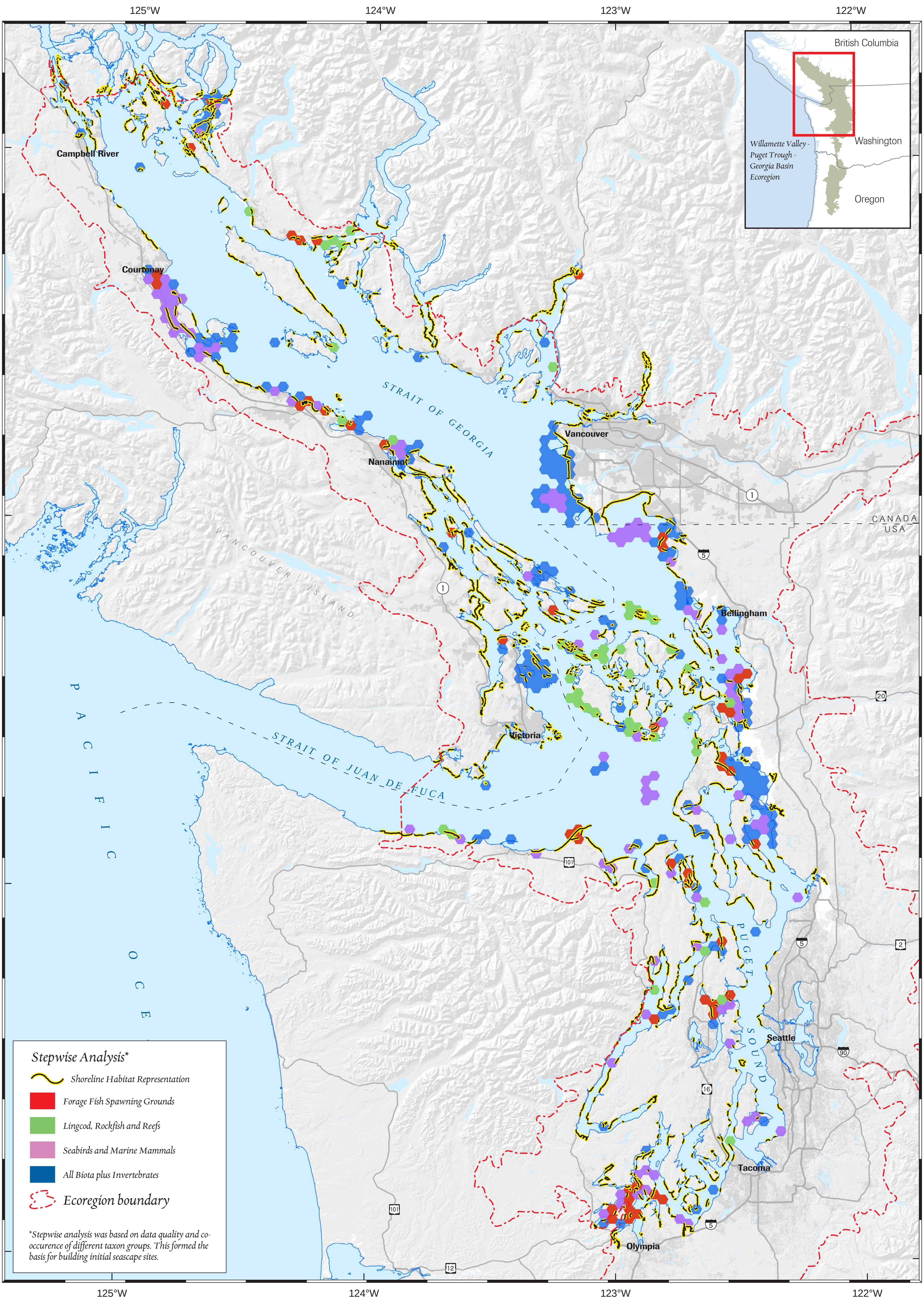

Georgia Basin and Puget Trough

Map 4.5: Stepwise Analysis for Building Initial Seascapes

1 inch equals 17 miles

0 8.5 17 Miles

0 10 20 30 Kilometers

N E S W

Sources: MRSM, TNC, WDFW, WDNR, USGS

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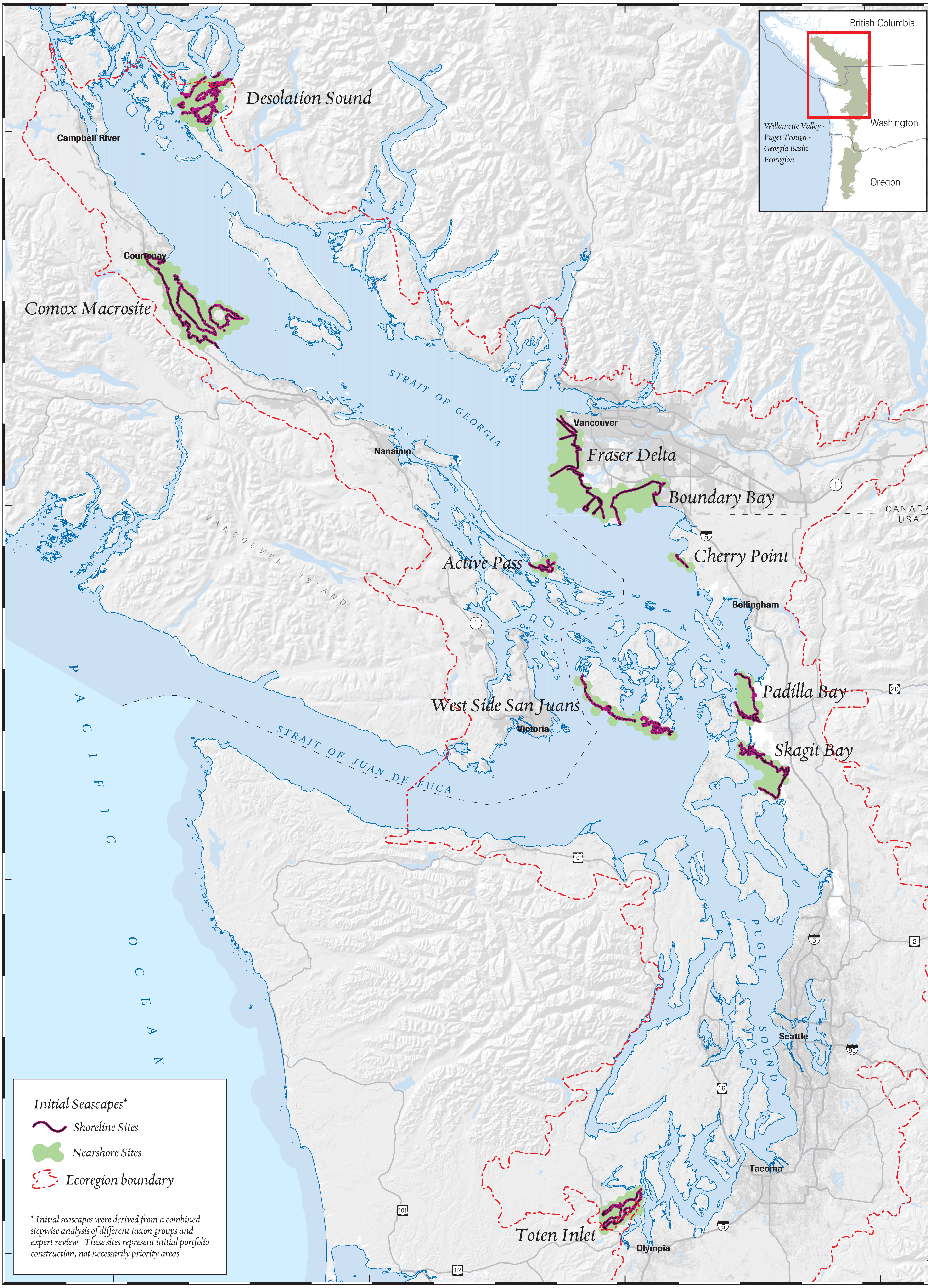

Georgia Basin and Puget Trough

Map 4.6: Initial Seascape Sites within the Ecoregion

1 inch equals 17 miles

0 8.5 17 Miles

0 10 20 30 Kilometers

Sources: MRSM, TNC, WDFW, WDNR, USGS

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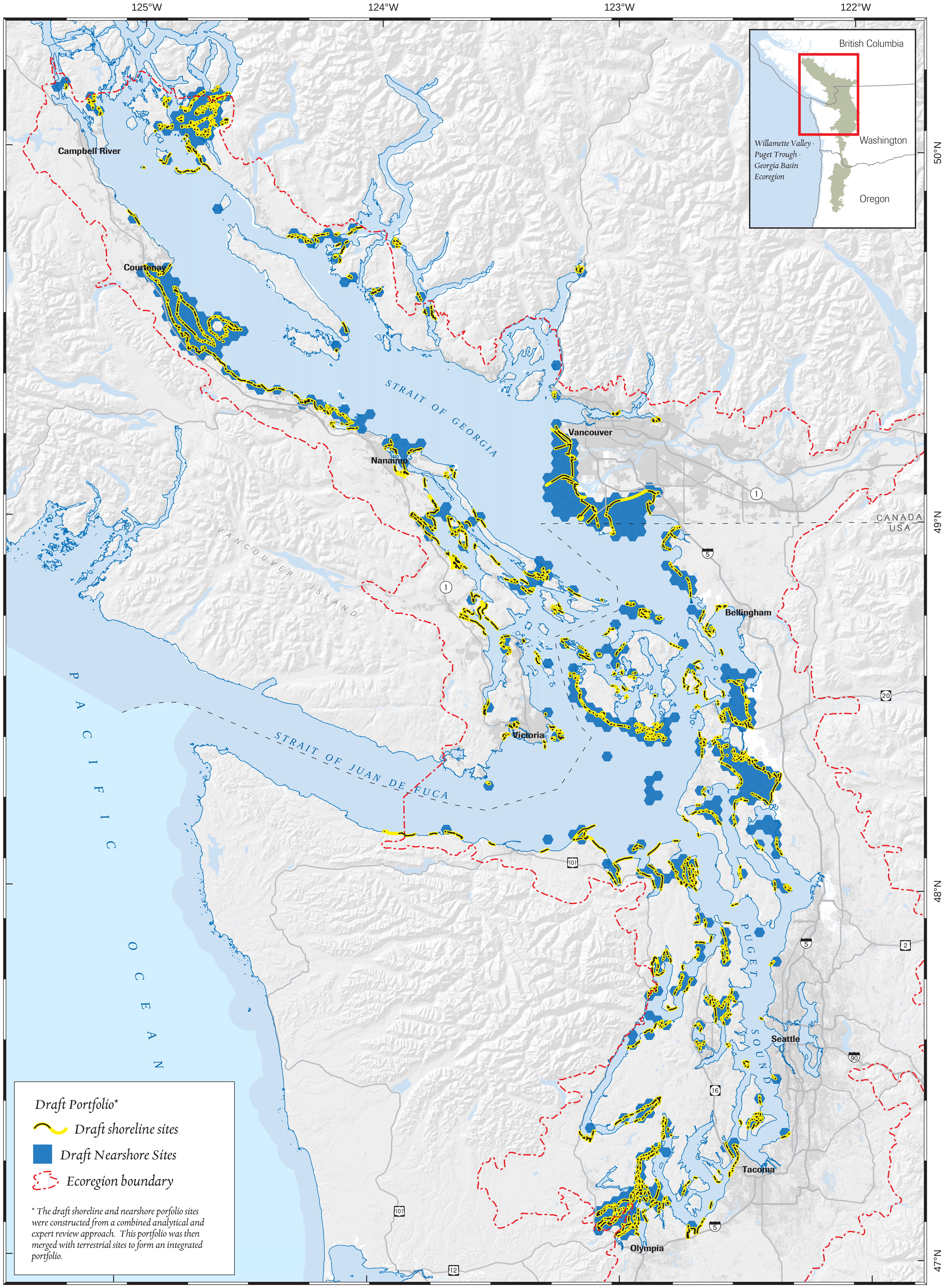

Georgia Basin and Puget Trough

Map 4.7: Draft Shoreline and Nearshore Portfolio

1 inch equals 17 miles

0 8.5 17 Miles

0 10 20 30 Kilometers

Sources: MRSM, TNC, WDFW, WDNR, USGS

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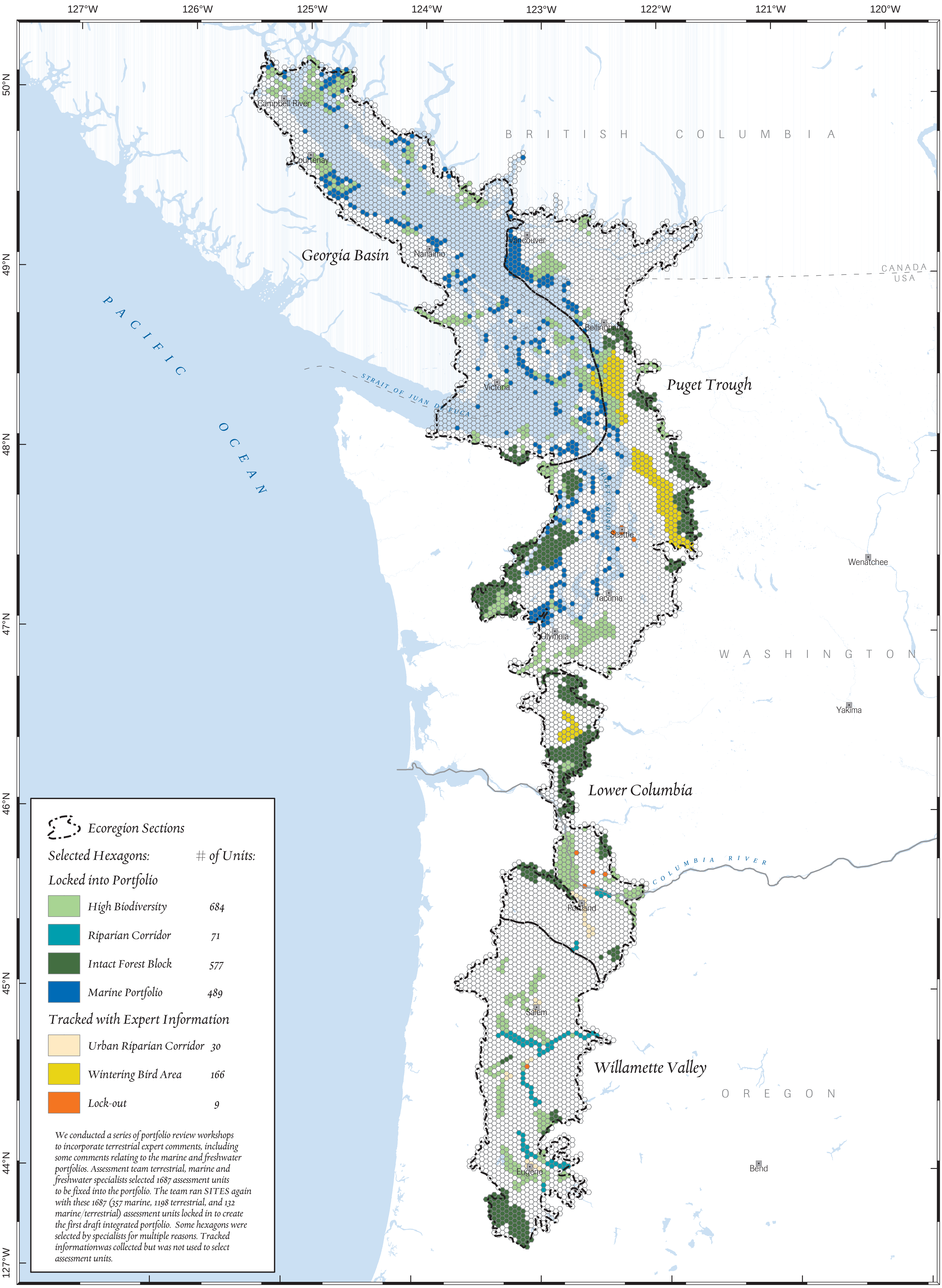

Willamette Valley - Puget Trough - Georgia Basin Ecoregion

Map 5.1: Assessment Units used to Refine Automated Portfolio

1 inch equals 35 miles

0 5 10 15 20 25 30 35 Miles

0 10 20 30 40 50 60 Kilometers

N E S W

Sources:
TNC, WDFW, WDNR

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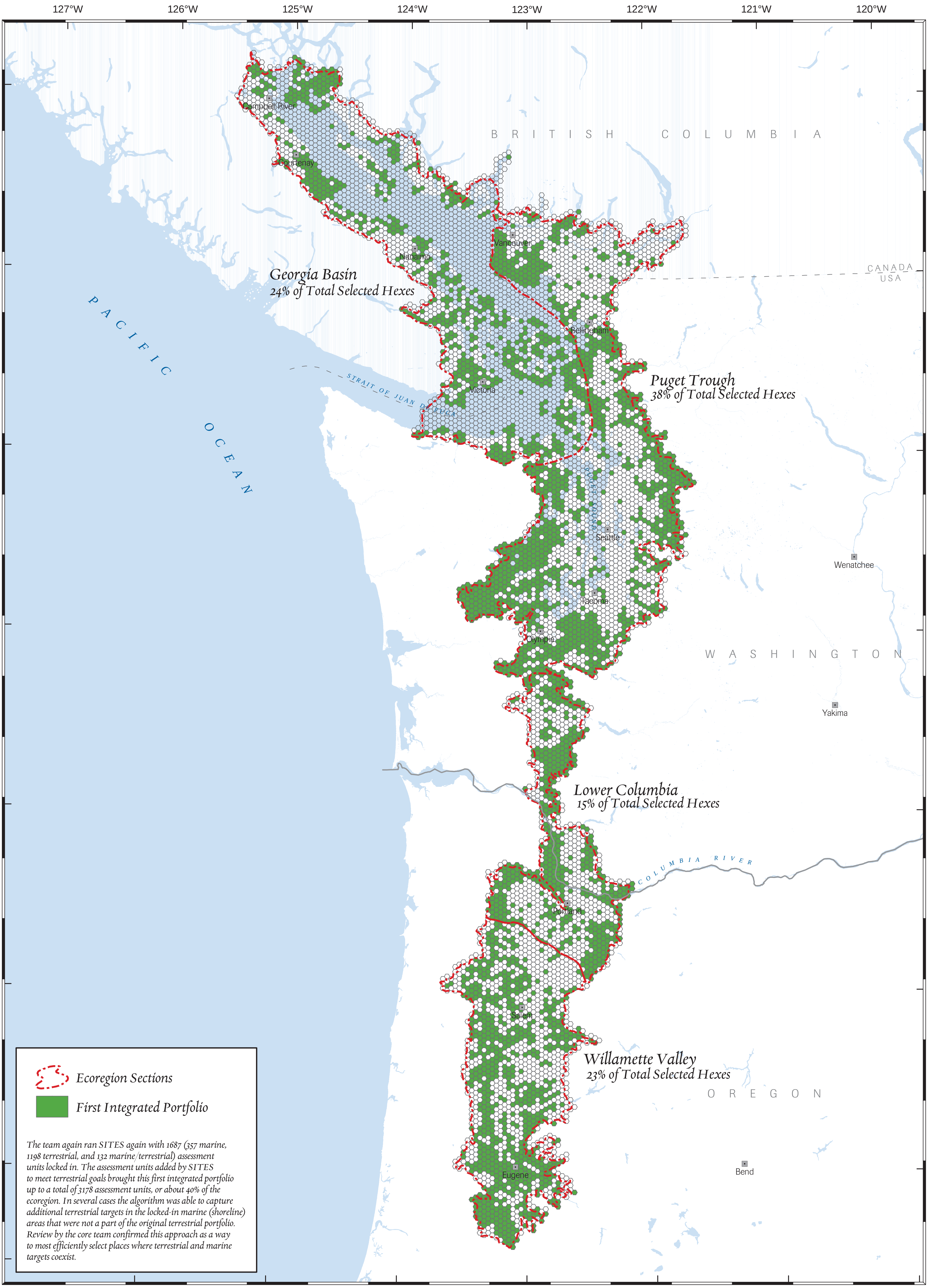

Willamette Valley - Puget Trough - Georgia Basin Ecoregion

Map 5.2: First Draft Integrated Portfolio

1 inch equals 35 miles

0 5 10 15 20 25 30 35 Miles

0 10 20 30 40 50 60 Kilometers

N E S W

Sources:
TNC, WDFW, WDNR

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Index to Priority Conservation Area maps 5.3a and 5.3b.

Unique ID	Conservation Area Name	Area in Hectares	Section	Jurisdiction	Marine Stratification	Integration
63	Active Pass	3,180	GB	BC	Marine	Terrestrial/Nearshore
318	Airlie Oaks	1,464	WV	OR		Terrestrial only
352	Alderwood Wayside	65	WV	OR		Terrestrial only
299	Amity Oaks	949	WV	OR		Terrestrial only
24	Anderson Beach	105	GB	BC	Estuarine	Nearshore only
246	Bald Hill	3,404	PT	WA		Terrestrial only
174	Bangor	1,616	PT	WA	Estuarine	Terrestrial/Nearshore
272	Banks Swamp	231	LC	OR		Terrestrial only
306	Basket Butte	5,618	WV	OR		Terrestrial only
351	Bear Creek Oaks	507	WV	OR		Terrestrial only
348	Bear Creek Wetlands	556	WV	OR		Terrestrial only
208	Black Diamond Lake	749	PT	WA		Terrestrial only
241	Black River - Mima Prairie	7,049	PT	WA		Terrestrial only
49	Blackjack-Harewood	8,996	GB	BC		Terrestrial only
187	Blake Island	183	PT	WA		Terrestrial/Nearshore
100	Blakely Island	1,684	GB	WA		Terrestrial only
44	Blaney Bog	764	PT	BC		Terrestrial only
30	Bowyer Island	165	GB	BC	Estuarine	Nearshore only
222	Brisco Point, South Hartstene Island	446	PT	WA	Estuarine	Nearshore only
25	Buccaneer Bay	1,519	GB	BC	Estuarine	Terrestrial/Nearshore
223	Buckley Hills	4,426	PT	WA		Terrestrial only
229	Budd Inlet	254	PT	WA	Estuarine	Nearshore only
304	Buell	160	WV	OR		Terrestrial only
51	Burn's Bog	3,324	PT	BC		Terrestrial only
344	Calapooia Oak Savanna	386	WV	OR		Terrestrial only
144	Camano Head	44	PT	WA		Terrestrial only
369	Camas Swale BLM RNA	81	WV	OR		Terrestrial only
363	Camas Swale Oaks	1,863	WV	OR		Terrestrial only
364	Camas Swale Wetlands	878	WV	OR		Terrestrial only
285	Camassia	18	LC	OR		Terrestrial only
356	Camp Creek Ridge	578	WV	OR		Terrestrial only
180	Camp Wesley Harris	843	PT	WA		Terrestrial only
215	Campbell Creek	639	PT	WA		Terrestrial only
103	Capsante, Fidalgo Island	67	GB	WA	Estuarine	Nearshore only
231	Carbon River Plateau	2,987	PT	WA		Terrestrial only
292	Cedar Creek	3,271	LC	OR		Terrestrial only
197	Cedar River	4,785	PT	WA		Terrestrial only
20	Central Texada Island	12,589	GB	BC		Terrestrial only
291	Champoeg State Park	114	WV	OR		Terrestrial only
61	Chemainus	1,683	GB	BC	Marine	Terrestrial/Nearshore
64	Cherry Point	3,248	PT	WA	Estuarine	Nearshore only
158	Chimacum Forest	2,538	PT	WA		Terrestrial only
86	Chuckanut Mountain	3,694	PT	WA		Terrestrial only
286	Clackamas	8,330	LC	OR		Terrestrial only
290	Clear Creek	7,148	LC	OR		Terrestrial only
227	Cloquallum	3,618	PT	WA		Terrestrial only
249	Coal Creek Forest	942	LC	WA		Terrestrial only
365	Coast Fork/Middle Fork Willamette Riparian	5,437	WV	OR		Terrestrial only
354	Coburg Ridge	2,018	WV	OR		Terrestrial only
343	Cogswell Foster	36	WV	OR		Terrestrial only
23	Comox Macrosite	25,581	GB	BC	Marine	Terrestrial/Nearshore
12	Conawaga Beach	743	GB	BC	Marine	Nearshore only
282	Cooper Mountain	434	LC	OR		Terrestrial only
1	Cortes Island	12,130	GB	BC	Estuarine	Terrestrial/Nearshore
333	Corvallis Watershed	3,948	WV	OR		Terrestrial only
331	Corvallis-Philomath Oaks	4,652	WV	OR		Terrestrial only
188	Cougar Mountain	1,604	PT	WA		Terrestrial only
193	Coulter Creek	3,848	PT	WA		Terrestrial only
202	Covington Creek	2,587	PT	WA		Terrestrial only
75	Cowichan	13,749	GB	BC	Marine	Terrestrial/Nearshore
261	Cowlitz Forest Corridor	19,498	LC	WA		Terrestrial only
258	Cowlitz Riparian	1,386	LC	WA		Terrestrial only
211	Cranberry Creek	2,405	PT	WA		Terrestrial only
342	Crawfordsville Oak-Pine Savanna	2,349	WV	OR		Terrestrial only
124	Crescent Harbot Forest	234	GB	WA		Terrestrial only
95	Cypress-Sinclair Islands	3,120	GB	WA	Estuarine	Terrestrial/Nearshore
219	Dayton Creek	2,910	PT	WA		Terrestrial only
118	Deception Pass	3,913	GB	WA	Estuarine/Marine	Terrestrial/Nearshore
207	Deer Creek	3,574	PT	WA		Terrestrial only
243	Deschutes Riparian	3,226	PT	WA		Terrestrial only
3	Desolation Sound	10,700	GB	BC	Estuarine	Terrestrial/Nearshore
225	Dickenson Point	236	PT	WA	Estuarine	Nearshore only
252	Dillenbaugh	1,127	LC	WA		Terrestrial only
152	Discovery Bay	902	GB	WA	Marine	Terrestrial/Nearshore
116	Discovery Island	856	GB	BC	Marine	Terrestrial/Nearshore
4	Discovery Passage	8,559	GB	BC	Marine	Terrestrial/Nearshore
220	Drayton Passage-Filucy Bay	373	PT	WA	Estuarine	Nearshore only
260	Drews Prairie	109	LC	WA		Terrestrial only
121	Dugualla Bay	774	GB	WA	Estuarine	Terrestrial/Nearshore
289	Dundee Oaks	722	WV	OR		Terrestrial only
135	Dungeness	4,734	GB	WA	Marine	Terrestrial/Nearshore
321	Dunn Forest	4,273	WV	OR		Terrestrial only
179	Dyes Inlet-Silverdale	131	PT	WA	Estuarine	Nearshore only
186	East Fork Issaquah Creek	2,109	PT	WA		Terrestrial only
267	East Fork Lewis Riparian	888	LC	WA		Terrestrial only
195	East Side Vashon	125	PT	WA	Estuarine	Nearshore only
120	East Sooke	2,578	GB	BC		Terrestrial only
131	Ebey's Landing	1,028	GB	WA		Terrestrial/Nearshore
171	Edmonds Point	84	PT	WA	Estuarine	Nearshore only
322	EE Wilson	1,010	WV	OR		Terrestrial only
213	Eells Hill	6,312	PT	WA		Terrestrial only
233	Eld Inlet	522	PT	WA	Estuarine	Nearshore only
372	Elk Creek	1,472	WV	OR		Terrestrial only

Index to Priority Conservation Area maps 5.3a and 5.3b.

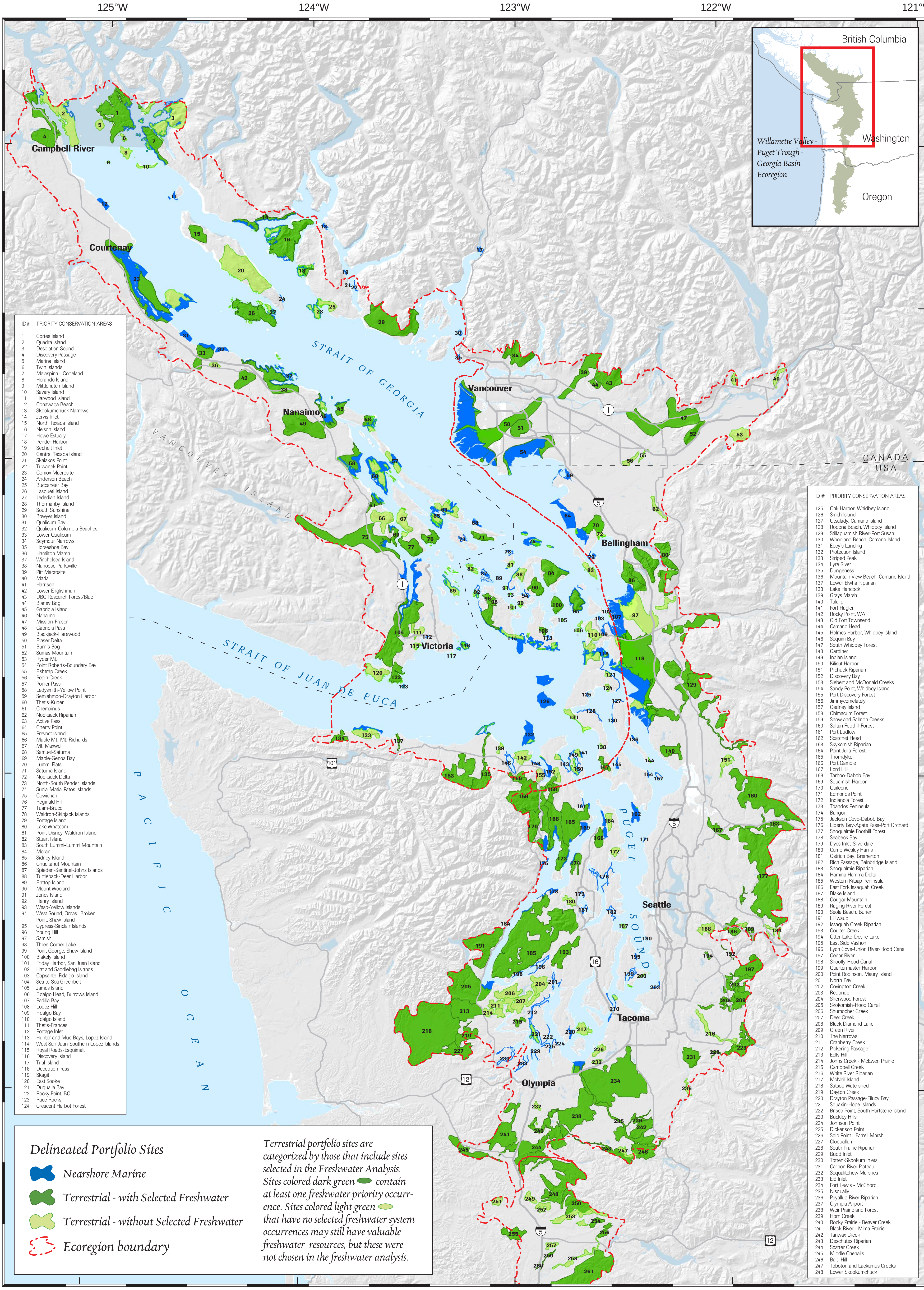
Unique ID	Conservation Area Name	Area in Hectares	Section	Jurisdiction	Marine Stratification	Integration
305	Eola Hills	9,293	WV	OR		Terrestrial only
357	Fern Ridge Reservoir	3,713	WV	OR		Terrestrial only
109	Fidalgo Bay	375	GB	WA	Estuarine/Marine	Nearshore only
106	Fidalgo Head, Burrows Island	346	GB	WA		Terrestrial/Nearshore
110	Fidalgo Island	1,745	GB	WA		Terrestrial only
55	Fishtrap Creek	299	PT	BC		Terrestrial only
89	Flattop Island	43	GB	WA	Marine	Nearshore only
270	Forest Park-Coast Range	30,838	LC	OR		Terrestrial only
141	Fort Flagler	521	GB	WA	Estuarine	Terrestrial/Nearshore
234	Fort Lewis - McChord	24,382	PT	WA		Terrestrial only
367	Fox Hollow BLM RNA	183	WV	OR		Terrestrial only
50	Fraser Delta	28,619	PT	BC	Estuarine/Marine	Terrestrial/Nearshore
101	Friday Harbor, San Juan Island	178	GB	WA		Terrestrial/Nearshore
45	Gabriola Island	1,362	GB	BC	Marine	Terrestrial/Nearshore
48	Gabriola Pass	1,873	GB	BC	Marine	Terrestrial/Nearshore
275	Gales Creek	28	LC	OR		Terrestrial only
148	Gardiner	197	GB	WA	Marine	Nearshore only
157	Gedney Island	212	PT	WA	Estuarine	Nearshore only
370	Gettings Creek	334	WV	OR		Terrestrial only
332	Golden Valley	2,983	WV	OR		Terrestrial only
274	Government Island	1,214	LC	OR		Terrestrial only
139	Grays Marsh	324	GB	WA		Terrestrial only
209	Green River	3,936	PT	WA		Terrestrial only
310	HABECK Oaks	7,139	WV	OR		Terrestrial only
36	Hamilton Marsh	553	GB	BC		Terrestrial only
184	Hamma Hamma Delta	21	PT	WA		Terrestrial only
41	Harrison	646	PT	BC		Terrestrial only
11	Harwood Island	299	GB	BC	Estuarine	Nearshore only
102	Hat and Saddlebag Islands	54	GB	WA	Estuarine	Terrestrial/Nearshore
92	Henry Island	620	GB	WA	Marine	Terrestrial/Nearshore
8	Herando Island	999	GB	BC		Terrestrial/Nearshore
309	Hidden Oaks	463	LC	OR		Terrestrial only
347	High Pass	4,083	WV	OR		Terrestrial only
145	Holmes Harbor, Whidbey Island	283	PT	WA	Estuarine	Nearshore only
239	Horn Creek	1,004	PT	WA		Terrestrial only
35	Horseshoe Bay	178	PT	BC	Estuarine	Nearshore only
17	Howe Estuary	362	GB	BC	Estuarine/Marine	Nearshore only
113	Hunter and Mud Bays, Lopez Island	192	GB	WA	Marine	Nearshore only
345	Indian Head/Horse Rock Ridge	12,457	WV	OR		Terrestrial only
149	Indian Island	1,087	GB	WA	Estuarine	Terrestrial/Nearshore
172	Indianola Forest	640	PT	WA		Terrestrial only
192	Issaquah Creek Riparian	132	PT	WA		Terrestrial only
175	Jackson Cove-Dabob Bay	323	PT	WA	Estuarine	Nearshore only
328	Jackson Fraiser Wetlands	380	WV	OR		Terrestrial only
105	James Island	47	GB	WA		Terrestrial only
361	Jasper Prairie	299	WV	OR		Terrestrial only
27	Jedediah Island	690	GB	BC	Estuarine	Terrestrial/Nearshore
14	Jervis Inlet	3,353	GB	BC	Estuarine	Terrestrial/Nearshore
156	Jimmycomelately	1,186	GB	WA		Terrestrial only
214	Johns Creek - McEwen Prairie	1,709	PT	WA		Terrestrial only
314	Johnson Hill	298	WV	OR		Terrestrial only
224	Johnson Point	205	PT	WA	Estuarine	Nearshore only
91	Jones Island	78	GB	WA		Terrestrial only
150	Kilisut Harbor	246	GB	WA	Estuarine	Nearshore only
316	Kingston Prairie	398	WV	OR		Terrestrial only
271	Lacamas Meadows	1,021	LC	WA		Terrestrial only
259	Lacamas Riparian	349	LC	WA		Terrestrial only
58	Ladysmith-Yellow Point	4,947	GB	BC	Marine	Terrestrial/Nearshore
138	Lake Hancock	36	GB	WA		Terrestrial only
80	Lake Whatcom	6,931	PT	WA		Terrestrial only
362	Lane Community College Basin	546	WV	OR		Terrestrial only
26	Lasqueti Island	6,997	GB	BC	Estuarine	Terrestrial/Nearshore
257	Lewis and Clark State Park	661	LC	WA		Terrestrial only
176	Liberty Bay-Agate Pass-Port Orchard	1,229	PT	WA	Estuarine	Nearshore only
191	Lilliwaup	8,648	PT	WA		Terrestrial only
311	Little Sink RNA	21	WV	OR		Terrestrial only
326	Logsden Ridge	454	WV	OR		Terrestrial only
108	Lopez Hill	454	GB	WA		Terrestrial only
167	Lord Hill	1,699	PT	WA		Terrestrial only
334	Lower Calapooia River Riparian	5,915	WV	OR		Terrestrial only
265	Lower Coweeman	1,682	LC	WA		Terrestrial only
137	Lower Elwha Riparian	360	GB	WA		Terrestrial only
42	Lower Englishman	2,979	GB	BC		Terrestrial only
266	Lower Kalama	5,524	LC	WA		Terrestrial only
355	Lower Mckenzie Riparian	3,877	WV	OR		Terrestrial only
33	Lower Qualicum	3,908	GB	BC	Marine	Terrestrial/Nearshore
248	Lower Skookumchuck	14,642	LC	WA		Terrestrial only
273	Lower Washougal	1,090	LC	WA		Terrestrial only
317	Luckiamute River Riparian	4,508	WV	OR		Terrestrial only
70	Lummi Flats	4,259	PT	WA	Estuarine	Terrestrial/Nearshore
196	Lych Cove-Union River-Hood Canal	620	PT	WA	Estuarine	Nearshore only
134	Lyre River	1,211	GB	WA		Terrestrial/Nearshore
329	Main Stem Willamette, Corvallis to Albany	2,876	WV	OR		Terrestrial only
341	Main Stem Willamette, Harrisburg to Corvallis	9,693	WV	OR		Terrestrial only
315	Main Stem Willamette, Luckiamute-Santiam confluence area	5,502	WV	OR		Terrestrial only
349	Main Stem Willamette, McKenzie confluence to Harrisburg	4,767	WV	OR		Terrestrial only
298	Main Stem Willamette, Mission Bottom area	11,898	WV	OR		Terrestrial only
7	Malaspina - Copeland	4,685	GB	BC	Estuarine	Terrestrial/Nearshore
66	Maple Mt.-Mt. Richards	3,334	GB	BC		Terrestrial only
69	Maple-Genoa Bay	1,228	GB	BC	Marine	Terrestrial/Nearshore
40	Maria	887	PT	BC		Terrestrial only
5	Marina Island	868	GB	BC		Terrestrial only
323	Maxfield Creerk BLM	666	WV	OR		Terrestrial only

Index to Priority Conservation Area maps 5.3a and 5.3b.

Unique ID	Conservation Area Name	Area in Hectares	Section	Jurisdiction	Marine Stratification	Integration
319	McCully Mtn BLM	192	WV	OR		Terrestrial only
327	McDonald Forest/Soap Creek Forest and Balds	4,976	WV	OR		Terrestrial only
217	McNeil Island	1,384	PT	WA		Terrestrial/Nearshore
245	Middle Chehalis	3,550	PT	WA		Terrestrial only
253	Middle Fork Newaukum	2,366	LC	WA		Terrestrial only
256	Mill Creek	1,158	LC	WA		Terrestrial only
308	Minto Island	1,008	WV	OR		Terrestrial only
47	Mission-Fraser	12,759	PT	BC		Terrestrial only
301	Missouri Ridge	2,994	WV	OR		Terrestrial only
9	Mittlenatch Island	37	GB	BC		Terrestrial/Nearshore
84	Moran	4,626	GB	WA	Estuarine	Terrestrial/Nearshore
302	Mount Angel	118	WV	OR		Terrestrial only
90	Mount Woolard	1,972	GB	WA		Terrestrial only
136	Mountain View Beach, Camano Island	217	PT	WA	Estuarine	Nearshore only
360	Mt Pisgah	1,118	WV	OR		Terrestrial only
67	Mt. Maxwell	2,610	GB	BC		Terrestrial/Nearshore
339	Muddy Creek/Finley	6,136	WV	OR		Terrestrial only
46	Nanaimo	2,713	GB	BC	Marine	Terrestrial/Nearshore
38	Nanoose-Parksville	7,896	GB	BC	Marine	Terrestrial/Nearshore
16	Nelson Island	12,531	GB	BC	Estuarine/Marine	Terrestrial/Nearshore
235	Nisqually	7,789	PT	WA	Estuarine	Terrestrial/Nearshore
72	Nooksack Delta	440	PT	WA		Terrestrial/Nearshore
62	Nooksack Riparian	1,097	PT	WA		Terrestrial only
201	North Bay	519	PT	WA	Estuarine	Nearshore only
250	North Fork Newaukum	4,630	LC	WA		Terrestrial only
324	North Santiam River Riparian	7,984	WV	OR		Terrestrial only
15	North Texada Island	2,518	GB	BC		Terrestrial only
73	North-South Pender Islands	293	GB	BC	Marine	Nearshore only
336	Oak Creek USFWS	148	WV	OR		Terrestrial only
330	Oak Creek/Freeway Lakes Park	55	WV	OR		Terrestrial only
125	Oak Harbor, Whidbey Island	79	GB	WA	Estuarine	Nearshore only
287	Oak Ridge/Moore's Valley	1,456	WV	OR		Terrestrial only
143	Old Fort Townsend	623	GB	WA	Estuarine	Terrestrial/Nearshore
237	Olympia Airport	379	PT	WA		Terrestrial only
346	Orchard Heights	923	WV	OR		Terrestrial only
359	Oregon Country Fair	439	WV	OR		Terrestrial only
264	Ostrander Forest Block	6,201	LC	WA		Terrestrial only
181	Ostrich Bay, Bremerton	272	PT	WA	Estuarine	Nearshore only
194	Otter Lake-Desire Lake	205	PT	WA		Terrestrial only
107	Padilla Bay	5,071	PT	WA	Estuarine/Marine	Terrestrial/Nearshore
18	Pender Harbor	1,753	GB	BC	Estuarine	Terrestrial/Nearshore
56	Pepin Creek	811	PT	BC		Terrestrial only
335	Peterson Butte	564	WV	OR		Terrestrial only
212	Pickering Passage	978	PT	WA	Estuarine	Nearshore only
151	Pilchuck Riparian	1,236	PT	WA		Terrestrial only
39	Pitt Macrosite	5,337	PT	BC		Terrestrial only
81	Point Disney, Waldron Island	408	GB	WA	Marine	Terrestrial/Nearshore
99	Point George, Shaw Island	192	GB	WA		Terrestrial/Nearshore
164	Point Julia Forest	878	PT	WA		Terrestrial only
54	Point Roberts-Boundary Bay	9,416	PT	BC	Estuarine/Marine	Terrestrial/Nearshore
200	Point Robinson, Maury Island	175	PT	WA		Terrestrial only
57	Porlier Pass	1,857	GB	BC	Marine	Terrestrial/Nearshore
155	Port Discovery Forest	990	GB	WA		Terrestrial only
166	Port Gamble	2,582	PT	WA	Estuarine	Terrestrial/Nearshore
161	Port Ludlow	128	PT	WA	Estuarine	Nearshore only
112	Portage Inlet	98	GB	BC	Marine	Nearshore only
79	Portage Island	363	PT	WA	Estuarine	Nearshore only
65	Prevost Island	1,676	GB	BC	Marine	Terrestrial/Nearshore
132	Protection Island	2,548	GB	WA	Marine	Terrestrial/Nearshore
293	Pudding River riparian	3,183	WV	OR		Terrestrial only
236	Puyallup River Riparian	471	PT	WA		Terrestrial only
2	Quadra Island	7,557	GB	BC	Estuarine/Marine	Terrestrial/Nearshore
31	Qualicum Bay	892	GB	BC	Marine	Nearshore only
32	Qualicum-Columbia Beaches	550	GB	BC	Marine	Nearshore only
199	Quartermaster Harbor	535	PT	WA	Estuarine	Nearshore only
170	Quilcene	7,837	PT	WA	Estuarine	Terrestrial/Nearshore
123	Race Rocks	124	GB	BC	Marine	Terrestrial/Nearshore
189	Raging River Forest	922	PT	WA		Terrestrial only
366	Rattlesnake Oaks	724	WV	OR		Terrestrial only
203	Redondo	164	PT	WA	Estuarine	Nearshore only
277	Reed Island	132	LC	WA		Terrestrial only
76	Reginald Hill	1,774	GB	BC		Terrestrial/Nearshore
182	Rich Passage, Bainbridge Island	415	PT	WA	Estuarine	Nearshore only
325	Richardson Gap/Crabtree Wetlands	4,936	WV	OR		Terrestrial only
350	Rock Hill	677	WV	OR		Terrestrial only
122	Rocky Point, BC	2,180	GB	BC		Terrestrial only
142	Rocky Point, WA	1,924	GB	WA		Terrestrial/Nearshore
240	Rocky Prairie - Beaver Creek	1,909	PT	WA		Terrestrial only
128	Rodena Beach, Whidbey Island	389	GB	WA	Estuarine	Nearshore only
278	Rooster Rock/Mirror Lake State Park	335	LC	OR		Terrestrial only
115	Royal Roads-Esquimalt	341	GB	BC		Terrestrial/Nearshore
53	Ryder Mt.	2,513	PT	BC		Terrestrial only
312	Salem Hills/Ankeny NWR	10,483	WV	OR		Terrestrial only
269	Salmon Creek Riparian	218	LC	WA		Terrestrial only
97	Samish	17,836	PT	WA	Estuarine	Terrestrial/Nearshore
68	Samuel-Saturna	391	GB	BC	Marine	Nearshore only
154	Sandy Point, Whidbey Island	109	PT	WA	Estuarine	Nearshore only
280	Sandy River	5,054	LC	OR		Terrestrial only
218	Satsop Watershed	33,431	PT	WA		Terrestrial only
71	Saturna Island	1,388	GB	BC		Terrestrial only
268	Sauvie Island	36,064	LC	OR		Terrestrial only
10	Savary Island	486	GB	BC		Terrestrial/Nearshore
162	Scatchet Head	1,339	PT	WA	Estuarine	Terrestrial/Nearshore

Index to Priority Conservation Area maps 5.3a and 5.3b.

Unique ID	Conservation Area Name	Area in Hectares	Section	Jurisdiction	Marine Stratification	Integration
244	Scatter Creek	9,417	PT	WA		Terrestrial only
320	Scio Oak Pine Savanna	760	WV	OR		Terrestrial only
104	Sea to Sea Greenbelt	18,543	GB	BC	Marine	Terrestrial/Nearshore
178	Seabeck Bay	448	PT	WA	Estuarine	Nearshore only
19	Sechelt Inlet	132	GB	BC	Marine	Nearshore only
59	Semiahmoo-Drayton Harbor	796	PT	WA	Estuarine	Nearshore only
190	Seola Beach, Burien	48	PT	WA	Estuarine	Nearshore only
232	Sequalitchew Marshes	395	PT	WA		Terrestrial only
146	Sequim Bay	661	GB	WA	Marine	Nearshore only
34	Seymour Narrows	4,431	PT	BC		Terrestrial only
204	Sherwood Forest	2,566	PT	WA		Terrestrial only
198	Shoofly-Hood Canal	149	PT	WA	Estuarine	Nearshore only
206	Shumocher Creek	2,990	PT	WA		Terrestrial only
85	Sidney Island	1,594	GB	BC	Marine	Terrestrial/Nearshore
153	Siebert and McDonald Creeks	7,257	GB	WA		Terrestrial only
307	Silver Creek	1,430	WV	OR		Terrestrial only
263	Silver Lake Watershed	9,004	LC	WA		Terrestrial only
119	Skagit	34,292	PT	WA	Estuarine	Terrestrial/Nearshore
21	Skaiakos Point	52	GB	BC	Marine	Nearshore only
205	Skokomish-Hood Canal	13,147	PT	WA	Estuarine	Terrestrial/Nearshore
13	Skookumchuck Narrows	209	GB	BC	Marine	Nearshore only
163	Skykomish Riparian	3,307	PT	WA		Terrestrial only
126	Smith Island	3,879	GB	WA	Marine	Nearshore only
177	Snoqualmie Foothill Forest	26,131	PT	WA		Terrestrial only
183	Snoqualmie Riparian	1,319	PT	WA		Terrestrial only
159	Snow and Salmon Creeks	10,807	PT	WA		Terrestrial only
226	Solo Point - Farrell Marsh	921	PT	WA		Terrestrial only
254	South Fork Newaukum	1,909	LC	WA		Terrestrial only
297	South Fork Yamhill River	4,949	WV	OR		Terrestrial only
83	South Lummi-Lummi Mountain	1,143	GB	WA		Terrestrial only
228	South Prairie Riparian	208	PT	WA		Terrestrial only
29	South Sunshine	11,340	GB	BC		Terrestrial only
147	South Whidbey Forest	932	GB	WA		Terrestrial only
87	Spieden-Sentinel-Johns Islands	611	GB	WA	Marine	Nearshore only
169	Squamish Harbor	796	PT	WA	Estuarine	Nearshore only
221	Squaxin-Hope Islands	1,233	PT	WA	Estuarine	Terrestrial/Nearshore
255	Stearns Creek	2,354	LC	WA		Terrestrial only
129	Stillaguamish River-Port Susan	17,427	PT	WA	Estuarine	Terrestrial/Nearshore
313	Stout Mountain	669	WV	OR		Terrestrial only
133	Striped Peak	3,113	GB	WA	Marine	Terrestrial/Nearshore
82	Stuart Island	679	GB	WA	Marine	Terrestrial/Nearshore
74	Sucia-Matia-Patos Islands	2,000	GB	WA	Estuarine	Terrestrial/Nearshore
160	Sultan Foothill Forest	16,121	PT	WA		Terrestrial only
52	Sumas Mountain	2,474	PT	BC		Terrestrial only
353	Swamp Creek Wetlands	597	WV	OR		Terrestrial only
242	Tanwax Creek	3,025	PT	WA		Terrestrial only
168	Tarboo-Dabob Bay	5,685	PT	WA	Estuarine	Terrestrial/Nearshore
294	The Butte RNA	51	WV	OR		Terrestrial only
210	The Narrows	759	PT	WA	Estuarine	Terrestrial/Nearshore
111	Thetis-Frances	1,174	GB	BC		Terrestrial only
60	Thetis-Kuper	6,088	GB	BC	Marine	Terrestrial/Nearshore
28	Thormanby Island	1,539	GB	BC	Estuarine	Terrestrial/Nearshore
165	Thorndyke	8,989	PT	WA	Estuarine	Terrestrial/Nearshore
98	Three Corner Lake	397	GB	WA		Terrestrial only
295	Timber Grove	3,882	LC	OR		Terrestrial only
173	Toandos Peninsula	2,849	PT	WA	Estuarine	Terrestrial/Nearshore
247	Toboton and Lackamus Creeks	917	PT	WA		Terrestrial only
230	Totten-Skookum Inlets	883	PT	WA	Estuarine	Nearshore only
262	Toutle Forest Corridor	14,142	LC	WA		Terrestrial only
117	Trial Island	18	GB	BC		Terrestrial/Nearshore
283	Tryon Creek Nature Park	374	LC	OR		Terrestrial only
284	Tualatin National Wildlife Refuge	3,910	LC	OR		Terrestrial only
279	Tualitan Hills Park	400	LC	OR		Terrestrial only
77	Tuam-Bruce	3,142	GB	BC		Terrestrial/Nearshore
140	Tulalip	2,290	PT	WA		Terrestrial only
88	Turtleback-Deer Harbor	1,485	GB	WA	Marine	Terrestrial/Nearshore
22	Tuwanek Point	168	GB	BC	Marine	Nearshore only
6	Twin Islands	285	GB	BC		Terrestrial only
43	UBC Research Forest/Blue	4,805	PT	BC		Terrestrial only
371	Upper Siuslaw Site	29,815	WV	OR		Terrestrial only
127	Utsalady, Camano Island	205	GB	WA	Estuarine	Nearshore only
251	Van Ornum Creek Forest	833	LC	WA		Terrestrial only
78	Waldron-Skipjack Islands	181	GB	WA	Marine	Nearshore only
281	Wapato Marsh	4,314	LC	OR		Terrestrial only
338	Ward Butte	151	WV	OR		Terrestrial only
340	Washburn Butte	1,357	WV	OR		Terrestrial only
276	Washougal Oaks - Steigerwald	1,347	LC	WA		Terrestrial only
93	Wasp-Yellow Islands	19	GB	WA		Terrestrial/Nearshore
337	Waterloo Rocks	450	WV	OR		Terrestrial only
238	Weir Prairie and Forest	10,345	PT	WA		Terrestrial only
368	Weiss Rd BLM Oaks	201	WV	OR		Terrestrial only
358	West Eugene/Spencer Creek	14,322	WV	OR		Terrestrial only
114	West San Juan-Southern Lopez Islands	7,535	GB	WA	Marine	Terrestrial/Nearshore
94	West Sound, Orcas- Broken Point, Shaw Island	255	GB	WA	Marine	Nearshore only
185	Western Kitsap Peninsula	36,779	PT	WA	Estuarine	Terrestrial/Nearshore
216	White River Riparian	1,859	PT	WA		Terrestrial only
288	Willamette Narrows	1,070	LC	OR		Terrestrial only
300	Willamina Oaks 1	1,871	WV	OR		Terrestrial only
303	Willamina Oaks 2	988	WV	OR		Terrestrial only
37	Winchelsea Island	1,193	GB	BC	Marine	Terrestrial/Nearshore
130	Woodland Beach, Camano Island	147	GB	WA	Estuarine	Nearshore only
296	Yamhill Oaks	5,648	WV	OR		Terrestrial only
96	Young Hill	669	GB	WA		Terrestrial only



Georgia Basin and Puget Trough

Map 5.3a: Final Integrated Portfolio

1 inch equals 20 miles

0 5 10 15 20 Miles

0 10 20 30 40 Kilometers

Sources: TNC, WDFW, WDFW, USGS

March 2004

The Nature Conservancy — SAVING THE LAST GREAT PLACES ON EARTH

Nature Conservancy Canada — Conservation de la Nature Canada

Washington Department of FISH and WILDLIFE

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Unique ID	Conservation Area Name	Area in Hectares	Section	Jurisdiction	Marine Stratification	Integration
63	Active Pass	3,180	GB	BC	Marine	Terrestrial/Nearshore
318	Airlie Oaks	1,464	WV	OR		Terrestrial only
352	Alderwood Wayside	65	WV	OR		Terrestrial only
299	Amity Oaks	949	WV	OR		Terrestrial only
24	Anderson Beach	105	GB	BC	Estuarine	Nearshore only
246	Bald Hill	3,404	PT	WA		Terrestrial only
174	Bangor	1,616	PT	WA	Estuarine	Terrestrial/Nearshore
272	Banks Swamp	231	LC	OR		Terrestrial only
306	Basket Butte	5,618	WV	OR		Terrestrial only
351	Bear Creek Oaks	507	WV	OR		Terrestrial only
348	Bear Creek Wetlands	556	WV	OR		Terrestrial only
208	Black Diamond Lake	749	PT	WA		Terrestrial only
241	Black River - Mima Prairie	7,049	PT	WA		Terrestrial only
49	Blackjack-Harewood	8,996	GB	BC		Terrestrial only
187	Blake Island	183	PT	WA		Terrestrial/Nearshore
100	Blakely Island	1,684	GB	WA		Terrestrial only
44	Blaney Bog	764	PT	BC		Terrestrial only
30	Bowyer Island	165	GB	BC	Estuarine	Nearshore only
222	Brisco Point, South Hartstene Island	446	PT	WA	Estuarine	Nearshore only
25	Buccaneer Bay	1,519	GB	BC	Estuarine	Terrestrial/Nearshore
223	Buckley Hills	4,426	PT	WA		Terrestrial only
229	Budd Inlet	254	PT	WA	Estuarine	Nearshore only
304	Buell	160	WV	OR		Terrestrial only
51	Burn's Bog	3,324	PT	BC		Terrestrial only
344	Calapooia Oak Savanna	386	WV	OR		Terrestrial only
144	Camano Head	44	PT	WA		Terrestrial only
369	Camas Swale BLM RNA	81	WV	OR		Terrestrial only
363	Camas Swale Oaks	1,863	WV	OR		Terrestrial only
364	Camas Swale Wetlands	878	WV	OR		Terrestrial only
285	Camassia	18	LC	OR		Terrestrial only
356	Camp Creek Ridge	578	WV	OR		Terrestrial only
180	Camp Wesley Harris	843	PT	WA		Terrestrial only
215	Campbell Creek	639	PT	WA		Terrestrial only
103	Capsante, Fidalgo Island	67	GB	WA	Estuarine	Nearshore only
231	Carbon River Plateau	2,987	PT	WA		Terrestrial only
292	Cedar Creek	3,271	LC	OR		Terrestrial only
197	Cedar River	4,785	PT	WA		Terrestrial only
20	Central Texada Island	12,589	GB	BC		Terrestrial only
291	Champoeg State Park	114	WV	OR		Terrestrial only
61	Chemainus	1,683	GB	BC	Marine	Terrestrial/Nearshore
64	Cherry Point	3,248	PT	WA	Estuarine	Nearshore only
158	Chimacum Forest	2,538	PT	WA		Terrestrial only
86	Chuckanut Mountain	3,694	PT	WA		Terrestrial only
286	Clackamas	8,330	LC	OR		Terrestrial only
290	Clear Creek	7,148	LC	OR		Terrestrial only
227	Cloquallum	3,618	PT	WA		Terrestrial only
249	Coal Creek Forest	942	LC	WA		Terrestrial only
365	Coast Fork/Middle Fork Willamette Riparian	5,437	WV	OR		Terrestrial only
354	Coburg Ridge	2,018	WV	OR		Terrestrial only
343	Cogswell Foster	36	WV	OR		Terrestrial only
23	Comox Macrosite	25,581	GB	BC	Marine	Terrestrial/Nearshore
12	Conawaga Beach	743	GB	BC	Marine	Nearshore only
282	Cooper Mountain	434	LC	OR		Terrestrial only
1	Cortes Island	12,130	GB	BC	Estuarine	Terrestrial/Nearshore
333	Corvallis Watershed	3,948	WV	OR		Terrestrial only
331	Corvallis-Philomath Oaks	4,652	WV	OR		Terrestrial only
188	Cougar Mountain	1,604	PT	WA		Terrestrial only
193	Coulter Creek	3,848	PT	WA		Terrestrial only
202	Covington Creek	2,587	PT	WA		Terrestrial only
75	Cowichan	13,749	GB	BC	Marine	Terrestrial/Nearshore
261	Cowlitz Forest Corridor	19,498	LC	WA		Terrestrial only
258	Cowlitz Riparian	1,386	LC	WA		Terrestrial only
211	Cranberry Creek	2,405	PT	WA		Terrestrial only
342	Crawfordsville Oak-Pine Savanna	2,349	WV	OR		Terrestrial only
124	Crescent Harbot Forest	234	GB	WA		Terrestrial only
95	Cypress-Sinclair Islands	3,120	GB	WA	Estuarine	Terrestrial/Nearshore
219	Dayton Creek	2,910	PT	WA		Terrestrial only
118	Deception Pass	3,913	GB	WA	Estuarine/Marine	Terrestrial/Nearshore
207	Deer Creek	3,574	PT	WA		Terrestrial only
243	Deschutes Riparian	3,226	PT	WA		Terrestrial only
3	Desolation Sound	10,700	GB	BC	Estuarine	Terrestrial/Nearshore
225	Dickenson Point	236	PT	WA	Estuarine	Nearshore only
252	Dillenbaugh	1,127	LC	WA		Terrestrial only
152	Discovery Bay	902	GB	WA	Marine	Terrestrial/Nearshore
116	Discovery Island	856	GB	BC	Marine	Terrestrial/Nearshore
4	Discovery Passage	8,559	GB	BC	Marine	Terrestrial/Nearshore
220	Drayton Passage-Filucy Bay	373	PT	WA	Estuarine	Nearshore only
260	Drews Prairie	109	LC	WA		Terrestrial only
121	Dugualla Bay	774	GB	WA	Estuarine	Terrestrial/Nearshore
289	Dundee Oaks	722	WV	OR		Terrestrial only
135	Dungeness	4,734	GB	WA	Marine	Terrestrial/Nearshore
321	Dunn Forest	4,273	WV	OR		Terrestrial only
179	Dyes Inlet-Silverdale	131	PT	WA	Estuarine	Nearshore only
186	East Fork Issaquah Creek	2,109	PT	WA		Terrestrial only
267	East Fork Lewis Riparian	888	LC	WA		Terrestrial only
195	East Side Vashon	125	PT	WA	Estuarine	Nearshore only
120	East Sooke	2,578	GB	BC		Terrestrial only
131	Ebey's Landing	1,028	GB	WA		Terrestrial/Nearshore
171	Edmonds Point	84	PT	WA	Estuarine	Nearshore only
322	EE Wilson	1,010	WV	OR		Terrestrial only
213	Eells Hill	6,312	PT	WA		Terrestrial only
233	Eld Inlet	522	PT	WA	Estuarine	Nearshore only
372	Elk Creek	1,472	WV	OR		Terrestrial only

Index to Priority Conservation Area maps 5.3a and 5.3b.

Unique ID	Conservation Area Name	Area in Hectares	Section	Jurisdiction	Marine Stratification	Integration
305	Eola Hills	9,293	WV	OR		Terrestrial only
357	Fern Ridge Reservoir	3,713	WV	OR		Terrestrial only
109	Fidalgo Bay	375	GB	WA	Estuarine/Marine	Nearshore only
106	Fidalgo Head, Burrows Island	346	GB	WA		Terrestrial/Nearshore
110	Fidalgo Island	1,745	GB	WA		Terrestrial only
55	Fishtrap Creek	299	PT	BC		Terrestrial only
89	Flattop Island	43	GB	WA	Marine	Nearshore only
270	Forest Park-Coast Range	30,838	LC	OR		Terrestrial only
141	Fort Flagler	521	GB	WA	Estuarine	Terrestrial/Nearshore
234	Fort Lewis - McChord	24,382	PT	WA		Terrestrial only
367	Fox Hollow BLM RNA	183	WV	OR		Terrestrial only
50	Fraser Delta	28,619	PT	BC	Estuarine/Marine	Terrestrial/Nearshore
101	Friday Harbor, San Juan Island	178	GB	WA		Terrestrial/Nearshore
45	Gabriola Island	1,362	GB	BC	Marine	Terrestrial/Nearshore
48	Gabriola Pass	1,873	GB	BC	Marine	Terrestrial/Nearshore
275	Gales Creek	28	LC	OR		Terrestrial only
148	Gardiner	197	GB	WA	Marine	Nearshore only
157	Gedney Island	212	PT	WA	Estuarine	Nearshore only
370	Gettings Creek	334	WV	OR		Terrestrial only
332	Golden Valley	2,983	WV	OR		Terrestrial only
274	Government Island	1,214	LC	OR		Terrestrial only
139	Grays Marsh	324	GB	WA		Terrestrial only
209	Green River	3,936	PT	WA		Terrestrial only
310	HABECK Oaks	7,139	WV	OR		Terrestrial only
36	Hamilton Marsh	553	GB	BC		Terrestrial only
184	Hamma Hamma Delta	21	PT	WA		Terrestrial only
41	Harrison	646	PT	BC		Terrestrial only
11	Harwood Island	299	GB	BC	Estuarine	Nearshore only
102	Hat and Saddlebag Islands	54	GB	WA	Estuarine	Terrestrial/Nearshore
92	Henry Island	620	GB	WA	Marine	Terrestrial/Nearshore
8	Herando Island	999	GB	BC		Terrestrial/Nearshore
309	Hidden Oaks	463	LC	OR		Terrestrial only
347	High Pass	4,083	WV	OR		Terrestrial only
145	Holmes Harbor, Whidbey Island	283	PT	WA	Estuarine	Nearshore only
239	Horn Creek	1,004	PT	WA		Terrestrial only
35	Horseshoe Bay	178	PT	BC	Estuarine	Nearshore only
17	Howe Estuary	362	GB	BC	Estuarine/Marine	Nearshore only
113	Hunter and Mud Bays, Lopez Island	192	GB	WA	Marine	Nearshore only
345	Indian Head/Horse Rock Ridge	12,457	WV	OR		Terrestrial only
149	Indian Island	1,087	GB	WA	Estuarine	Terrestrial/Nearshore
172	Indianola Forest	640	PT	WA		Terrestrial only
192	Issaquah Creek Riparian	132	PT	WA		Terrestrial only
175	Jackson Cove-Dabob Bay	323	PT	WA	Estuarine	Nearshore only
328	Jackson Fraiser Wetlands	380	WV	OR		Terrestrial only
105	James Island	47	GB	WA		Terrestrial only
361	Jasper Prairie	299	WV	OR		Terrestrial only
27	Jedediah Island	690	GB	BC	Estuarine	Terrestrial/Nearshore
14	Jervis Inlet	3,353	GB	BC	Estuarine	Terrestrial/Nearshore
156	Jimmycomelately	1,186	GB	WA		Terrestrial only
214	Johns Creek - McEwen Prairie	1,709	PT	WA		Terrestrial only
314	Johnson Hill	298	WV	OR		Terrestrial only
224	Johnson Point	205	PT	WA	Estuarine	Nearshore only
91	Jones Island	78	GB	WA		Terrestrial only
150	Kilisut Harbor	246	GB	WA	Estuarine	Nearshore only
316	Kingston Prairie	398	WV	OR		Terrestrial only
271	Lacamas Meadows	1,021	LC	WA		Terrestrial only
259	Lacamas Riparian	349	LC	WA		Terrestrial only
58	Ladysmith-Yellow Point	4,947	GB	BC	Marine	Terrestrial/Nearshore
138	Lake Hancock	36	GB	WA		Terrestrial only
80	Lake Whatcom	6,931	PT	WA		Terrestrial only
362	Lane Community College Basin	546	WV	OR		Terrestrial only
26	Lasqueti Island	6,997	GB	BC	Estuarine	Terrestrial/Nearshore
257	Lewis and Clark State Park	661	LC	WA		Terrestrial only
176	Liberty Bay-Agate Pass-Port Orchard	1,229	PT	WA	Estuarine	Nearshore only
191	Lilliwaup	8,648	PT	WA		Terrestrial only
311	Little Sink RNA	21	WV	OR		Terrestrial only
326	Logsden Ridge	454	WV	OR		Terrestrial only
108	Lopez Hill	454	GB	WA		Terrestrial only
167	Lord Hill	1,699	PT	WA		Terrestrial only
334	Lower Calapooia River Riparian	5,915	WV	OR		Terrestrial only
265	Lower Coweeman	1,682	LC	WA		Terrestrial only
137	Lower Elwha Riparian	360	GB	WA		Terrestrial only
42	Lower Englishman	2,979	GB	BC		Terrestrial only
266	Lower Kalama	5,524	LC	WA		Terrestrial only
355	Lower Mckenzie Riparian	3,877	WV	OR		Terrestrial only
33	Lower Qualicum	3,908	GB	BC	Marine	Terrestrial/Nearshore
248	Lower Skookumchuck	14,642	LC	WA		Terrestrial only
273	Lower Washougal	1,090	LC	WA		Terrestrial only
317	Luckiamute River Riparian	4,508	WV	OR		Terrestrial only
70	Lummi Flats	4,259	PT	WA	Estuarine	Terrestrial/Nearshore
196	Lych Cove-Union River-Hood Canal	620	PT	WA	Estuarine	Nearshore only
134	Lyre River	1,211	GB	WA		Terrestrial/Nearshore
329	Main Stem Willamette, Corvallis to Albany	2,876	WV	OR		Terrestrial only
341	Main Stem Willamette, Harrisburg to Corvallis	9,693	WV	OR		Terrestrial only
315	Main Stem Willamette, Luckiamute-Santiam confluence area	5,502	WV	OR		Terrestrial only
349	Main Stem Willamette, McKenzie confluence to Harrisburg	4,767	WV	OR		Terrestrial only
298	Main Stem Willamette, Mission Bottom area	11,898	WV	OR		Terrestrial only
7	Malaspina - Copeland	4,685	GB	BC	Estuarine	Terrestrial/Nearshore
66	Maple Mt.-Mt. Richards	3,334	GB	BC		Terrestrial only
69	Maple-Genoa Bay	1,228	GB	BC	Marine	Terrestrial/Nearshore
40	Maria	887	PT	BC		Terrestrial only
5	Marina Island	868	GB	BC		Terrestrial only
323	Maxfield Creerk BLM	666	WV	OR		Terrestrial only

Index to Priority Conservation Area maps 5.3a and 5.3b.

Unique ID	Conservation Area Name	Area in Hectares	Section	Jurisdiction	Marine Stratification	Integration
319	McCully Mtn BLM	192	WV	OR		Terrestrial only
327	McDonald Forest/Soap Creek Forest and Balds	4,976	WV	OR		Terrestrial only
217	McNeil Island	1,384	PT	WA		Terrestrial/Nearshore
245	Middle Chehalis	3,550	PT	WA		Terrestrial only
253	Middle Fork Newaukum	2,366	LC	WA		Terrestrial only
256	Mill Creek	1,158	LC	WA		Terrestrial only
308	Minto Island	1,008	WV	OR		Terrestrial only
47	Mission-Fraser	12,759	PT	BC		Terrestrial only
301	Missouri Ridge	2,994	WV	OR		Terrestrial only
9	Mittlenatch Island	37	GB	BC		Terrestrial/Nearshore
84	Moran	4,626	GB	WA	Estuarine	Terrestrial/Nearshore
302	Mount Angel	118	WV	OR		Terrestrial only
90	Mount Woolard	1,972	GB	WA		Terrestrial only
136	Mountain View Beach, Camano Island	217	PT	WA	Estuarine	Nearshore only
360	Mt Pisgah	1,118	WV	OR		Terrestrial only
67	Mt. Maxwell	2,610	GB	BC		Terrestrial/Nearshore
339	Muddy Creek/Finley	6,136	WV	OR		Terrestrial only
46	Nanaimo	2,713	GB	BC	Marine	Terrestrial/Nearshore
38	Nanoose-Parksville	7,896	GB	BC	Marine	Terrestrial/Nearshore
16	Nelson Island	12,531	GB	BC	Estuarine/Marine	Terrestrial/Nearshore
235	Nisqually	7,789	PT	WA	Estuarine	Terrestrial/Nearshore
72	Nooksack Delta	440	PT	WA		Terrestrial/Nearshore
62	Nooksack Riparian	1,097	PT	WA		Terrestrial only
201	North Bay	519	PT	WA	Estuarine	Nearshore only
250	North Fork Newaukum	4,630	LC	WA		Terrestrial only
324	North Santiam River Riparian	7,984	WV	OR		Terrestrial only
15	North Texada Island	2,518	GB	BC		Terrestrial only
73	North-South Pender Islands	293	GB	BC	Marine	Nearshore only
336	Oak Creek USFWS	148	WV	OR		Terrestrial only
330	Oak Creek/Freeway Lakes Park	55	WV	OR		Terrestrial only
125	Oak Harbor, Whidbey Island	79	GB	WA	Estuarine	Nearshore only
287	Oak Ridge/Moore's Valley	1,456	WV	OR		Terrestrial only
143	Old Fort Townsend	623	GB	WA	Estuarine	Terrestrial/Nearshore
237	Olympia Airport	379	PT	WA		Terrestrial only
346	Orchard Heights	923	WV	OR		Terrestrial only
359	Oregon Country Fair	439	WV	OR		Terrestrial only
264	Ostrander Forest Block	6,201	LC	WA		Terrestrial only
181	Ostrich Bay, Bremerton	272	PT	WA	Estuarine	Nearshore only
194	Otter Lake-Desire Lake	205	PT	WA		Terrestrial only
107	Padilla Bay	5,071	PT	WA	Estuarine/Marine	Terrestrial/Nearshore
18	Pender Harbor	1,753	GB	BC	Estuarine	Terrestrial/Nearshore
56	Pepin Creek	811	PT	BC		Terrestrial only
335	Peterson Butte	564	WV	OR		Terrestrial only
212	Pickering Passage	978	PT	WA	Estuarine	Nearshore only
151	Pilchuck Riparian	1,236	PT	WA		Terrestrial only
39	Pitt Macrosite	5,337	PT	BC		Terrestrial only
81	Point Disney, Waldron Island	408	GB	WA	Marine	Terrestrial/Nearshore
99	Point George, Shaw Island	192	GB	WA		Terrestrial/Nearshore
164	Point Julia Forest	878	PT	WA		Terrestrial only
54	Point Roberts-Boundary Bay	9,416	PT	BC	Estuarine/Marine	Terrestrial/Nearshore
200	Point Robinson, Maury Island	175	PT	WA		Terrestrial only
57	Porlier Pass	1,857	GB	BC	Marine	Terrestrial/Nearshore
155	Port Discovery Forest	990	GB	WA		Terrestrial only
166	Port Gamble	2,582	PT	WA	Estuarine	Terrestrial/Nearshore
161	Port Ludlow	128	PT	WA	Estuarine	Nearshore only
112	Portage Inlet	98	GB	BC	Marine	Nearshore only
79	Portage Island	363	PT	WA	Estuarine	Nearshore only
65	Prevost Island	1,676	GB	BC	Marine	Terrestrial/Nearshore
132	Protection Island	2,548	GB	WA	Marine	Terrestrial/Nearshore
293	Pudding River riparian	3,183	WV	OR		Terrestrial only
236	Puyallup River Riparian	471	PT	WA		Terrestrial only
2	Quadra Island	7,557	GB	BC	Estuarine/Marine	Terrestrial/Nearshore
31	Qualicum Bay	892	GB	BC	Marine	Nearshore only
32	Qualicum-Columbia Beaches	550	GB	BC	Marine	Nearshore only
199	Quartermaster Harbor	535	PT	WA	Estuarine	Nearshore only
170	Quilcene	7,837	PT	WA	Estuarine	Terrestrial/Nearshore
123	Race Rocks	124	GB	BC	Marine	Terrestrial/Nearshore
189	Raging River Forest	922	PT	WA		Terrestrial only
366	Rattlesnake Oaks	724	WV	OR		Terrestrial only
203	Redondo	164	PT	WA	Estuarine	Nearshore only
277	Reed Island	132	LC	WA		Terrestrial only
76	Reginald Hill	1,774	GB	BC		Terrestrial/Nearshore
182	Rich Passage, Bainbridge Island	415	PT	WA	Estuarine	Nearshore only
325	Richardson Gap/Crabtree Wetlands	4,936	WV	OR		Terrestrial only
350	Rock Hill	677	WV	OR		Terrestrial only
122	Rocky Point, BC	2,180	GB	BC		Terrestrial only
142	Rocky Point, WA	1,924	GB	WA		Terrestrial/Nearshore
240	Rocky Prairie - Beaver Creek	1,909	PT	WA		Terrestrial only
128	Rodena Beach, Whidbey Island	389	GB	WA	Estuarine	Nearshore only
278	Rooster Rock/Mirror Lake State Park	335	LC	OR		Terrestrial only
115	Royal Roads-Esquimalt	341	GB	BC		Terrestrial/Nearshore
53	Ryder Mt.	2,513	PT	BC		Terrestrial only
312	Salem Hills/Ankeny NWR	10,483	WV	OR		Terrestrial only
269	Salmon Creek Riparian	218	LC	WA		Terrestrial only
97	Samish	17,836	PT	WA	Estuarine	Terrestrial/Nearshore
68	Samuel-Saturna	391	GB	BC	Marine	Nearshore only
154	Sandy Point, Whidbey Island	109	PT	WA	Estuarine	Nearshore only
280	Sandy River	5,054	LC	OR		Terrestrial only
218	Satsop Watershed	33,431	PT	WA		Terrestrial only
71	Saturna Island	1,388	GB	BC		Terrestrial only
268	Sauvie Island	36,064	LC	OR		Terrestrial only
10	Savary Island	486	GB	BC		Terrestrial/Nearshore
162	Scatchet Head	1,339	PT	WA	Estuarine	Terrestrial/Nearshore

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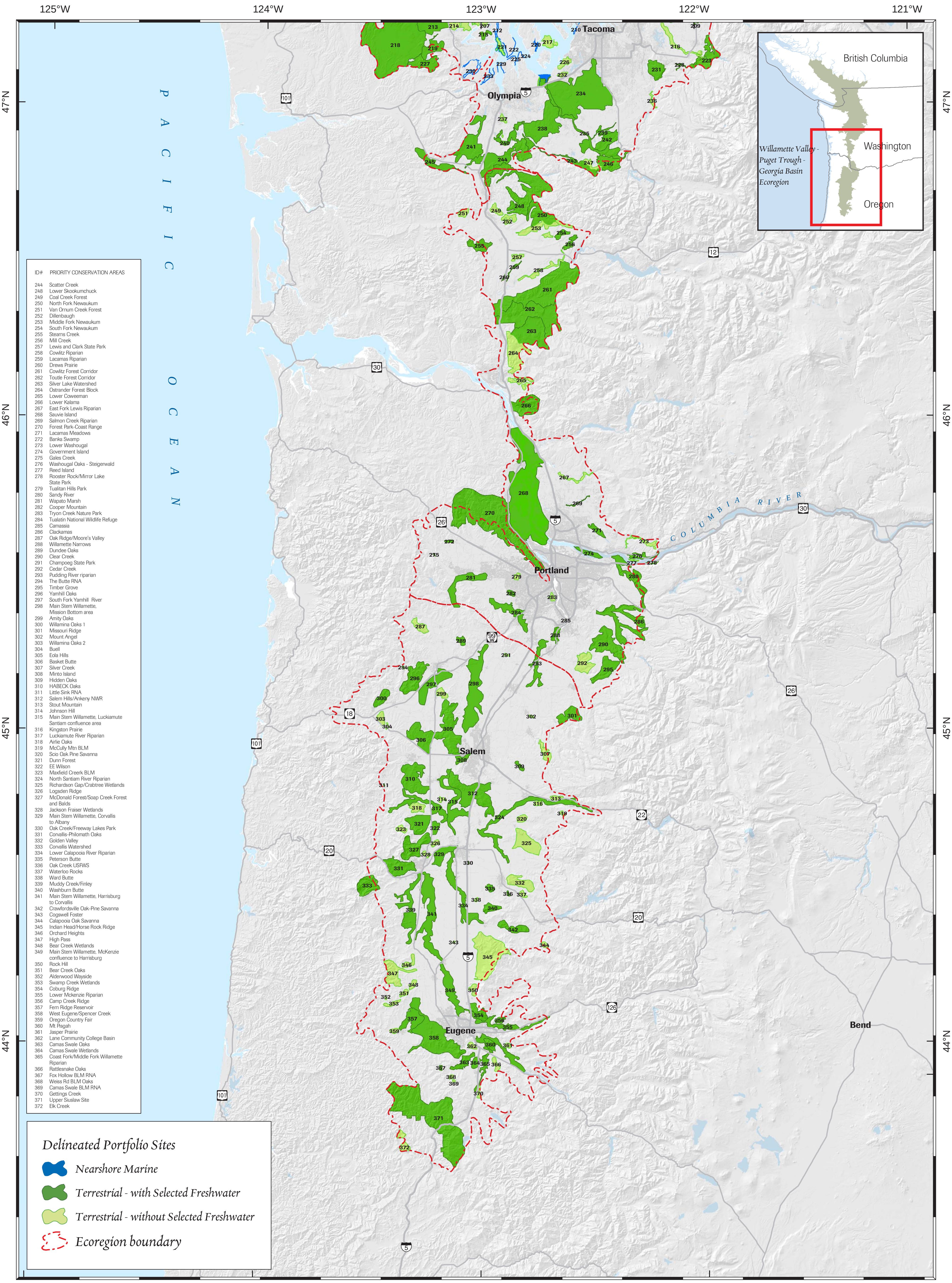
Unique ID	Conservation Area Name	Area in Hectares	Section	Jurisdiction	Marine Stratification	Integration
244	Scatter Creek	9,417	PT	WA		Terrestrial only
320	Scio Oak Pine Savanna	760	WV	OR		Terrestrial only
104	Sea to Sea Greenbelt	18,543	GB	BC	Marine	Terrestrial/Nearshore
178	Seabeck Bay	448	PT	WA	Estuarine	Nearshore only
19	Sechelt Inlet	132	GB	BC	Marine	Nearshore only
59	Semiahmoo-Drayton Harbor	796	PT	WA	Estuarine	Nearshore only
190	Seola Beach, Burien	48	PT	WA	Estuarine	Nearshore only
232	Sequalitchew Marshes	395	PT	WA		Terrestrial only
146	Sequim Bay	661	GB	WA	Marine	Nearshore only
34	Seymour Narrows	4,431	PT	BC		Terrestrial only
204	Sherwood Forest	2,566	PT	WA		Terrestrial only
198	Shoofly-Hood Canal	149	PT	WA	Estuarine	Nearshore only
206	Shumocher Creek	2,990	PT	WA		Terrestrial only
85	Sidney Island	1,594	GB	BC	Marine	Terrestrial/Nearshore
153	Siebert and McDonald Creeks	7,257	GB	WA		Terrestrial only
307	Silver Creek	1,430	WV	OR		Terrestrial only
263	Silver Lake Watershed	9,004	LC	WA		Terrestrial only
119	Skagit	34,292	PT	WA	Estuarine	Terrestrial/Nearshore
21	Skaiakos Point	52	GB	BC	Marine	Nearshore only
205	Skokomish-Hood Canal	13,147	PT	WA	Estuarine	Terrestrial/Nearshore
13	Skookumchuck Narrows	209	GB	BC	Marine	Nearshore only
163	Skykomish Riparian	3,307	PT	WA		Terrestrial only
126	Smith Island	3,879	GB	WA	Marine	Nearshore only
177	Snoqualmie Foothill Forest	26,131	PT	WA		Terrestrial only
183	Snoqualmie Riparian	1,319	PT	WA		Terrestrial only
159	Snow and Salmon Creeks	10,807	PT	WA		Terrestrial only
226	Solo Point - Farrell Marsh	921	PT	WA		Terrestrial only
254	South Fork Newaukum	1,909	LC	WA		Terrestrial only
297	South Fork Yamhill River	4,949	WV	OR		Terrestrial only
83	South Lummi-Lummi Mountain	1,143	GB	WA		Terrestrial only
228	South Prairie Riparian	208	PT	WA		Terrestrial only
29	South Sunshine	11,340	GB	BC		Terrestrial only
147	South Whidbey Forest	932	GB	WA		Terrestrial only
87	Spieden-Sentinel-Johns Islands	611	GB	WA	Marine	Nearshore only
169	Squamish Harbor	796	PT	WA	Estuarine	Nearshore only
221	Squaxin-Hope Islands	1,233	PT	WA	Estuarine	Terrestrial/Nearshore
255	Stearns Creek	2,354	LC	WA		Terrestrial only
129	Stillaguamish River-Port Susan	17,427	PT	WA	Estuarine	Terrestrial/Nearshore
313	Stout Mountain	669	WV	OR		Terrestrial only
133	Striped Peak	3,113	GB	WA	Marine	Terrestrial/Nearshore
82	Stuart Island	679	GB	WA	Marine	Terrestrial/Nearshore
74	Sucia-Matia-Patos Islands	2,000	GB	WA	Estuarine	Terrestrial/Nearshore
160	Sultan Foothill Forest	16,121	PT	WA		Terrestrial only
52	Sumas Mountain	2,474	PT	BC		Terrestrial only
353	Swamp Creek Wetlands	597	WV	OR		Terrestrial only
242	Tanwax Creek	3,025	PT	WA		Terrestrial only
168	Tarboo-Dabob Bay	5,685	PT	WA	Estuarine	Terrestrial/Nearshore
294	The Butte RNA	51	WV	OR		Terrestrial only
210	The Narrows	759	PT	WA	Estuarine	Terrestrial/Nearshore
111	Thetis-Frances	1,174	GB	BC		Terrestrial only
60	Thetis-Kuper	6,088	GB	BC	Marine	Terrestrial/Nearshore
28	Thormanby Island	1,539	GB	BC	Estuarine	Terrestrial/Nearshore
165	Thorndyke	8,989	PT	WA	Estuarine	Terrestrial/Nearshore
98	Three Corner Lake	397	GB	WA		Terrestrial only
295	Timber Grove	3,882	LC	OR		Terrestrial only
173	Toandos Peninsula	2,849	PT	WA	Estuarine	Terrestrial/Nearshore
247	Toboton and Lackamus Creeks	917	PT	WA		Terrestrial only
230	Totten-Skookum Inlets	883	PT	WA	Estuarine	Nearshore only
262	Toutle Forest Corridor	14,142	LC	WA		Terrestrial only
117	Trial Island	18	GB	BC		Terrestrial/Nearshore
283	Tryon Creek Nature Park	374	LC	OR		Terrestrial only
284	Tualatin National Wildlife Refuge	3,910	LC	OR		Terrestrial only
279	Tualitan Hills Park	400	LC	OR		Terrestrial only
77	Tuam-Bruce	3,142	GB	BC		Terrestrial/Nearshore
140	Tulalip	2,290	PT	WA		Terrestrial only
88	Turtleback-Deer Harbor	1,485	GB	WA	Marine	Terrestrial/Nearshore
22	Tuwanek Point	168	GB	BC	Marine	Nearshore only
6	Twin Islands	285	GB	BC		Terrestrial only
43	UBC Research Forest/Blue	4,805	PT	BC		Terrestrial only
371	Upper Siuslaw Site	29,815	WV	OR		Terrestrial only
127	Utsalady, Camano Island	205	GB	WA	Estuarine	Nearshore only
251	Van Ornum Creek Forest	833	LC	WA		Terrestrial only
78	Waldron-Skipjack Islands	181	GB	WA	Marine	Nearshore only
281	Wapato Marsh	4,314	LC	OR		Terrestrial only
338	Ward Butte	151	WV	OR		Terrestrial only
340	Washburn Butte	1,357	WV	OR		Terrestrial only
276	Washougal Oaks - Steigerwald	1,347	LC	WA		Terrestrial only
93	Wasp-Yellow Islands	19	GB	WA		Terrestrial/Nearshore
337	Waterloo Rocks	450	WV	OR		Terrestrial only
238	Weir Prairie and Forest	10,345	PT	WA		Terrestrial only
368	Weiss Rd BLM Oaks	201	WV	OR		Terrestrial only
358	West Eugene/Spencer Creek	14,322	WV	OR		Terrestrial only
114	West San Juan-Southern Lopez Islands	7,535	GB	WA	Marine	Terrestrial/Nearshore
94	West Sound, Orcas- Broken Point, Shaw Island	255	GB	WA	Marine	Nearshore only
185	Western Kitsap Peninsula	36,779	PT	WA	Estuarine	Terrestrial/Nearshore
216	White River Riparian	1,859	PT	WA		Terrestrial only
288	Willamette Narrows	1,070	LC	OR		Terrestrial only
300	Willamina Oaks 1	1,871	WV	OR		Terrestrial only
303	Willamina Oaks 2	988	WV	OR		Terrestrial only
37	Winchelsea Island	1,193	GB	BC	Marine	Terrestrial/Nearshore
130	Woodland Beach, Camano Island	147	GB	WA	Estuarine	Nearshore only
296	Yamhill Oaks	5,648	WV	OR		Terrestrial only
96	Young Hill	669	GB	WA		Terrestrial only



Lower Columbia and Willamette Valley

Map 5.3b: Final Integrated Portfolio

1 inch equals 20 miles

0 5 10 15 20 Miles

0 10 20 30 40 Kilometers

Sources: TNC, WDNR, WDFW, USGS

March 2004

The Nature Conservancy — SAVING THE LAST GREAT PLACES ON EARTH

Nature Conservancy Canada — Conservation de la Nature Canada

Washington Department of FISH and WILDLIFE

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Unique ID	Conservation Area Name	Area in Hectares	Section	Jurisdiction	Marine Stratification	Integration
63	Active Pass	3,180	GB	BC	Marine	Terrestrial/Nearshore
318	Airlie Oaks	1,464	WV	OR		Terrestrial only
352	Alderwood Wayside	65	WV	OR		Terrestrial only
299	Amity Oaks	949	WV	OR		Terrestrial only
24	Anderson Beach	105	GB	BC	Estuarine	Nearshore only
246	Bald Hill	3,404	PT	WA		Terrestrial only
174	Bangor	1,616	PT	WA	Estuarine	Terrestrial/Nearshore
272	Banks Swamp	231	LC	OR		Terrestrial only
306	Basket Butte	5,618	WV	OR		Terrestrial only
351	Bear Creek Oaks	507	WV	OR		Terrestrial only
348	Bear Creek Wetlands	556	WV	OR		Terrestrial only
208	Black Diamond Lake	749	PT	WA		Terrestrial only
241	Black River - Mima Prairie	7,049	PT	WA		Terrestrial only
49	Blackjack-Harewood	8,996	GB	BC		Terrestrial only
187	Blake Island	183	PT	WA		Terrestrial/Nearshore
100	Blakely Island	1,684	GB	WA		Terrestrial only
44	Blaney Bog	764	PT	BC		Terrestrial only
30	Bowyer Island	165	GB	BC	Estuarine	Nearshore only
222	Brisco Point, South Hartstene Island	446	PT	WA	Estuarine	Nearshore only
25	Buccaneer Bay	1,519	GB	BC	Estuarine	Terrestrial/Nearshore
223	Buckley Hills	4,426	PT	WA		Terrestrial only
229	Budd Inlet	254	PT	WA	Estuarine	Nearshore only
304	Buell	160	WV	OR		Terrestrial only
51	Burn's Bog	3,324	PT	BC		Terrestrial only
344	Calapooia Oak Savanna	386	WV	OR		Terrestrial only
144	Camano Head	44	PT	WA		Terrestrial only
369	Camas Swale BLM RNA	81	WV	OR		Terrestrial only
363	Camas Swale Oaks	1,863	WV	OR		Terrestrial only
364	Camas Swale Wetlands	878	WV	OR		Terrestrial only
285	Camassia	18	LC	OR		Terrestrial only
356	Camp Creek Ridge	578	WV	OR		Terrestrial only
180	Camp Wesley Harris	843	PT	WA		Terrestrial only
215	Campbell Creek	639	PT	WA		Terrestrial only
103	Capsante, Fidalgo Island	67	GB	WA	Estuarine	Nearshore only
231	Carbon River Plateau	2,987	PT	WA		Terrestrial only
292	Cedar Creek	3,271	LC	OR		Terrestrial only
197	Cedar River	4,785	PT	WA		Terrestrial only
20	Central Texada Island	12,589	GB	BC		Terrestrial only
291	Champoeg State Park	114	WV	OR		Terrestrial only
61	Chemainus	1,683	GB	BC	Marine	Terrestrial/Nearshore
64	Cherry Point	3,248	PT	WA	Estuarine	Nearshore only
158	Chimacum Forest	2,538	PT	WA		Terrestrial only
86	Chuckanut Mountain	3,694	PT	WA		Terrestrial only
286	Clackamas	8,330	LC	OR		Terrestrial only
290	Clear Creek	7,148	LC	OR		Terrestrial only
227	Cloquallum	3,618	PT	WA		Terrestrial only
249	Coal Creek Forest	942	LC	WA		Terrestrial only
365	Coast Fork/Middle Fork Willamette Riparian	5,437	WV	OR		Terrestrial only
354	Coburg Ridge	2,018	WV	OR		Terrestrial only
343	Cogswell Foster	36	WV	OR		Terrestrial only
23	Comox Macrosite	25,581	GB	BC	Marine	Terrestrial/Nearshore
12	Conawaga Beach	743	GB	BC	Marine	Nearshore only
282	Cooper Mountain	434	LC	OR		Terrestrial only
1	Cortes Island	12,130	GB	BC	Estuarine	Terrestrial/Nearshore
333	Corvallis Watershed	3,948	WV	OR		Terrestrial only
331	Corvallis-Philomath Oaks	4,652	WV	OR		Terrestrial only
188	Cougar Mountain	1,604	PT	WA		Terrestrial only
193	Coulter Creek	3,848	PT	WA		Terrestrial only
202	Covington Creek	2,587	PT	WA		Terrestrial only
75	Cowichan	13,749	GB	BC	Marine	Terrestrial/Nearshore
261	Cowlitz Forest Corridor	19,498	LC	WA		Terrestrial only
258	Cowlitz Riparian	1,386	LC	WA		Terrestrial only
211	Cranberry Creek	2,405	PT	WA		Terrestrial only
342	Crawfordsville Oak-Pine Savanna	2,349	WV	OR		Terrestrial only
124	Crescent Harbot Forest	234	GB	WA		Terrestrial only
95	Cypress-Sinclair Islands	3,120	GB	WA	Estuarine	Terrestrial/Nearshore
219	Dayton Creek	2,910	PT	WA		Terrestrial only
118	Deception Pass	3,913	GB	WA	Estuarine/Marine	Terrestrial/Nearshore
207	Deer Creek	3,574	PT	WA		Terrestrial only
243	Deschutes Riparian	3,226	PT	WA		Terrestrial only
3	Desolation Sound	10,700	GB	BC	Estuarine	Terrestrial/Nearshore
225	Dickenson Point	236	PT	WA	Estuarine	Nearshore only
252	Dillenbaugh	1,127	LC	WA		Terrestrial only
152	Discovery Bay	902	GB	WA	Marine	Terrestrial/Nearshore
116	Discovery Island	856	GB	BC	Marine	Terrestrial/Nearshore
4	Discovery Passage	8,559	GB	BC	Marine	Terrestrial/Nearshore
220	Drayton Passage-Filucy Bay	373	PT	WA	Estuarine	Nearshore only
260	Drews Prairie	109	LC	WA		Terrestrial only
121	Dugualla Bay	774	GB	WA	Estuarine	Terrestrial/Nearshore
289	Dundee Oaks	722	WV	OR		Terrestrial only
135	Dungeness	4,734	GB	WA	Marine	Terrestrial/Nearshore
321	Dunn Forest	4,273	WV	OR		Terrestrial only
179	Dyes Inlet-Silverdale	131	PT	WA	Estuarine	Nearshore only
186	East Fork Issaquah Creek	2,109	PT	WA		Terrestrial only
267	East Fork Lewis Riparian	888	LC	WA		Terrestrial only
195	East Side Vashon	125	PT	WA	Estuarine	Nearshore only
120	East Sooke	2,578	GB	BC		Terrestrial only
131	Ebey's Landing	1,028	GB	WA		Terrestrial/Nearshore
171	Edmonds Point	84	PT	WA	Estuarine	Nearshore only
322	EE Wilson	1,010	WV	OR		Terrestrial only
213	Eells Hill	6,312	PT	WA		Terrestrial only
233	Eld Inlet	522	PT	WA	Estuarine	Nearshore only
372	Elk Creek	1,472	WV	OR		Terrestrial only

Index to Priority Conservation Area maps 5.3a and 5.3b.

Unique ID	Conservation Area Name	Area in Hectares	Section	Jurisdiction	Marine Stratification	Integration
305	Eola Hills	9,293	WV	OR		Terrestrial only
357	Fern Ridge Reservoir	3,713	WV	OR		Terrestrial only
109	Fidalgo Bay	375	GB	WA	Estuarine/Marine	Nearshore only
106	Fidalgo Head, Burrows Island	346	GB	WA		Terrestrial/Nearshore
110	Fidalgo Island	1,745	GB	WA		Terrestrial only
55	Fishtrap Creek	299	PT	BC		Terrestrial only
89	Flattop Island	43	GB	WA	Marine	Nearshore only
270	Forest Park-Coast Range	30,838	LC	OR		Terrestrial only
141	Fort Flagler	521	GB	WA	Estuarine	Terrestrial/Nearshore
234	Fort Lewis - McChord	24,382	PT	WA		Terrestrial only
367	Fox Hollow BLM RNA	183	WV	OR		Terrestrial only
50	Fraser Delta	28,619	PT	BC	Estuarine/Marine	Terrestrial/Nearshore
101	Friday Harbor, San Juan Island	178	GB	WA		Terrestrial/Nearshore
45	Gabriola Island	1,362	GB	BC	Marine	Terrestrial/Nearshore
48	Gabriola Pass	1,873	GB	BC	Marine	Terrestrial/Nearshore
275	Gales Creek	28	LC	OR		Terrestrial only
148	Gardiner	197	GB	WA	Marine	Nearshore only
157	Gedney Island	212	PT	WA	Estuarine	Nearshore only
370	Gettings Creek	334	WV	OR		Terrestrial only
332	Golden Valley	2,983	WV	OR		Terrestrial only
274	Government Island	1,214	LC	OR		Terrestrial only
139	Grays Marsh	324	GB	WA		Terrestrial only
209	Green River	3,936	PT	WA		Terrestrial only
310	HABECK Oaks	7,139	WV	OR		Terrestrial only
36	Hamilton Marsh	553	GB	BC		Terrestrial only
184	Hamma Hamma Delta	21	PT	WA		Terrestrial only
41	Harrison	646	PT	BC		Terrestrial only
11	Harwood Island	299	GB	BC	Estuarine	Nearshore only
102	Hat and Saddlebag Islands	54	GB	WA	Estuarine	Terrestrial/Nearshore
92	Henry Island	620	GB	WA	Marine	Terrestrial/Nearshore
8	Herando Island	999	GB	BC		Terrestrial/Nearshore
309	Hidden Oaks	463	LC	OR		Terrestrial only
347	High Pass	4,083	WV	OR		Terrestrial only
145	Holmes Harbor, Whidbey Island	283	PT	WA	Estuarine	Nearshore only
239	Horn Creek	1,004	PT	WA		Terrestrial only
35	Horseshoe Bay	178	PT	BC	Estuarine	Nearshore only
17	Howe Estuary	362	GB	BC	Estuarine/Marine	Nearshore only
113	Hunter and Mud Bays, Lopez Island	192	GB	WA	Marine	Nearshore only
345	Indian Head/Horse Rock Ridge	12,457	WV	OR		Terrestrial only
149	Indian Island	1,087	GB	WA	Estuarine	Terrestrial/Nearshore
172	Indianola Forest	640	PT	WA		Terrestrial only
192	Issaquah Creek Riparian	132	PT	WA		Terrestrial only
175	Jackson Cove-Dabob Bay	323	PT	WA	Estuarine	Nearshore only
328	Jackson Fraiser Wetlands	380	WV	OR		Terrestrial only
105	James Island	47	GB	WA		Terrestrial only
361	Jasper Prairie	299	WV	OR		Terrestrial only
27	Jedediah Island	690	GB	BC	Estuarine	Terrestrial/Nearshore
14	Jervis Inlet	3,353	GB	BC	Estuarine	Terrestrial/Nearshore
156	Jimmycomelately	1,186	GB	WA		Terrestrial only
214	Johns Creek - McEwen Prairie	1,709	PT	WA		Terrestrial only
314	Johnson Hill	298	WV	OR		Terrestrial only
224	Johnson Point	205	PT	WA	Estuarine	Nearshore only
91	Jones Island	78	GB	WA		Terrestrial only
150	Kilisut Harbor	246	GB	WA	Estuarine	Nearshore only
316	Kingston Prairie	398	WV	OR		Terrestrial only
271	Lacamas Meadows	1,021	LC	WA		Terrestrial only
259	Lacamas Riparian	349	LC	WA		Terrestrial only
58	Ladysmith-Yellow Point	4,947	GB	BC	Marine	Terrestrial/Nearshore
138	Lake Hancock	36	GB	WA		Terrestrial only
80	Lake Whatcom	6,931	PT	WA		Terrestrial only
362	Lane Community College Basin	546	WV	OR		Terrestrial only
26	Lasqueti Island	6,997	GB	BC	Estuarine	Terrestrial/Nearshore
257	Lewis and Clark State Park	661	LC	WA		Terrestrial only
176	Liberty Bay-Agate Pass-Port Orchard	1,229	PT	WA	Estuarine	Nearshore only
191	Lilliwaup	8,648	PT	WA		Terrestrial only
311	Little Sink RNA	21	WV	OR		Terrestrial only
326	Logsden Ridge	454	WV	OR		Terrestrial only
108	Lopez Hill	454	GB	WA		Terrestrial only
167	Lord Hill	1,699	PT	WA		Terrestrial only
334	Lower Calapooia River Riparian	5,915	WV	OR		Terrestrial only
265	Lower Coweeman	1,682	LC	WA		Terrestrial only
137	Lower Elwha Riparian	360	GB	WA		Terrestrial only
42	Lower Englishman	2,979	GB	BC		Terrestrial only
266	Lower Kalama	5,524	LC	WA		Terrestrial only
355	Lower Mckenzie Riparian	3,877	WV	OR		Terrestrial only
33	Lower Qualicum	3,908	GB	BC	Marine	Terrestrial/Nearshore
248	Lower Skookumchuck	14,642	LC	WA		Terrestrial only
273	Lower Washougal	1,090	LC	WA		Terrestrial only
317	Luckiamute River Riparian	4,508	WV	OR		Terrestrial only
70	Lummi Flats	4,259	PT	WA	Estuarine	Terrestrial/Nearshore
196	Lych Cove-Union River-Hood Canal	620	PT	WA	Estuarine	Nearshore only
134	Lyre River	1,211	GB	WA		Terrestrial/Nearshore
329	Main Stem Willamette, Corvallis to Albany	2,876	WV	OR		Terrestrial only
341	Main Stem Willamette, Harrisburg to Corvallis	9,693	WV	OR		Terrestrial only
315	Main Stem Willamette, Luckiamute-Santiam confluence area	5,502	WV	OR		Terrestrial only
349	Main Stem Willamette, McKenzie confluence to Harrisburg	4,767	WV	OR		Terrestrial only
298	Main Stem Willamette, Mission Bottom area	11,898	WV	OR		Terrestrial only
7	Malaspina - Copeland	4,685	GB	BC	Estuarine	Terrestrial/Nearshore
66	Maple Mt.-Mt. Richards	3,334	GB	BC		Terrestrial only
69	Maple-Genoa Bay	1,228	GB	BC	Marine	Terrestrial/Nearshore
40	Maria	887	PT	BC		Terrestrial only
5	Marina Island	868	GB	BC		Terrestrial only
323	Maxfield Creerk BLM	666	WV	OR		Terrestrial only

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Unique ID	Conservation Area Name	Area in Hectares	Section	Jurisdiction	Marine Stratification	Integration
319	McCully Mtn BLM	192	WV	OR		Terrestrial only
327	McDonald Forest/Soap Creek Forest and Balds	4,976	WV	OR		Terrestrial only
217	McNeil Island	1,384	PT	WA		Terrestrial/Nearshore
245	Middle Chehalis	3,550	PT	WA		Terrestrial only
253	Middle Fork Newaukum	2,366	LC	WA		Terrestrial only
256	Mill Creek	1,158	LC	WA		Terrestrial only
308	Minto Island	1,008	WV	OR		Terrestrial only
47	Mission-Fraser	12,759	PT	BC		Terrestrial only
301	Missouri Ridge	2,994	WV	OR		Terrestrial only
9	Mittlenatch Island	37	GB	BC		Terrestrial/Nearshore
84	Moran	4,626	GB	WA	Estuarine	Terrestrial/Nearshore
302	Mount Angel	118	WV	OR		Terrestrial only
90	Mount Woolard	1,972	GB	WA		Terrestrial only
136	Mountain View Beach, Camano Island	217	PT	WA	Estuarine	Nearshore only
360	Mt Pisgah	1,118	WV	OR		Terrestrial only
67	Mt. Maxwell	2,610	GB	BC		Terrestrial/Nearshore
339	Muddy Creek/Finley	6,136	WV	OR		Terrestrial only
46	Nanaimo	2,713	GB	BC	Marine	Terrestrial/Nearshore
38	Nanoose-Parksville	7,896	GB	BC	Marine	Terrestrial/Nearshore
16	Nelson Island	12,531	GB	BC	Estuarine/Marine	Terrestrial/Nearshore
235	Nisqually	7,789	PT	WA	Estuarine	Terrestrial/Nearshore
72	Nooksack Delta	440	PT	WA		Terrestrial/Nearshore
62	Nooksack Riparian	1,097	PT	WA		Terrestrial only
201	North Bay	519	PT	WA	Estuarine	Nearshore only
250	North Fork Newaukum	4,630	LC	WA		Terrestrial only
324	North Santiam River Riparian	7,984	WV	OR		Terrestrial only
15	North Texada Island	2,518	GB	BC		Terrestrial only
73	North-South Pender Islands	293	GB	BC	Marine	Nearshore only
336	Oak Creek USFWS	148	WV	OR		Terrestrial only
330	Oak Creek/Freeway Lakes Park	55	WV	OR		Terrestrial only
125	Oak Harbor, Whidbey Island	79	GB	WA	Estuarine	Nearshore only
287	Oak Ridge/Moore's Valley	1,456	WV	OR		Terrestrial only
143	Old Fort Townsend	623	GB	WA	Estuarine	Terrestrial/Nearshore
237	Olympia Airport	379	PT	WA		Terrestrial only
346	Orchard Heights	923	WV	OR		Terrestrial only
359	Oregon Country Fair	439	WV	OR		Terrestrial only
264	Ostrander Forest Block	6,201	LC	WA		Terrestrial only
181	Ostrich Bay, Bremerton	272	PT	WA	Estuarine	Nearshore only
194	Otter Lake-Desire Lake	205	PT	WA		Terrestrial only
107	Padilla Bay	5,071	PT	WA	Estuarine/Marine	Terrestrial/Nearshore
18	Pender Harbor	1,753	GB	BC	Estuarine	Terrestrial/Nearshore
56	Pepin Creek	811	PT	BC		Terrestrial only
335	Peterson Butte	564	WV	OR		Terrestrial only
212	Pickering Passage	978	PT	WA	Estuarine	Nearshore only
151	Pilchuck Riparian	1,236	PT	WA		Terrestrial only
39	Pitt Macrosite	5,337	PT	BC		Terrestrial only
81	Point Disney, Waldron Island	408	GB	WA	Marine	Terrestrial/Nearshore
99	Point George, Shaw Island	192	GB	WA		Terrestrial/Nearshore
164	Point Julia Forest	878	PT	WA		Terrestrial only
54	Point Roberts-Boundary Bay	9,416	PT	BC	Estuarine/Marine	Terrestrial/Nearshore
200	Point Robinson, Maury Island	175	PT	WA		Terrestrial only
57	Porlier Pass	1,857	GB	BC	Marine	Terrestrial/Nearshore
155	Port Discovery Forest	990	GB	WA		Terrestrial only
166	Port Gamble	2,582	PT	WA	Estuarine	Terrestrial/Nearshore
161	Port Ludlow	128	PT	WA	Estuarine	Nearshore only
112	Portage Inlet	98	GB	BC	Marine	Nearshore only
79	Portage Island	363	PT	WA	Estuarine	Nearshore only
65	Prevost Island	1,676	GB	BC	Marine	Terrestrial/Nearshore
132	Protection Island	2,548	GB	WA	Marine	Terrestrial/Nearshore
293	Pudding River riparian	3,183	WV	OR		Terrestrial only
236	Puyallup River Riparian	471	PT	WA		Terrestrial only
2	Quadra Island	7,557	GB	BC	Estuarine/Marine	Terrestrial/Nearshore
31	Qualicum Bay	892	GB	BC	Marine	Nearshore only
32	Qualicum-Columbia Beaches	550	GB	BC	Marine	Nearshore only
199	Quartermaster Harbor	535	PT	WA	Estuarine	Nearshore only
170	Quilcene	7,837	PT	WA	Estuarine	Terrestrial/Nearshore
123	Race Rocks	124	GB	BC	Marine	Terrestrial/Nearshore
189	Raging River Forest	922	PT	WA		Terrestrial only
366	Rattlesnake Oaks	724	WV	OR		Terrestrial only
203	Redondo	164	PT	WA	Estuarine	Nearshore only
277	Reed Island	132	LC	WA		Terrestrial only
76	Reginald Hill	1,774	GB	BC		Terrestrial/Nearshore
182	Rich Passage, Bainbridge Island	415	PT	WA	Estuarine	Nearshore only
325	Richardson Gap/Crabtree Wetlands	4,936	WV	OR		Terrestrial only
350	Rock Hill	677	WV	OR		Terrestrial only
122	Rocky Point, BC	2,180	GB	BC		Terrestrial only
142	Rocky Point, WA	1,924	GB	WA		Terrestrial/Nearshore
240	Rocky Prairie - Beaver Creek	1,909	PT	WA		Terrestrial only
128	Rodena Beach, Whidbey Island	389	GB	WA	Estuarine	Nearshore only
278	Rooster Rock/Mirror Lake State Park	335	LC	OR		Terrestrial only
115	Royal Roads-Esquimalt	341	GB	BC		Terrestrial/Nearshore
53	Ryder Mt.	2,513	PT	BC		Terrestrial only
312	Salem Hills/Ankeny NWR	10,483	WV	OR		Terrestrial only
269	Salmon Creek Riparian	218	LC	WA		Terrestrial only
97	Samish	17,836	PT	WA	Estuarine	Terrestrial/Nearshore
68	Samuel-Saturna	391	GB	BC	Marine	Nearshore only
154	Sandy Point, Whidbey Island	109	PT	WA	Estuarine	Nearshore only
280	Sandy River	5,054	LC	OR		Terrestrial only
218	Satsop Watershed	33,431	PT	WA		Terrestrial only
71	Saturna Island	1,388	GB	BC		Terrestrial only
268	Sauvie Island	36,064	LC	OR		Terrestrial only
10	Savary Island	486	GB	BC		Terrestrial/Nearshore
162	Scatchet Head	1,339	PT	WA	Estuarine	Terrestrial/Nearshore

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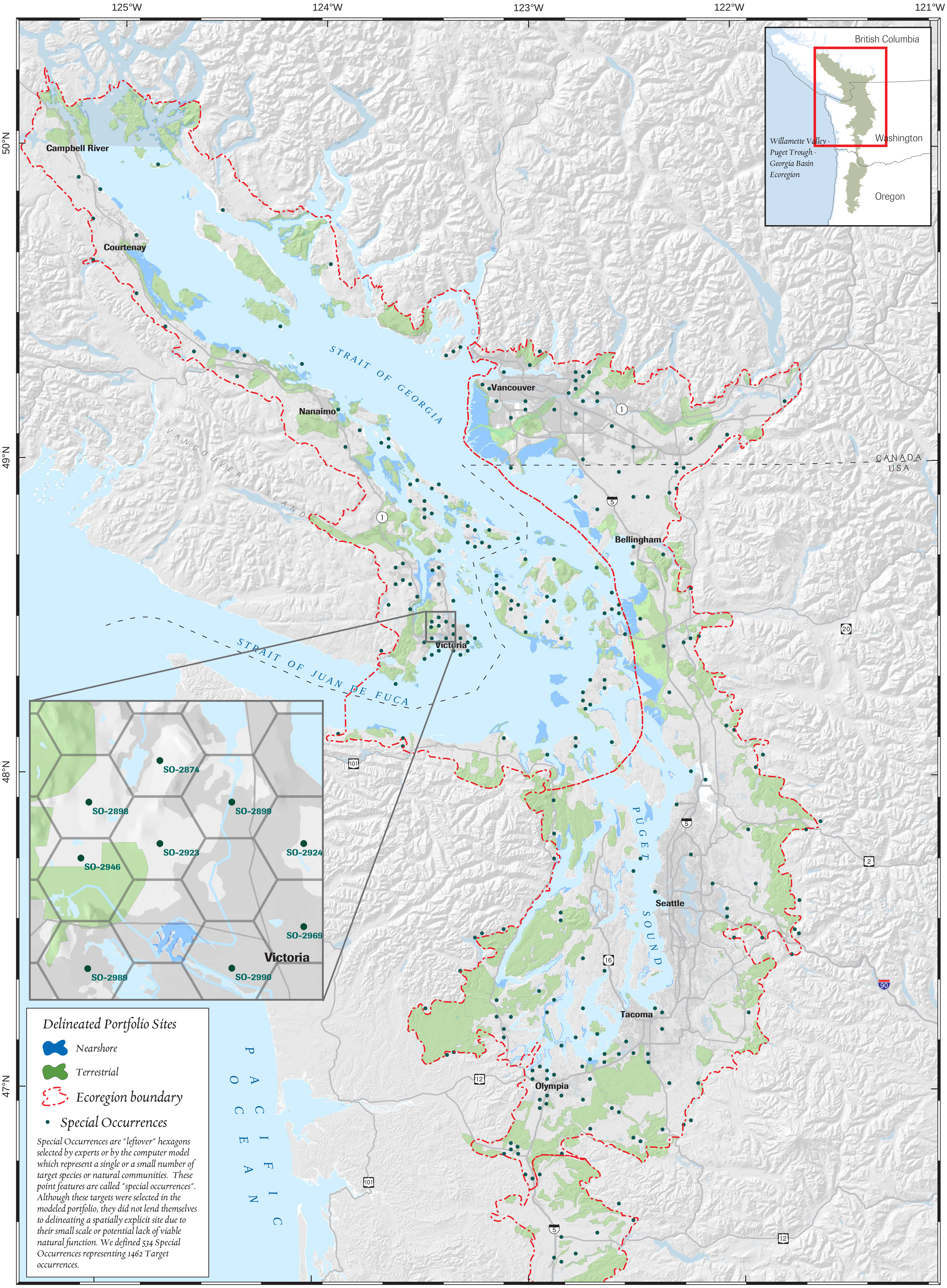
Unique ID	Conservation Area Name	Area in Hectares	Section	Jurisdiction	Marine Stratification	Integration
244	Scatter Creek	9,417	PT	WA		Terrestrial only
320	Scio Oak Pine Savanna	760	WV	OR		Terrestrial only
104	Sea to Sea Greenbelt	18,543	GB	BC	Marine	Terrestrial/Nearshore
178	Seabeck Bay	448	PT	WA	Estuarine	Nearshore only
19	Sechelt Inlet	132	GB	BC	Marine	Nearshore only
59	Semiahmoo-Drayton Harbor	796	PT	WA	Estuarine	Nearshore only
190	Seola Beach, Burien	48	PT	WA	Estuarine	Nearshore only
232	Sequalitchew Marshes	395	PT	WA		Terrestrial only
146	Sequim Bay	661	GB	WA	Marine	Nearshore only
34	Seymour Narrows	4,431	PT	BC		Terrestrial only
204	Sherwood Forest	2,566	PT	WA		Terrestrial only
198	Shoofly-Hood Canal	149	PT	WA	Estuarine	Nearshore only
206	Shumocher Creek	2,990	PT	WA		Terrestrial only
85	Sidney Island	1,594	GB	BC	Marine	Terrestrial/Nearshore
153	Siebert and McDonald Creeks	7,257	GB	WA		Terrestrial only
307	Silver Creek	1,430	WV	OR		Terrestrial only
263	Silver Lake Watershed	9,004	LC	WA		Terrestrial only
119	Skagit	34,292	PT	WA	Estuarine	Terrestrial/Nearshore
21	Skaiakos Point	52	GB	BC	Marine	Nearshore only
205	Skokomish-Hood Canal	13,147	PT	WA	Estuarine	Terrestrial/Nearshore
13	Skookumchuck Narrows	209	GB	BC	Marine	Nearshore only
163	Skykomish Riparian	3,307	PT	WA		Terrestrial only
126	Smith Island	3,879	GB	WA	Marine	Nearshore only
177	Snoqualmie Foothill Forest	26,131	PT	WA		Terrestrial only
183	Snoqualmie Riparian	1,319	PT	WA		Terrestrial only
159	Snow and Salmon Creeks	10,807	PT	WA		Terrestrial only
226	Solo Point - Farrell Marsh	921	PT	WA		Terrestrial only
254	South Fork Newaukum	1,909	LC	WA		Terrestrial only
297	South Fork Yamhill River	4,949	WV	OR		Terrestrial only
83	South Lummi-Lummi Mountain	1,143	GB	WA		Terrestrial only
228	South Prairie Riparian	208	PT	WA		Terrestrial only
29	South Sunshine	11,340	GB	BC		Terrestrial only
147	South Whidbey Forest	932	GB	WA		Terrestrial only
87	Spieden-Sentinel-Johns Islands	611	GB	WA	Marine	Nearshore only
169	Squamish Harbor	796	PT	WA	Estuarine	Nearshore only
221	Squaxin-Hope Islands	1,233	PT	WA	Estuarine	Terrestrial/Nearshore
255	Stearns Creek	2,354	LC	WA		Terrestrial only
129	Stillaguamish River-Port Susan	17,427	PT	WA	Estuarine	Terrestrial/Nearshore
313	Stout Mountain	669	WV	OR		Terrestrial only
133	Striped Peak	3,113	GB	WA	Marine	Terrestrial/Nearshore
82	Stuart Island	679	GB	WA	Marine	Terrestrial/Nearshore
74	Sucia-Matia-Patos Islands	2,000	GB	WA	Estuarine	Terrestrial/Nearshore
160	Sultan Foothill Forest	16,121	PT	WA		Terrestrial only
52	Sumas Mountain	2,474	PT	BC		Terrestrial only
353	Swamp Creek Wetlands	597	WV	OR		Terrestrial only
242	Tanwax Creek	3,025	PT	WA		Terrestrial only
168	Tarboo-Dabob Bay	5,685	PT	WA	Estuarine	Terrestrial/Nearshore
294	The Butte RNA	51	WV	OR		Terrestrial only
210	The Narrows	759	PT	WA	Estuarine	Terrestrial/Nearshore
111	Thetis-Frances	1,174	GB	BC		Terrestrial only
60	Thetis-Kuper	6,088	GB	BC	Marine	Terrestrial/Nearshore
28	Thormanby Island	1,539	GB	BC	Estuarine	Terrestrial/Nearshore
165	Thorndyke	8,989	PT	WA	Estuarine	Terrestrial/Nearshore
98	Three Corner Lake	397	GB	WA		Terrestrial only
295	Timber Grove	3,882	LC	OR		Terrestrial only
173	Toandos Peninsula	2,849	PT	WA	Estuarine	Terrestrial/Nearshore
247	Toboton and Lackamus Creeks	917	PT	WA		Terrestrial only
230	Totten-Skookum Inlets	883	PT	WA	Estuarine	Nearshore only
262	Toutle Forest Corridor	14,142	LC	WA		Terrestrial only
117	Trial Island	18	GB	BC		Terrestrial/Nearshore
283	Tryon Creek Nature Park	374	LC	OR		Terrestrial only
284	Tualatin National Wildlife Refuge	3,910	LC	OR		Terrestrial only
279	Tualitan Hills Park	400	LC	OR		Terrestrial only
77	Tuam-Bruce	3,142	GB	BC		Terrestrial/Nearshore
140	Tulalip	2,290	PT	WA		Terrestrial only
88	Turtleback-Deer Harbor	1,485	GB	WA	Marine	Terrestrial/Nearshore
22	Tuwanek Point	168	GB	BC	Marine	Nearshore only
6	Twin Islands	285	GB	BC		Terrestrial only
43	UBC Research Forest/Blue	4,805	PT	BC		Terrestrial only
371	Upper Siuslaw Site	29,815	WV	OR		Terrestrial only
127	Utsalady, Camano Island	205	GB	WA	Estuarine	Nearshore only
251	Van Ornum Creek Forest	833	LC	WA		Terrestrial only
78	Waldron-Skipjack Islands	181	GB	WA	Marine	Nearshore only
281	Wapato Marsh	4,314	LC	OR		Terrestrial only
338	Ward Butte	151	WV	OR		Terrestrial only
340	Washburn Butte	1,357	WV	OR		Terrestrial only
276	Washougal Oaks - Steigerwald	1,347	LC	WA		Terrestrial only
93	Wasp-Yellow Islands	19	GB	WA		Terrestrial/Nearshore
337	Waterloo Rocks	450	WV	OR		Terrestrial only
238	Weir Prairie and Forest	10,345	PT	WA		Terrestrial only
368	Weiss Rd BLM Oaks	201	WV	OR		Terrestrial only
358	West Eugene/Spencer Creek	14,322	WV	OR		Terrestrial only
114	West San Juan-Southern Lopez Islands	7,535	GB	WA	Marine	Terrestrial/Nearshore
94	West Sound, Orcas- Broken Point, Shaw Island	255	GB	WA	Marine	Nearshore only
185	Western Kitsap Peninsula	36,779	PT	WA	Estuarine	Terrestrial/Nearshore
216	White River Riparian	1,859	PT	WA		Terrestrial only
288	Willamette Narrows	1,070	LC	OR		Terrestrial only
300	Willamina Oaks 1	1,871	WV	OR		Terrestrial only
303	Willamina Oaks 2	988	WV	OR		Terrestrial only
37	Winchelsea Island	1,193	GB	BC	Marine	Terrestrial/Nearshore
130	Woodland Beach, Camano Island	147	GB	WA	Estuarine	Nearshore only
296	Yamhill Oaks	5,648	WV	OR		Terrestrial only
96	Young Hill	669	GB	WA		Terrestrial only



Georgia Basin and Puget Trough

Map 5.4a: Special Occurrences

1 inch equals 20 miles

0 5 10 15 20 Miles

0 10 20 30 40 Kilometers

Sources: TNC, WDFW, WDFW, USGS

March 2004

The Nature Conservancy — Saving the Last Great Places on Earth

Nature Conservancy Canada — Conservation de la Nature Canada

Washington Department of Fish and Wildlife

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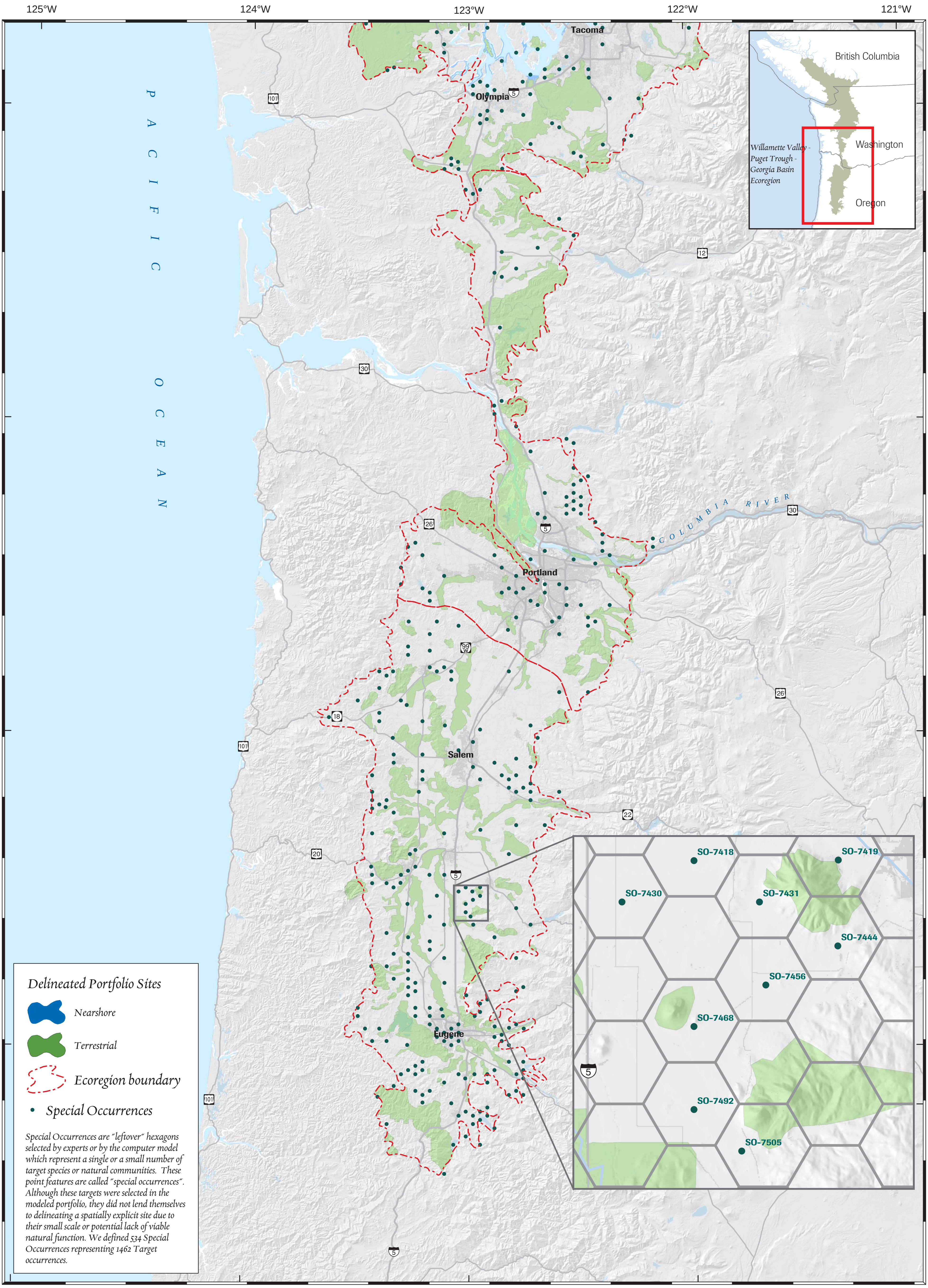


Lower Columbia and Willamette Valley

Map 5.4b: Special Occurrences

1 inch equals 20 miles

0 5 10 15 20 Miles

0 10 20 30 40 Kilometers

N W E S

Sources: TNC, WDNR, WDFW, USGS

March 2004

The Nature Conservancy — Saving the Last Great Places on Earth

Nature Conservancy Canada — Conservation de la Nature Canada

Washington Department of Fish and Wildlife

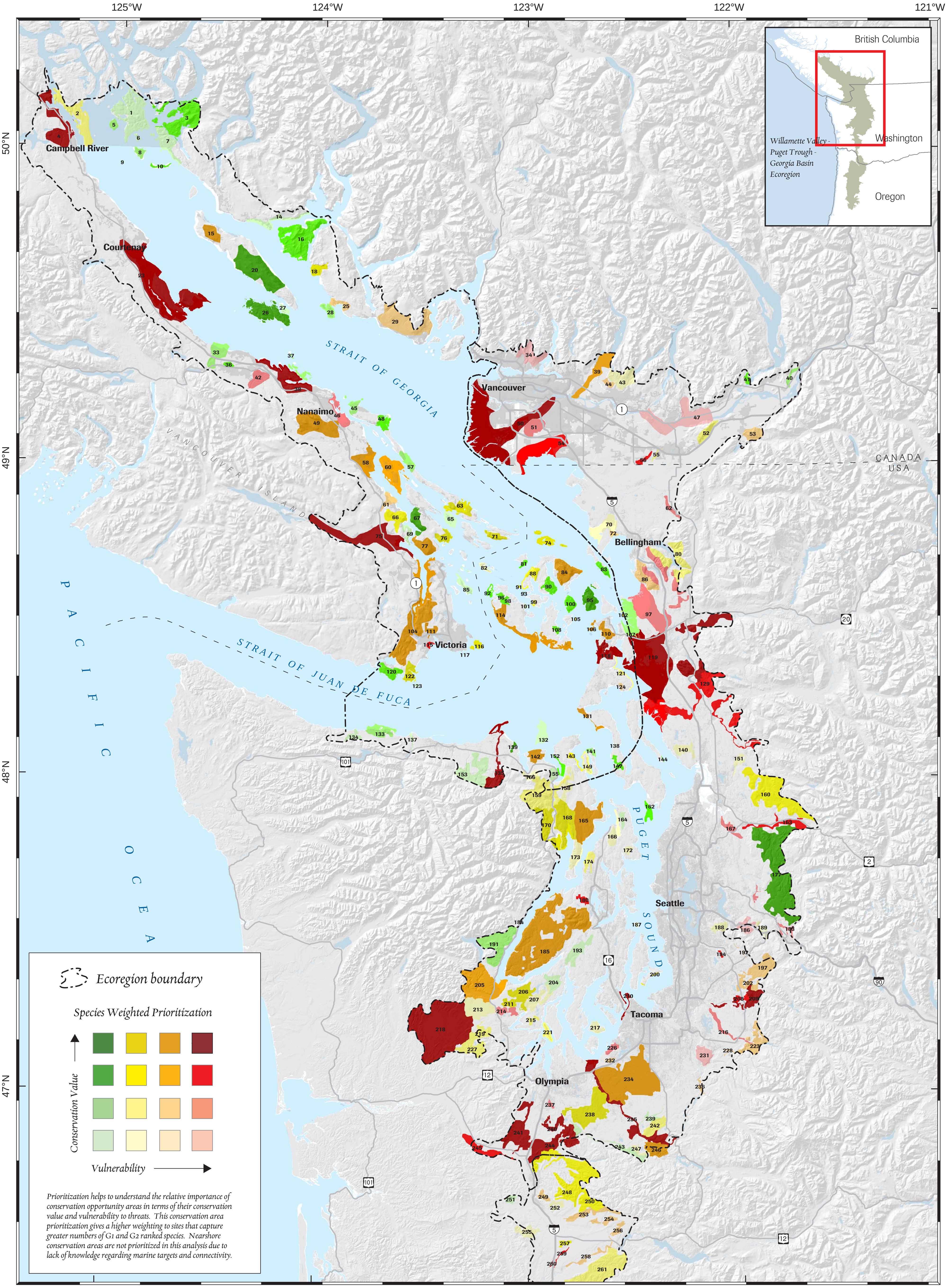
Conservation areas sorted by quartile for conservation value and vulnerability, and weighted toward species factors. Low, medium low, medium high, and high correspond to the first, second, third, and fourth quartiles, respectively. No marine areas are included in this list.

Conservation Value	Vulnerability: Low	Vulnerability: Medium Low	Vulnerability: Medium High	Vulnerability: High
High	Basket Butte Central Texada Island Dunn Forest Grays Marsh Indian Head/Horse Rock Ridge Mt. Maxwell Snoqualmie Foothill Forest Upper Siuslaw Site Wasp-Yellow Islands Cypress-Sinclair Islands Lasqueti Island	Camp Creek Ridge Cranberry Creek EE Wilson Fern Ridge Reservoir James Island Jones Island McDonald Forest/Soap Creek Forest and Balds Mt Pisgah Reginald Hill Rocky Point, BC Saturna Island Shumocher Creek Trial Island Weir Prairie and Forest Active Pass Discovery Island Pender Harbor Quilcene Sucia-Matia-Patos Islands Tarboo-Dabob Bay	Bald Hill Blackjack-Harewood Ebey's Landing Fidalgo Head, Burrows Island Fidalgo Island Fort Lewis - McChord Golden Valley Kingston Prairie Luckiamute River Riparian Muddy Creek/Finley North Texada Island Rocky Point, WA Stout Mountain Thetis-Frances Tuam-Bruce Willamette Narrows Ladysmith-Yellow Point Moran Sea to Sea Greenbelt Thorndyke West San Juan-Southern Lopez Islands Western Kitsap Peninsula	Black River - Mima Prairie Camassia Corvallis-Philomath Oaks Drews Prairie Green River Lacamas Meadows North Santiam River Riparian Rocky Prairie - Beaver Creek Sandy River Satsop Watershed Sauvie Island Scatter Creek South Fork Yamhill River Washougal Oaks - Steigerwald West Eugene/Spencer Creek Comox Macrosite Cowichan Deception Pass Discovery Passage Dungeness Fraser Delta Nanoose-Parksville Nisqually Skagit The Narrows

Conservation Value	Vulnerability: Low	Vulnerability: Medium Low	Vulnerability: Medium High	Vulnerability: High
Medium High	Blakely Island Camano Head Camas Swale BLM RNA East Sooke Fox Hollow BLM RNA Hamilton Marsh Harrison High Pass Lopez Hill Minto Island Mount Woolard Savary Island South Lummi-Lummi Mountain South Whidbey Forest Three Corner Lake Washburn Butte Young Hill Desolation Sound Discovery Bay Gabriola Pass Henry Island Nelson Island Point Disney, Waldron Island Scatchet Head	Cogswell Foster Forest Park-Coast Range Gales Creek Lewis and Clark State Park Lower Skookumchuck Maple Mt.-Mt. Richards North Fork Newaukum Point George, Shaw Island Point Robinson, Maury Island Sultan Foothill Forest Timber Grove Ward Butte Hat and Saddlebag Islands Old Fort Townsend Turtleback-Deer Harbor	Banks Swamp Clear Creek Coast Fork/Middle Fork Willamette Riparian Crawfordsville Oak-Pine Savanna HABECK Oaks Lane Community College Basin Lower Kalama Oak Creek USFWS Orchard Heights Oregon Country Fair Pitt Macrosite Pudding River riparian Tualatin National Wildlife Refuge Skokomish-Hood Canal Thetis-Kuper	Black Diamond Lake Camp Wesley Harris Clackamas Coburg Ridge Eola Hills Government Island Jackson Fraiser Wetlands Lacamas Riparian Logsden Ridge Lower Calapooia River Riparian Lower Mckenzie Riparian Main Stem Willamette, Harrisburg to Corvallis Main Stem Willamette, McKenzie confluence to Harrisburg Main Stem Willamette, Mission Bottom area Middle Chehalis Otter Lake-Desire Lake Pepin Creek Peterson Butte Royal Roads-Esquimalt Skykomish Riparian Yamhill Oaks Point Roberts-Boundary Bay Stillaguamish River-Port Susan

Conservation Value	Vulnerability: Low	Vulnerability: Medium Low	Vulnerability: Medium High	Vulnerability: High
Medium Low	Champoeg State Park Gabriola Island Hamma Hamma Delta Herando Island Lilliwaup Maria Marina Island Maxfield Creerk BLM Weiss Rd BLM Oaks Fort Flagler Lower Qualicum Padilla Bay Porlier Pass Striped Peak Thormanby Island Winchelsea Island	Bear Creek Wetlands Campbell Creek Cloquallum Cowlitz Forest Corridor Dayton Creek Fishtrap Creek Lake Whatcom Ostrander Forest Block Rooster Rock/Mirror Lake State Park Snow and Salmon Creeks Sumas Mountain Swamp Creek Wetlands Tanwax Creek Bangor Dugualla Bay Indian Island Quadra Island Squaxin-Hope Islands	Airlie Oaks Blaney Bog Buckley Hills Buell Cedar Creek Chuckanut Mountain Cowlitz Riparian East Fork Lewis Riparian Hidden Oaks Jasper Prairie Lower Washougal Middle Fork Newaukum Nooksack Delta Oak Creek/Freeway Lakes Park Oak Ridge/Moore's Valley Richardson Gap/Crabtree Wetlands Ryder Mt. Salem Hills/Ankeny NWR Sequalitchew Marshes South Fork Newaukum Toutle Forest Corridor Willamina Oaks 1 Chemainus	Amity Oaks Burn's Bog Camas Swale Oaks Cooper Mountain Gettings Creek Johns Creek - McEwen Prairie Lord Hill Lower Englishman Main Stem Willamette, Corvallis to Albany Main Stem Willamette, Luckiamute-Santiam confluence area Nooksack Riparian Olympia Airport Rattlesnake Oaks Scio Oak Pine Savanna Snoqualmie Riparian Solo Point - Farrell Marsh Wapato Marsh Waterloo Rocks White River Riparian Nanaimo Samish

Conservation Value	Vulnerability: Low	Vulnerability: Medium Low	Vulnerability: Medium High	Vulnerability: High
Low	Alderwood Wayside Coulter Creek Deschutes Riparian Elk Creek Friday Harbor, San Juan Island Horn Creek Lake Hancock Little Sink RNA Lower Elwha Riparian Lyre River Mittlenatch Island Point Julia Forest Port Discovery Forest Sherwood Forest Siebert and McDonald Creeks The Butte RNA Twin Islands Van Ornum Creek Forest Cortes Island Jedediah Island Jervis Inlet Malaspina - Copeland Maple-Genoa Bay Prevost Island Protection Island Race Rocks Sidney Island	Blake Island Calapooia Oak Savanna Chimacum Forest Corvallis Watershed Cougar Mountain Deer Creek Dillenbaugh Eells Hill Indianola Forest Jimmycomelately Lower Coweeman McCully Mtn BLM McNeil Island Pilchuck Riparian Raging River Forest Rock Hill Silver Creek Stearns Creek Toboton and Lackamus Creeks Tulalip UBC Research Forest/Blue Lummi Flats Port Gamble Stuart Island Toandos Peninsula	Bear Creek Oaks Camas Swale Wetlands Cedar River Coal Creek Forest Covington Creek Crescent Harbot Forest Issaquah Creek Riparian Mill Creek Missouri Ridge Mount Angel Puyallup River Riparian Reed Island South Prairie Riparian South Sunshine Tryon Creek Nature Park Willamina Oaks 2 Buccaneer Bay	Carbon River Plateau Dundee Oaks East Fork Issaquah Creek Johnson Hill Mission-Fraser Salmon Creek Riparian Seymour Narrows Silver Lake Watershed Tualitan Hills Park



Georgia Basin and Puget Trough

Map 6.1a: Species Weighted Prioritization of Priority Conservation Areas

1 inch equals 20 miles

0 5 10 15 20 Miles

0 10 20 30 40 Kilometers

Sources: TNC, WDFW, WDNR, USGS

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Conservation Value	Vulnerability: Low	Vulnerability: Medium Low	Vulnerability: Medium High	Vulnerability: High
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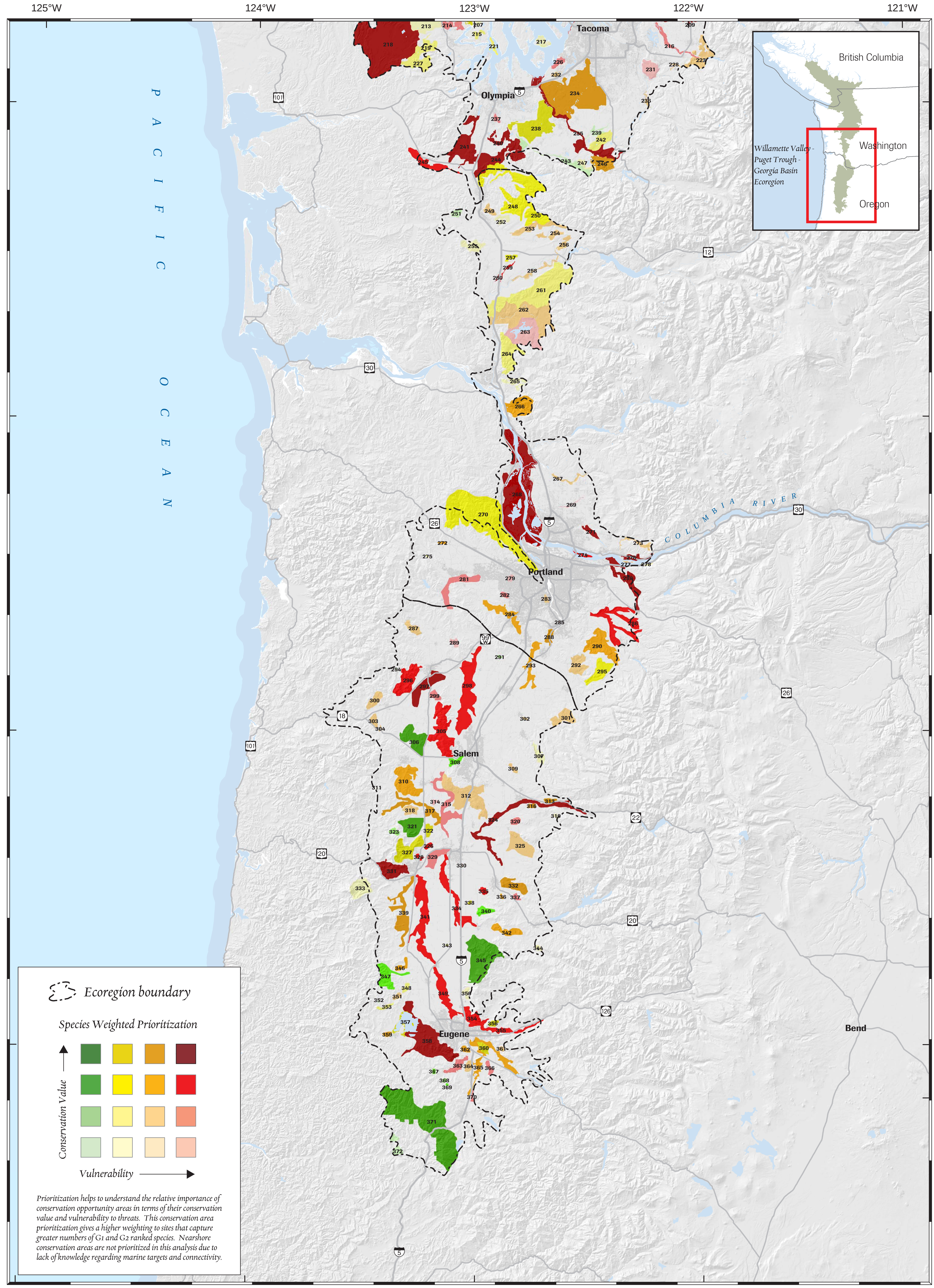

Lower Columbia and Willamette Valley

Map 6.1b: Species Weighted Prioritization of Priority Conservation Areas

1 inch equals 20 miles

0 5 10 15 20 Miles

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Sources: TNC, WDFW, WDNR, USGS

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Conservation Value	Vulnerability: Low	Vulnerability: Medium Low	Vulnerability: Medium High	Vulnerability: High
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	Vulnerability			
Conservation Value	**Low**	**Medium Low**	**Medium High**	**High**
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	Vulnerability			
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Conservation Value	**Low**	**Medium Low**	**Medium High**	**High**
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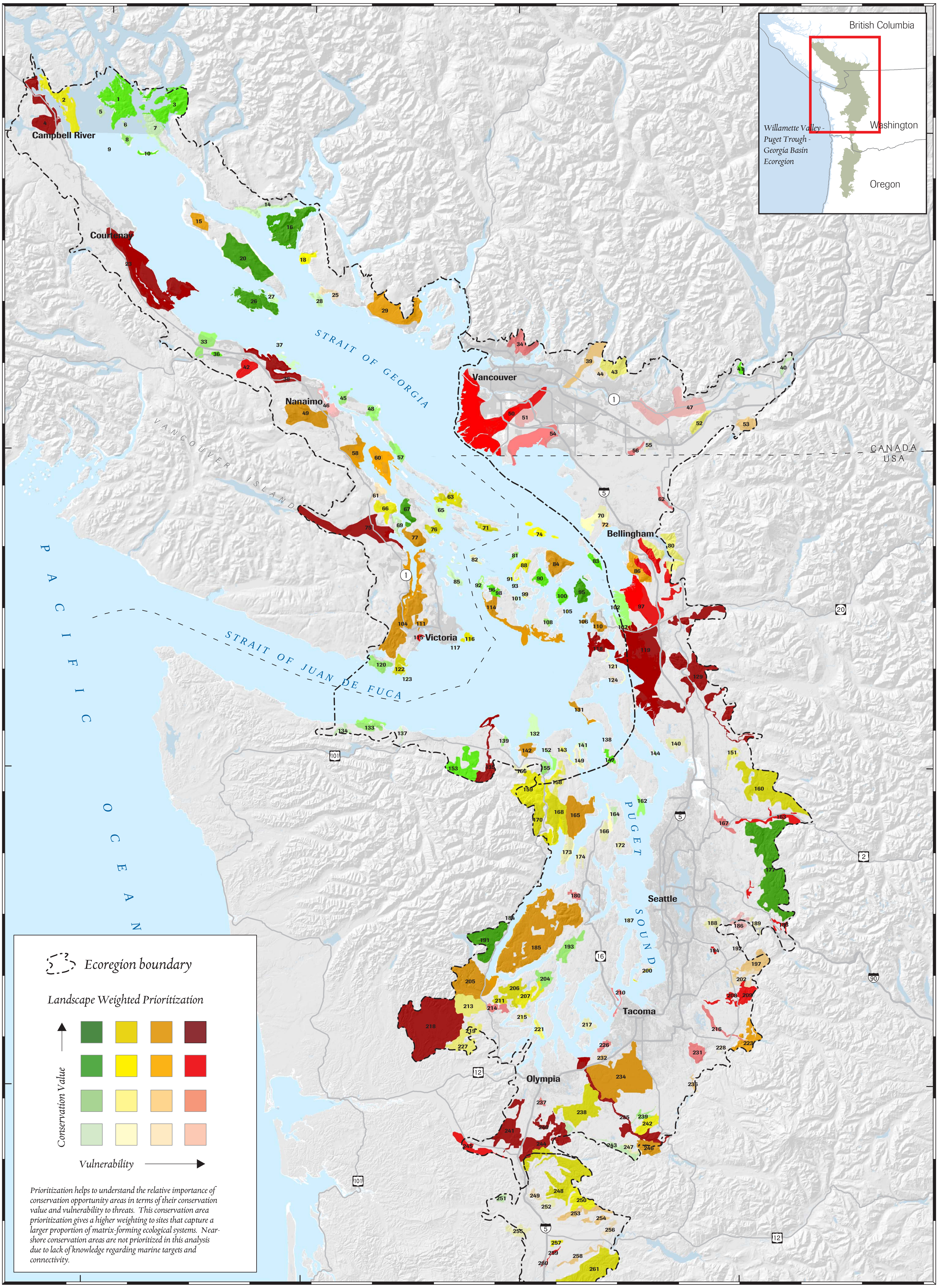

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Map 6.2a: Landscape Weighted Prioritization of Priority Conservation Areas

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The Nature Conservancy (TNC) does not verify or guarantee the accuracy, reliability, or completeness of any data provided. TNC provides this data without any warranty of any kind whatsoever, either express or implied. TNC shall not be liable for incidental, consequential, or special damages arising out of the use of any data provided by TNC.

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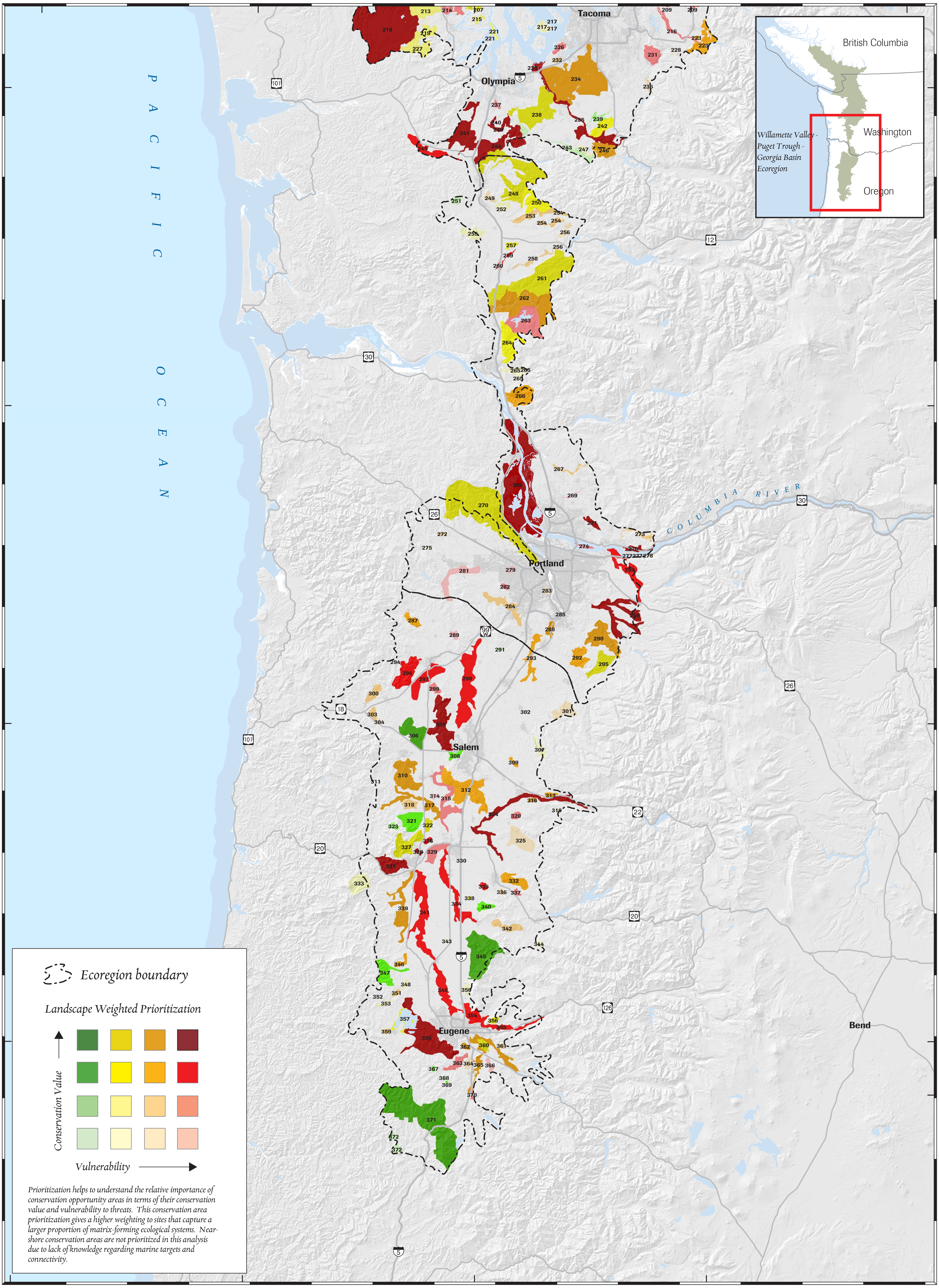
High	Basket Butte Central Texada Island Indian Head/Horse Rock Ridge Lilliwaup Mt. Maxwell Snoqualmie Foothill Forest Upper Siuslaw Site Cypress-Sinclair Islands Lasqueti Island Nelson Island	Cowlitz Forest Corridor Cranberry Creek EE Wilson Forest Park-Coast Range Lower Skookumchuck McDonald Forest/Soap Creek Forest and Balds Mt Pisgah Reginald Hill Rocky Point, BC Saturna Island Shumocher Creek Sultan Foothill Forest Timber Grove Trial Island Weir Prairie and Forest Active Pass Discovery Island Quilcene Tarboo-Dabob Bay	Bald Hill Blackjack-Harewood Clear Creek Coast Fork/Middle Fork Willamette Riparian Ebey's Landing Fidalgo Head, Burrows Island Fidalgo Island Fort Lewis - McChord HABECK Oaks Kingston Prairie Lane Community College Basin Luckiamute River Riparian Muddy Creek/Finley Rocky Point, WA Thetis-Frances Toutle Forest Corridor Tuam-Bruce Willamette Narrows Ladysmith-Yellow Point Moran Sea to Sea Greenbelt Skokomish-Hood Canal Thorndyke West San Juan-Southern Lopez Islands Western Kitsap Peninsula	Black River - Mima Prairie Camassia Clackamas Corvallis-Philomath Oaks Drews Prairie Eola Hills Jackson Fraiser Wetlands Lacamas Meadows North Santiam River Riparian Rocky Prairie - Beaver Creek Satsop Watershed Sauvie Island Scatter Creek Washougal Oaks - Steigerwald West Eugene/Spencer Creek Comox Macrosite Cowichan Deception Pass Discovery Passage Dungeness Nanoose-Parksville Nisqually Skagit Stillaguamish River-Port Susan

Conservation Value	Vulnerability: Low	Vulnerability: Medium Low	Vulnerability: Medium High	Vulnerability: High
Medium High	Blakely Island Camano Head Camas Swale BLM RNA Dunn Forest Fox Hollow BLM RNA Hamilton Marsh Hamma Hamma Delta Harrison High Pass Minto Island Mount Woolard Savary Island Siebert and McDonald Creeks South Lummi-Lummi Mountain South Whidbey Forest Three Corner Lake Washburn Butte Wasp-Yellow Islands Young Hill Cortes Island Desolation Sound	Camp Creek Ridge Cogswell Foster Deer Creek Fern Ridge Reservoir Gales Creek James Island Jones Island Lewis and Clark State Park Maple Mt.-Mt. Richards North Fork Newaukum Ostrander Forest Block Point Robinson, Maury Island Snow and Salmon Creeks Tanwax Creek Ward Butte Pender Harbor Quadra Island Sucia-Matia-Patos Islands Turtleback-Deer Harbor	Buckley Hills Cedar Creek Chuckanut Mountain Golden Valley Hidden Oaks Lower Kalama North Texada Island Oak Creek USFWS Oak Ridge/Moore's Valley Orchard Heights Pudding River riparian Salem Hills/Ankeny NWR South Sunshine Stout Mountain Thetis-Kuper	Black Diamond Lake Coburg Ridge Green River Lacamas Riparian Logsden Ridge Lower Calapooia River Riparian Lower Englishman Lower Mckenzie Riparian Main Stem Willamette, Harrisburg to Corvallis Main Stem Willamette, McKenzie confluence to Harrisburg Main Stem Willamette, Mission Bottom area Middle Chehalis Otter Lake-Desire Lake Peterson Butte Royal Roads-Esquimalt Sandy River Skykomish Riparian Snoqualmie Riparian South Fork Yamhill River Yamhill Oaks Fraser Delta Samish

Conservation Value	Vulnerability: Low	Vulnerability: Medium Low	Vulnerability: Medium High	Vulnerability: High
Medium Low	Champoeg State Park Coulter Creek East Sooke Gabriola Island Grays Marsh Herando Island Horn Creek Lopez Hill Maxfield Creerk BLM Port Discovery Forest Sherwood Forest Discovery Bay Gabriola Pass Henry Island Lower Qualicum Padilla Bay Point Disney, Waldron Island Porlier Pass Scatchet Head Striped Peak	Campbell Creek Chimacum Forest Cloquallum Dayton Creek Eells Hill Lake Whatcom Pilchuck Riparian Point George, Shaw Island Rooster Rock/Mirror Lake State Park Sumas Mountain UBC Research Forest/Blue Hat and Saddlebag Islands Old Fort Townsend Squaxin-Hope Islands	Airlie Oaks Banks Swamp Bear Creek Oaks Buell Cedar River Cowlitz Riparian Crawfordsville Oak-Pine Savanna East Fork Lewis Riparian Jasper Prairie Lower Washougal Middle Fork Newaukum Nooksack Delta Oak Creek/Freeway Lakes Park Oregon Country Fair Pitt Macrosite Puyallup River Riparian Ryder Mt. Sequalitchew Marshes South Fork Newaukum Tualatin National Wildlife Refuge Willamina Oaks 1 Willamina Oaks 2	Amity Oaks Camas Swale Oaks Camp Wesley Harris Carbon River Plateau Cooper Mountain Gettings Creek Government Island Johns Creek - McEwen Prairie Lord Hill Main Stem Willamette, Corvallis to Albany Main Stem Willamette, Luckiamute-Santiam confluence area Nooksack Riparian Olympia Airport Pepin Creek Scio Oak Pine Savanna Seymour Narrows Silver Lake Watershed Solo Point - Farrell Marsh Waterloo Rocks White River Riparian Point Roberts-Boundary Bay The Narrows

Conservation Value	Vulnerability: Low	Vulnerability: Medium Low	Vulnerability: Medium High	Vulnerability: High
Low	Alderwood Wayside Deschutes Riparian Elk Creek Friday Harbor, San Juan Island Lake Hancock Little Sink RNA Lower Elwha Riparian Lyre River Maria Marina Island Mittlenatch Island Point Julia Forest The Butte RNA Twin Islands Van Ornum Creek Forest Weiss Rd BLM Oaks Fort Flagler Jedediah Island Jervis Inlet Malaspina - Copeland Maple-Genoa Bay Prevost Island Protection Island Race Rocks Sidney Island Thormanby Island Winchelsea Island	Bear Creek Wetlands Blake Island Calapooia Oak Savanna Corvallis Watershed Cougar Mountain Dillenbaugh Fishtrap Creek Indianola Forest Jimmycomelately Lower Coweeman McCully Mtn BLM McNeil Island Raging River Forest Rock Hill Silver Creek Stearns Creek Swamp Creek Wetlands Toboton and Lackamus Creeks Tulalip Bangor Dugualla Bay Indian Island Lummi Flats Port Gamble Stuart Island Toandos Peninsula	Blaney Bog Camas Swale Wetlands Coal Creek Forest Covington Creek Crescent Harbot Forest Issaquah Creek Riparian Mill Creek Missouri Ridge Mount Angel Reed Island Richardson Gap/Crabtree Wetlands South Prairie Riparian Tryon Creek Nature Park Buccaneer Bay Chemainus	Burn's Bog Dundee Oaks East Fork Issaquah Creek Johnson Hill Mission-Fraser Rattlesnake Oaks Salmon Creek Riparian Tualitan Hills Park Wapato Marsh Nanaimo



Lower Columbia and Willamette Valley

Map 6.2b: Landscape Weighted Prioritization of Priority Conservation Areas

1 inch equals 20 miles

0 5 10 15 20 Miles

0 10 20 30 40 Kilometers

Sources: TNC, WDFW, WDNR, USGS

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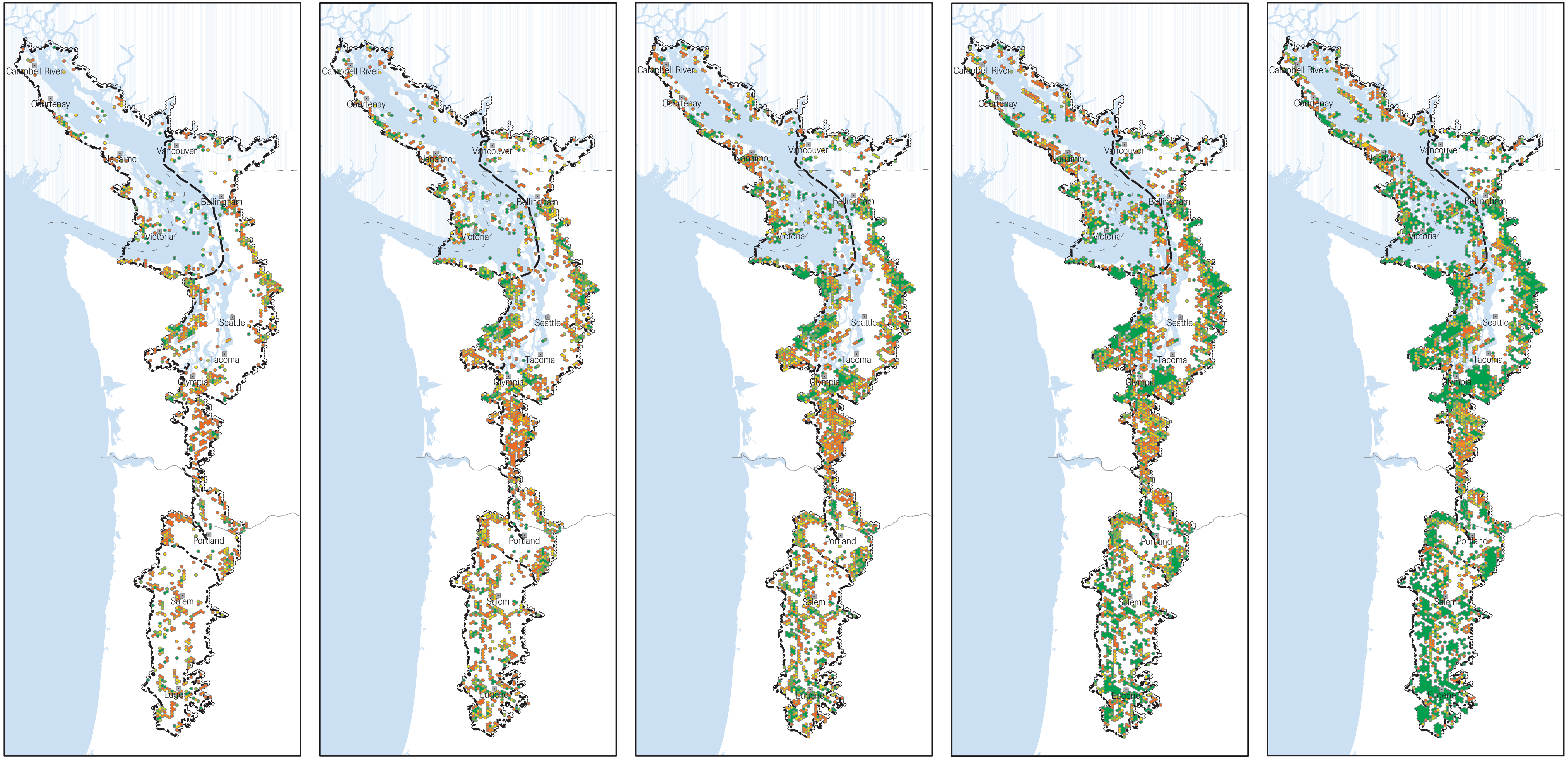
Conservation areas sorted by quartile for conservation value and vulnerability, and weighted toward landscape factors. Low, medium low, medium high, and high correspond to the first, second, third, and fourth quartiles, respectively. No marine areas are included in this list.

Conservation Value	Vulnerability: Low	Vulnerability: Medium Low	Vulnerability: Medium High	Vulnerability: High
High	Basket Butte Central Texada Island Indian Head/Horse Rock Ridge Lilliwaup Mt. Maxwell Snoqualmie Foothill Forest Upper Siuslaw Site Cypress-Sinclair Islands Lasqueti Island Nelson Island	Cowlitz Forest Corridor Cranberry Creek EE Wilson Forest Park-Coast Range Lower Skookumchuck McDonald Forest/Soap Creek Forest and Balds Mt Pisgah Reginald Hill Rocky Point, BC Saturna Island Shumocher Creek Sultan Foothill Forest Timber Grove Trial Island Weir Prairie and Forest Active Pass Discovery Island Quilcene Tarboo-Dabob Bay	Bald Hill Blackjack-Harewood Clear Creek Coast Fork/Middle Fork Willamette Riparian Ebey's Landing Fidalgo Head, Burrows Island Fidalgo Island Fort Lewis - McChord HABECK Oaks Kingston Prairie Lane Community College Basin Luckiamute River Riparian Muddy Creek/Finley Rocky Point, WA Thetis-Frances Toutle Forest Corridor Tuam-Bruce Willamette Narrows Ladysmith-Yellow Point Moran Sea to Sea Greenbelt Skokomish-Hood Canal Thorndyke West San Juan-Southern Lopez Islands Western Kitsap Peninsula	Black River - Mima Prairie Camassia Clackamas Corvallis-Philomath Oaks Drews Prairie Eola Hills Jackson Fraiser Wetlands Lacamas Meadows North Santiam River Riparian Rocky Prairie - Beaver Creek Satsop Watershed Sauvie Island Scatter Creek Washougal Oaks - Steigerwald West Eugene/Spencer Creek Comox Macrosite Cowichan Deception Pass Discovery Passage Dungeness Nanoose-Parksville Nisqually Skagit Stillaguamish River-Port Susan

Conservation Value	Vulnerability: Low	Vulnerability: Medium Low	Vulnerability: Medium High	Vulnerability: High
Medium High	Blakely Island Camano Head Camas Swale BLM RNA Dunn Forest Fox Hollow BLM RNA Hamilton Marsh Hamma Hamma Delta Harrison High Pass Minto Island Mount Woolard Savary Island Siebert and McDonald Creeks South Lummi-Lummi Mountain South Whidbey Forest Three Corner Lake Washburn Butte Wasp-Yellow Islands Young Hill Cortes Island Desolation Sound	Camp Creek Ridge Cogswell Foster Deer Creek Fern Ridge Reservoir Gales Creek James Island Jones Island Lewis and Clark State Park Maple Mt.-Mt. Richards North Fork Newaukum Ostrander Forest Block Point Robinson, Maury Island Snow and Salmon Creeks Tanwax Creek Ward Butte Pender Harbor Quadra Island Sucia-Matia-Patos Islands Turtleback-Deer Harbor	Buckley Hills Cedar Creek Chuckanut Mountain Golden Valley Hidden Oaks Lower Kalama North Texada Island Oak Creek USFWS Oak Ridge/Moore's Valley Orchard Heights Pudding River riparian Salem Hills/Ankeny NWR South Sunshine Stout Mountain Thetis-Kuper	Black Diamond Lake Coburg Ridge Green River Lacamas Riparian Logsden Ridge Lower Calapooia River Riparian Lower Englishman Lower Mckenzie Riparian Main Stem Willamette, Harrisburg to Corvallis Main Stem Willamette, McKenzie confluence to Harrisburg Main Stem Willamette, Mission Bottom area Middle Chehalis Otter Lake-Desire Lake Peterson Butte Royal Roads-Esquimalt Sandy River Skykomish Riparian Snoqualmie Riparian South Fork Yamhill River Yamhill Oaks Fraser Delta Samish

Conservation Value	Vulnerability: Low	Vulnerability: Medium Low	Vulnerability: Medium High	Vulnerability: High
Medium Low	Champoeg State Park Coulter Creek East Sooke Gabriola Island Grays Marsh Herando Island Horn Creek Lopez Hill Maxfield Creerk BLM Port Discovery Forest Sherwood Forest Discovery Bay Gabriola Pass Henry Island Lower Qualicum Padilla Bay Point Disney, Waldron Island Porlier Pass Scatchet Head Striped Peak	Campbell Creek Chimacum Forest Cloquallum Dayton Creek Eells Hill Lake Whatcom Pilchuck Riparian Point George, Shaw Island Rooster Rock/Mirror Lake State Park Sumas Mountain UBC Research Forest/Blue Hat and Saddlebag Islands Old Fort Townsend Squaxin-Hope Islands	Airlie Oaks Banks Swamp Bear Creek Oaks Buell Cedar River Cowlitz Riparian Crawfordsville Oak-Pine Savanna East Fork Lewis Riparian Jasper Prairie Lower Washougal Middle Fork Newaukum Nooksack Delta Oak Creek/Freeway Lakes Park Oregon Country Fair Pitt Macrosite Puyallup River Riparian Ryder Mt. Sequalitchew Marshes South Fork Newaukum Tualatin National Wildlife Refuge Willamina Oaks 1 Willamina Oaks 2	Amity Oaks Camas Swale Oaks Camp Wesley Harris Carbon River Plateau Cooper Mountain Gettings Creek Government Island Johns Creek - McEwen Prairie Lord Hill Main Stem Willamette, Corvallis to Albany Main Stem Willamette, Luckiamute-Santiam confluence area Nooksack Riparian Olympia Airport Pepin Creek Scio Oak Pine Savanna Seymour Narrows Silver Lake Watershed Solo Point - Farrell Marsh Waterloo Rocks White River Riparian Point Roberts-Boundary Bay The Narrows

Conservation Value	Vulnerability: Low	Vulnerability: Medium Low	Vulnerability: Medium High	Vulnerability: High
Low	Alderwood Wayside Deschutes Riparian Elk Creek Friday Harbor, San Juan Island Lake Hancock Little Sink RNA Lower Elwha Riparian Lyre River Maria Marina Island Mittlenatch Island Point Julia Forest The Butte RNA Twin Islands Van Ornum Creek Forest Weiss Rd BLM Oaks Fort Flagler Jedediah Island Jervis Inlet Malaspina - Copeland Maple-Genoa Bay Prevost Island Protection Island Race Rocks Sidney Island Thormanby Island Winchelsea Island	Bear Creek Wetlands Blake Island Calapooia Oak Savanna Corvallis Watershed Cougar Mountain Dillenbaugh Fishtrap Creek Indianola Forest Jimmycomelately Lower Coweeman McCully Mtn BLM McNeil Island Raging River Forest Rock Hill Silver Creek Stearns Creek Swamp Creek Wetlands Toboton and Lackamus Creeks Tulalip Bangor Dugualla Bay Indian Island Lummi Flats Port Gamble Stuart Island Toandos Peninsula	Blaney Bog Camas Swale Wetlands Coal Creek Forest Covington Creek Crescent Harbot Forest Issaquah Creek Riparian Mill Creek Missouri Ridge Mount Angel Reed Island Richardson Gap/Crabtree Wetlands South Prairie Riparian Tryon Creek Nature Park Buccaneer Bay Chemainus	Burn's Bog Dundee Oaks East Fork Issaquah Creek Johnson Hill Mission-Fraser Rattlesnake Oaks Salmon Creek Riparian Tualitan Hills Park Wapato Marsh Nanaimo



20% of standard goals for all targets — *40% of standard goals for all targets* — *60% of standard goals for all targets* — *80% of standard goals for all targets* — *100% of standard goals for all targets*

Relative Importance

Not Selected — *Low* — *High*

Willamette Valley - Puget Trough - Georgia Basin Ecoregion

Map 6.3: SITES Model Sensitivity Analysis with Suitability Index

Changes in site selection as conservation goals are increased and with the suitability index. Colors indicate the relative importance of a hexagon for meeting the conservation goals. Dark green hexagons must always be included in the solution. Yellow and orange hexagons can be swapped with other yellow or orange hexagons. As goals increase the number of hexagons selected also increases, and as goals increase there are fewer options for meeting the goals. This is indicated by the number of green hexagons, which increases with increasing goals. The suitability index directs the solution toward public lands and away from urban areas.

1 inch equals 65 miles

0 10 20 30 40 50 60 70 Miles

0 20 40 60 80 100 120 140 Kilometers

N W E S

Sources:
TNC, WDFW

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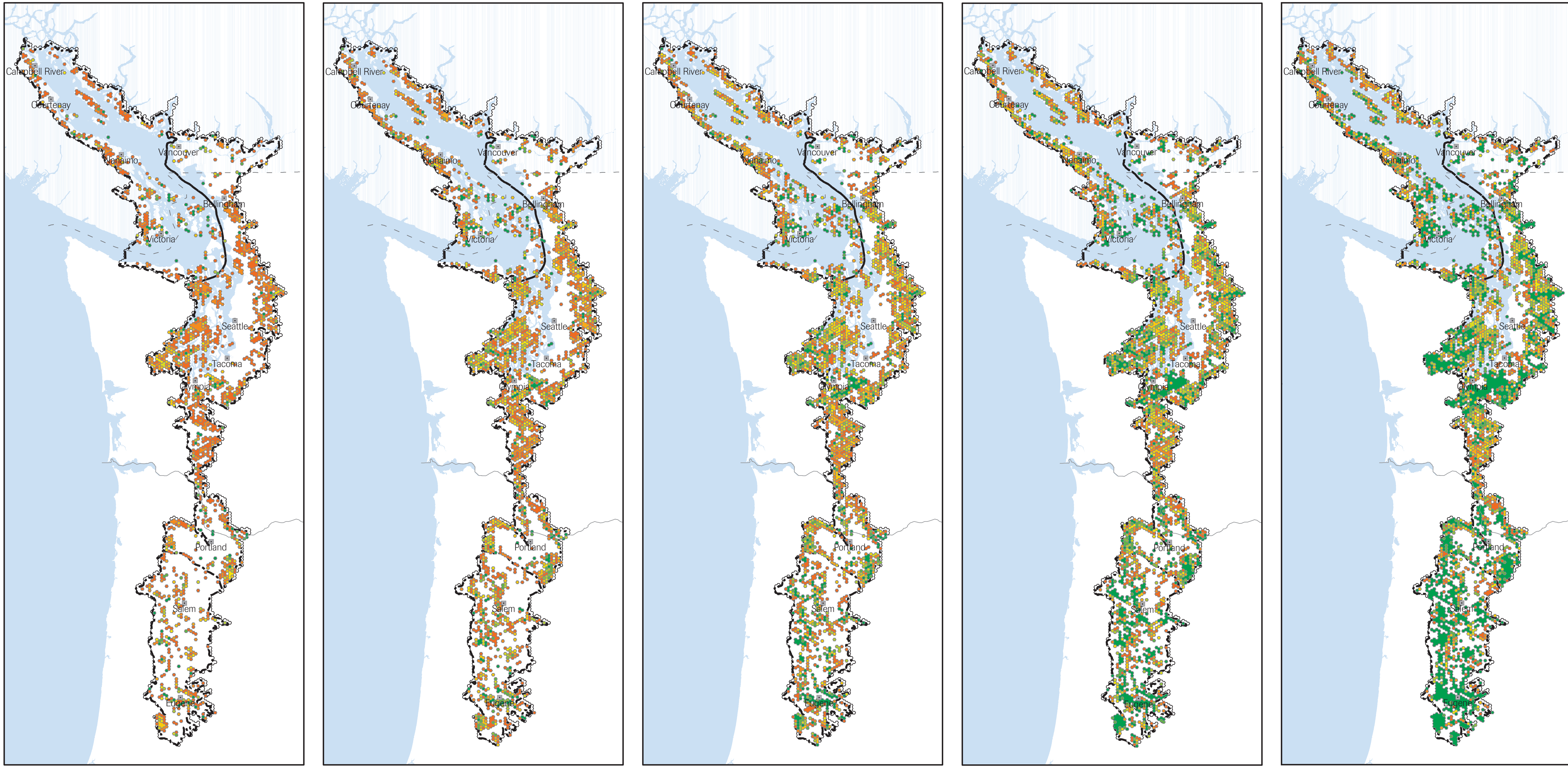

20% of standard goals for all targets

40% of standard goals for all targets

60% of standard goals for all targets

80% of standard goals for all targets

100% of standard goals for all targets

Relative Importance

Not Selected — Low — High

Willamette Valley - Puget Trough - Georgia Basin Ecoregion

Map 6.4: SITES Model Sensitivity Analysis without Suitability Index

Changes in site selection as conservation goals are increased and without the suitability index. Colors indicate the relative importance of a hexagon for meeting the conservation goals. Dark green hexagons must always be included in the solution. Yellow and orange hexagons can be swapped with other yellow or orange hexagons. As goals increase the number of hexagons selected also increases. As goals increase there are fewer options for meeting the goals. This is indicated by the number of green hexagons, which increases with increasing goals. Without the suitability index, the algorithm has more options to meet the conservation goals than with the index (see Map 6.6). Also, the solution is more dispersed without the index and will include hexagons where conservation is less feasible.

1 inch equals 65 miles

0 10 20 30 40 50 60 70 Miles

0 20 40 60 80 100 120 140 Kilometers

N W E S

Sources:
TNC, WDFW

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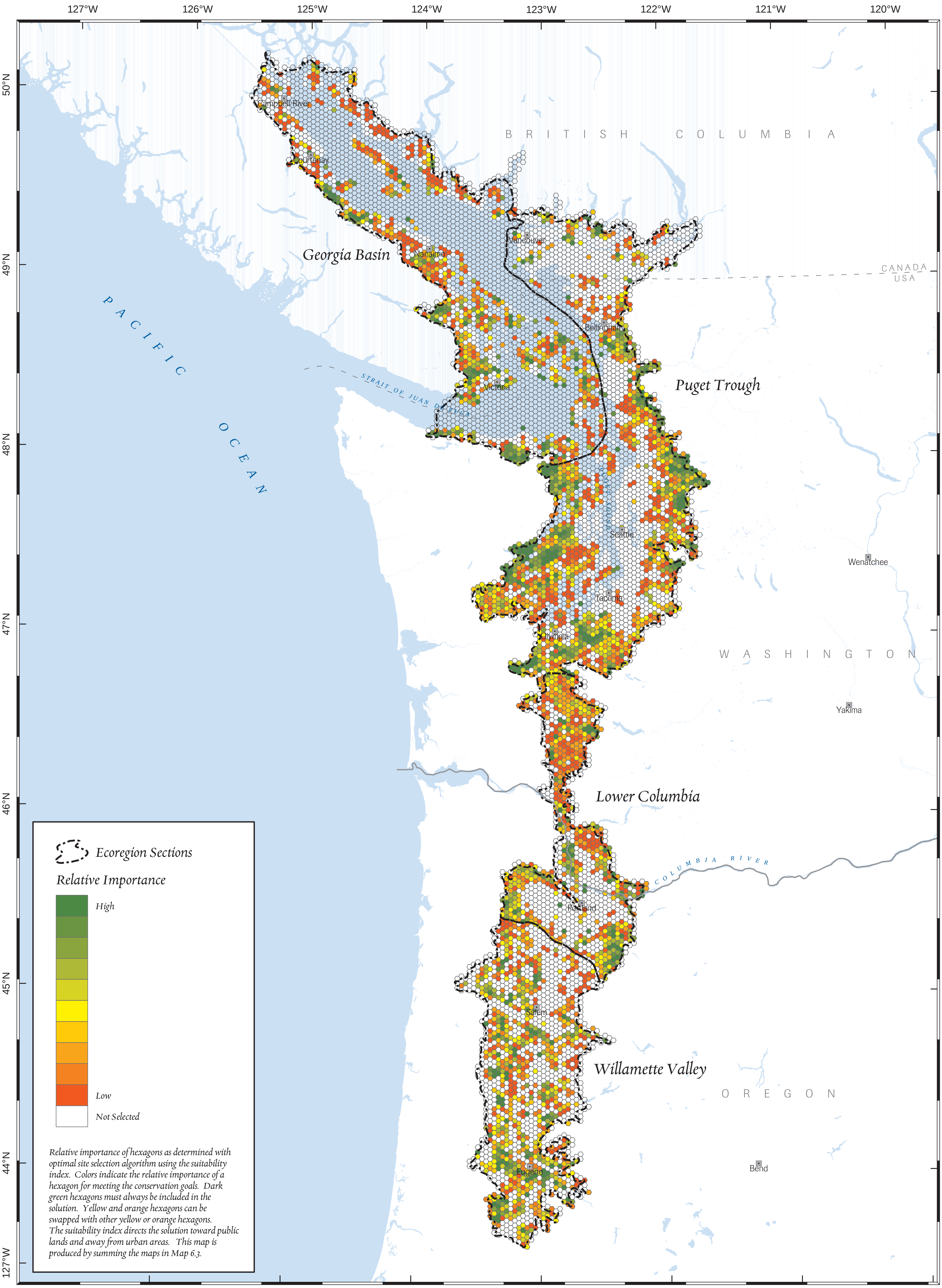

Willamette Valley - Puget Trough - Georgia Basin Ecoregion

Map 6.5: Sensitivity Analysis: Summed Solution with Suitability Index

1 inch equals 35 miles

0 5 10 15 20 25 30 35 Miles

0 10 20 30 40 50 60 Kilometers

N W E S

Sources:
MSRM, TNC, WDFW, WDNR, USGS

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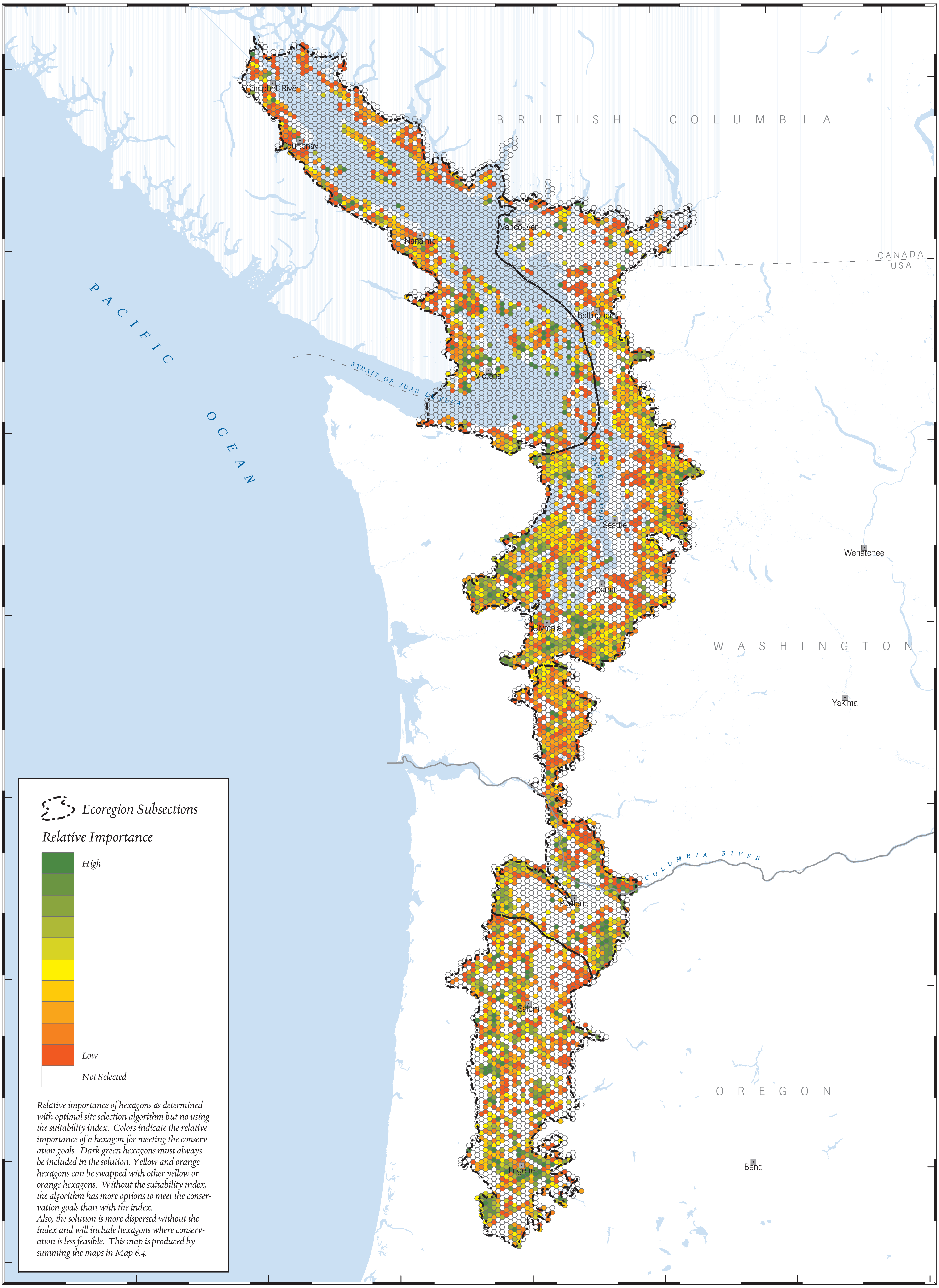

Willamette Valley - Puget Trough - Georgia Basin Ecoregion

Map 6.6: Sensitivity Analysis: Summed Solution without Suitability Index

1 inch equals 35 miles

0 5 10 15 20 25 30 35 *Miles*

0 10 20 30 40 50 60 *Kilometers*

N W E S

Sources: MSRM, TNC, WDFW, WDNR, USGS

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