VOLUME

1

REPORT

Okanagan Ecoregional Assessment

October 2006

Nature Conservancy Canada

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Washington Department of FISH and WILDLIFE

Okanagan Ecoregional Assessment

October 2006

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

Okanagan Ecoregional Assessment

Volume 1 – Report

Citation:

Pryce, B., P. Iachetti, G. Wilhere, K. Ciruna, J. Floberg, R. Crawford, R. Dye, M. Fairbarns, S. Farone, S. Ford, M. Goering, M. Heiner, G. Kittel, J. Lewis, D. Nicolson, and N. Warner. 2006. *Okanagan Ecoregional Assessment, Volume 1 – Report*. Prepared by Nature Conservancy of Canada, The Nature Conservancy of Washington, and the Washington Department of Fish and Wildlife with support from the British Columbia Conservation Data Centre, Washington Department of Natural Resources Natural Heritage Program, and NatureServe. Nature Conservancy of Canada, Victoria, British Columbia.

Issued by:
The Nature Conservancy of Canada
#300 – 1205 Broad Street
Victoria, British Columbia, Canada V8W 2A4
Email: bcoffice@natureconservancy.ca

Canadian Cataloguing in Publication Data:

ISBN 1-897386-00-1
1. Biological inventory and assessment – Okanagan.
I. Nature Conservancy of Canada.
II. Okanagan Ecoregional Assessment, Volume 1 – Report. Includes bibliographical references

Cover Design:
Paul Mazzucca
Vancouver, British Columbia

Cover Photo Credits:
Methow Valley, Robin Dye; Western screech owl, A.M. Bezener/One Wild Earth Photography; Great basin spadefoot toad, A.M. Bezener/One Wild Earth Photography; Seton Lake, Ian Routley; Townsends big-eared bat, Harry van Oort; Mormon metalmark, Orville Dyer; East Chopaka, Barbara Pryce; Mountain bluebird, Ian Routley; Sockeye salmon, Kristy Ciruna; Badgers, Philippe Verkerk; Lynx, Grant Merrill; Mountain lady's slipper, George Thornton; Long-billed curlew, Ian Routley; Similkameen River, Barbara Pryce.

Acknowledgements

A charter for the Okanagan Ecoregional Assessment was signed in October 2003 initiating a process to develop a biodiversity conservation assessment unprecedented in this geographic area. Since that time, many people have supported the project to develop this document and a set of tools to assist in the conservation of this ecoregion's unique, irreplaceable and vulnerable species, natural communities and ecological systems.

This ambitious undertaking would not have been possible without generous funding provided by the W. Garfield Weston Foundation, the Bullitt Foundation, the Icicle Fund, the Donner Canadian Foundation, the Nature Conservancy of Canada's British Columbia Region and National Offices, The Nature Conservancy's Washington Chapter, and the Washington Department of Fish and Wildlife. Funding was also provided by Parks Canada and through a state wildlife grant from the United States Fish and Wildlife Service. The British Columbia Conservation Data Centre, the Washington Department of Natural Resources' Natural Heritage Program, and NatureServe provided significant in-kind support to the Okanagan Ecoregional Assessment.

The authors want to thank a number of people who provided us with extraordinary data and expertise which greatly enhanced our assessment. Thank you to Dennis Lloyd of the Ministry of Forests and Range for giving us his biogeoclimatic ecosystem classification update in advance of publication; Orville Dyer of the Ministry of Environment for his work with the Animals Subteam and for providing us with the Okanagan Regional Wildlife Sitings Database; Peter Morrison of the Pacific Biodiversity Institute, Chris Chappell of the Washington Natural Heritage Program, George Wooten of Conservation Northwest and Terry Lillybridge and Rod Clausnitzner of the U.S. Forest Service all made significant contribution to the terrestrial ecosystem classification; Andrew Harcombe, Shane Ford, Carmen Cadrin and other staff at the BC Conservation Data Centre provided not only data, but guidance and expertise as well; Bruno Delesalle, Ryan Holmes and Graham MacGregor of the Grassland Conservation Council of British Columbia for provision of their extensive Priority Grasslands Mapping Initiative database and considerable expertise. We want to thank Brian Wikeem, Mike Ryan and Dave Jones who gave of their time and knowledge. Katherine Glew must be acknowledged for compiling information on lichens in the ecoregion and also Geoff Scudder for his participation on the Animals and Freshwater Subteams as well as his input during the process. Huilin Wang of the Washington Department of Fish and Wildlife did most of the GIS work for the irreplaceability analysis. Brad Thompson of the Washington Department of Fish and Wildlife re-analyzed the salmon EDT outputs and provided advice on how to use this information. Margaret Hartzell with the USFS was very helpful in arranging meetings with her staff early on so they could learn about the assessment and collaborate as appropriate and possible. Joe Peone, Rebecca Peone and Sheri Sears from the Colville Confederated Tribes deserve special praise for their expertise, provision of data, access to their staff and guidance as well as for allowing us to use their offices for workshops and meetings.

We are indebted to the many experts who participated in a wide variety of ways throughout the process to bring the Okanagan Ecoregional Assessment to completion. We have listed the many people who helped us in Appendix 3.

Okanagan Ecoregional Assessment Core Team

Leadership for the assessment process was shared between the Nature Conservancy Canada (NCC) and The Nature Conservancy (TNC). The Core Team members and their roles are listed below.

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Appendix 2 lists the many people who supported the Core Team through the assessment process

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EXECUTIVE SUMMARY

Ecoregional assessments provide a regional scale, biodiversity-based context for implementing conservation efforts. The intent of the assessments is to create a shared vision for agencies and other organizations at the provincial or state, regional, and local levels to form partnerships and ensure efficient allocation of conservation resources. The assessments identify a portfolio of sites for conservation action with a goal of protecting representative biodiversity and ecologically significant populations. These assessments are the result of rigorous scientific analyses, which incorporate expert review, and are the most comprehensive and current efforts to set conservation priorities at an ecoregional scale. Biodiversity conservation in an ecoregion will attain its fullest potential if all conservation organizations coordinate their strategies to protect and restore biodiversity according to the priorities identified in this process.

The Okanagan Ecoregional Assessment resulted in the selection of 430 conservation targets, including 220 terrestrial species targets, 48 freshwater species targets, 66 rare plant community types and 96 system targets. These system targets are the major ecological systems that make up the terrestrial and freshwater environments.

Conservation goals were set for each target. They defined the abundance and spatial distribution needed to adequately conserve each target in an ecoregion and provided an estimate of how much effort will be needed to sustain the targets well into the future. A suitability index was used to determine the areas of the ecoregion that had the highest likelihood of successful conservation. The suitability index incorporated five biological and non-biological factors: converted land (agriculture, urban, mining); level of protection (GAP status); urban proximity; road density; and fire condition. The conservation goals and the suitability index were used to develop a portfolio of priority conservation areas (PCAs) that represent characteristic landscape settings which support all of the ecoregion’s biodiversity.

The terrestrial portfolio (Map 22) includes 137 PCAs with an area of 3,093,000 ha (7,642,969 ac), which represents 32% of the total area of the ecoregion. The freshwater portfolio, including 135 PCAs, (Map 24) extends beyond the ecoregion boundary to capture whole watersheds. The portion of the portfolio falling within the ecoregion boundary, 113 PCAs, totals 3,301,359 ha (8,157,835 ac) and represents 34% of the ecoregion. The area of overlap between the terrestrial and freshwater portfolios represents 14% of the ecoregion (Map 26). These portfolios include 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 in these portfolios are regarded as having the highest likelihood of successful conservation according to the suitability factors used in the assessment. While integration of the Okanagan’s terrestrial and freshwater portfolios was not achieved, future iterations of this assessment will strive to produce a fully integrated portfolio.

Threats to biodiversity in the ecoregion were determined based on a literature review and on assessment team members’ experience and on-the-ground knowledge of the ecoregion, and interviews with experts who were knowledgeable about the area. The major threats to biodiversity in the Okanagan Ecoregion include:

- urban growth
- agricultural practices
- water management
- invasive species, pests, and pathogens
- roads
- transportation and utility corridors

- forest practices
- altered fire regimes
- climate change
- point/non-point source pollution
- recreational development and use

Approximately 23% of the terrestrial portfolio is currently in designated protected areas (Table 6.2, Map 23). In order to conserve the entire terrestrial portfolio, conservation strategies over the remaining portion of the portfolio, or 25% of the ecoregion, would need to be applied. Approximately 14% of the freshwater portfolio within the ecoregion is currently in designated protected areas (Table 6.4, Map 25). In order to conserve the entire freshwater portfolio within the ecoregion, conservation strategies over 30% of the ecoregion would need to be applied. These areas are not mutually exclusive.

This assessment resulted in a series of products that will be useful to those involved in biodiversity conservation in the Okanagan Ecoregion. These products can be used alone, in conjunction with one another, or with other information to enhance communication about on-the-ground conservation of biodiversity values in the ecoregion. The main products developed were

- terrestrial and freshwater ecological system classifications

- terrestrial and freshwater conservation portfolios showing the most important and suitable areas for conservation of ecoregional terrestrial and freshwater biodiversity, respectively. A summary of known target occurrences, land cover, land use, etc., is provided for each PCA along with an illustration of relative priority based on biodiversity value and suitability for conservation.

- irreplaceability maps showing the relative conservation value of all places in the ecoregion

- utility maps showing the relative conservation value and suitability for conservation of all places in the ecoregion

- overlaid terrestrial and freshwater portfolios showing the area of overlap between the two portfolios

- three scenarios for biodiversity conservation representing different levels of risk

Conservation projects within portfolio sites and high value assessment units (AUs) should receive special consideration. The conservation portfolios and irreplaceability and utility maps are useful for a full range of biodiversity conservation strategies; therefore, we encourage government agencies, non governmental conservation organizations and other conservation practitioners to consider these products in their work. To date, the Washington Department of Fish and Wildlife has committed to using the conservation utility maps in developing their State Comprehensive Wildlife Conservation Strategy (SCWCS) along with other governmental and non-governmental organizations. The Nature Conservancy uses portfolio sites to focus all of their on-the-ground conservation and policy work. Similar ecoregional assessments are being prepared for other ecoregions in support of Washington's and Oregon's SCWCS. In British Columbia, provincial government agencies will use the assessment to inform their decision-making. The Nature Conservancy of Canada will use the assessment products to develop a conservation program in the ecoregion. The ultimate vision of the ecoregional assessment process is to facilitate the thoughtful coordination of current and future conservation efforts by the growing number of federal, state, local, private and non-governmental organizations engaged in this field.

Chapter 1 – Introduction

The Okanagan Ecoregion is a biologically rich area consisting of numerous convergent ecological habitat types. The climate and abundant natural resources of the ecoregion have supported a rapidly expanding human population and agricultural industry; however, intensive land use threatens the region's biodiversity. Conservation organizations and government agencies are increasing their protection and restoration efforts in the region, but their limited resources make careful coordination of conservation efforts a necessity. To address the growing need for cooperation among these groups, the Nature Conservancy of Canada (NCC), The Nature Conservancy (TNC), and the Washington Department of Fish and Wildlife (WDFW), worked with various partners to complete an ecoregional assessment intended so that government agencies, non-governmental conservation organizations, and other decision makers and planners could direct their resources towards the most important places for conserving the ecoregion's biodiversity.

The purpose of the project was to use the best available information about the ecology of the region to identify lands and waters needed to maintain the biodiversity of the ecoregion. Assessment products that were developed include (1) a terrestrial portfolio and a freshwater portfolio of priority conservation areas (PCAs) that are of exceptional biological value and/or are the most likely places for conservation to succeed based on their current condition or status; (2) maps depicting the relative irreplaceability of all sites across the entire ecoregion; and (3) lower and higher risk portfolios depicting a wide range of options for the conservation of biodiversity. Numerous scientists and other experts from federal, state, provincial and local agencies, academia and conservation organizations contributed to this ecoregional assessment.

Assessment Methods

This assessment uses an approach developed by TNC (Groves et al. 2000; Groves et al. 2002) and scientists in other organizations to establish conservation priorities within ecoregions whose boundaries are defined by distinct climate, geology, landforms, and native species (Bailey et al. 1994). Similar assessments have been completed for 9 of the 14 ecoregions in southern Canada, 45 of the 81 ecoregions in the U.S., and several other ecoregions outside North America. The objective is to complete assessments throughout the U.S. and in many parts of Canada and other countries by 2008.

The Okanagan Ecoregion Core Team, comprised of six expert technical sub-teams, collaborated on a series of analyses. Three teams selected species, communities and ecological systems that served as terrestrial conservation targets; a fourth team selected animals and ecological systems that served as freshwater conservation targets. Conservation targets are those elements that were considered to represent optimal concentration of biodiversity. A fifth team developed an index of the threats to the conservation targets; the sixth team conducted the analysis and data management aspects of the project.

A computer program, MARXAN, was used to select the optimal portfolio of sites—i.e., that set of sites which met the goal of the most targets at the lowest cost, or the suite of factors thought to influence the likelihood of conservation success. Cost was minimized by selecting the most compact set of sites in areas rated as most suitable for long-term conservation. Site suitability was described by an index of existing land use and impacts. The MARXAN program then compared each part of the ecoregion against all others and analyzed millions of possible portfolios to select the most efficient alternative. Separate portfolios were created for terrestrial and freshwater biodiversity. The MARXAN tool was also used to generate maps depicting the relative irreplaceability of all sites across the ecoregion.

The technical teams then worked with MARXAN outputs to refine the terrestrial and freshwater portfolios based on expert review. Sites in both portfolios were prioritized for action based on the irreplaceability (biodiversity value) and suitability (biodiversity value and suitability for conservation) values encompassed by each site. These portfolios highlight areas of high conservation value for terrestrial and freshwater species and systems. The terrestrial and freshwater portfolios were then overlaid in order to identify areas of overlap between the two portfolios.

Using the Assessment

The Okanagan Ecoregional Assessment is a resource for planners, decision makers and others interested in the status or conservation of biodiversity in the region. This assessment has no regulatory authority; it is simply a guide for prioritizing conservation of habitats that support the extraordinary biological diversity of the ecoregion. The results of the assessment can be used to set conservation priorities, raise funds for conservation, measure progress, and influence how people think about the future of their ecoregion. The assessment should be used in conjunction with other biological information, particularly at more local scales, and with information about social and economic priorities to guide biodiversity conservation actions in the region.

The Report

The Okanagan Ecoregional Assessment consists of four separate documents. This document, the main report, contains an overview of the assessment process, methods and results. More detail on the methods, a glossary of terms, lists of participants, and references has been placed in separate appendices. Maps of the ecoregion, the terrestrial and freshwater ecological system classifications, and the various portfolios are in a separate volume. Summary reports for the terrestrial and freshwater priority conservation areas identified in the portfolios can be found in the site summary document.

The assessment report and the final product data are available to all interested parties. The Nature Conservancy of Canada, The Nature Conservancy, and the Washington Department of Fish and Wildlife will use the assessment results and those of similar assessments for other northwest ecoregions to prioritize projects and funding. Governments, land trusts, and others are encouraged to use the assessment as a supplementary resource to other planning information. It is our intent that the rich ecological landscape of the Okanagan region persist so that future generations of all species will prosper within it.

1.1 Okanagan Ecoregion Overview

General Description

The Okanagan Ecoregion occupies portions of south-central British Columbia (BC) and north-central Washington State (Map 1), and is 9,605,000 ha (23,724,350 ac) in area. About 69% of the ecoregion is in British Columbia; 31% is in Washington. Approximately 14% of Washington and 6% of British Columbia is within this ecoregion. The ecoregion supports one of the largest assemblages of nationally rare plant species in Canada and the greatest diversity of breeding bird species in British Columbia and Washington. Endemic species found within this ecoregion include the night snake (*Hypsiglena torquata*) and pygmy short-horned lizard (*Phrynosoma douglasii*). The ecoregion contains most of the remaining grasslands, shrub-steppe, and low-elevation dry forests in British Columbia. The low elevations of the Okanogan and Similkameen River valleys, where dry climate and desert-like habitats are northern extensions of the Great Basin, are particularly important for shrub-steppe species. This area is a critically important movement corridor into the mountainous areas of the western United States for wide-ranging carnivores such as grizzly bears (*Ursus arctos*), grey wolves (*Canis lupus*), lynx (*Lynx canadensis*) and wolverines (*Gulo gulo*). This biologically rich landscape is of international importance.

The Okanagan Ecoregion lies east of the crest of the Coast and Cascade Mountain ranges and west of the Columbia and Selkirk Mountains. The ecoregion is characterized by long, rounded ridges, rolling plateaus, wide valleys, and large lakes with the Thompson-Okanagan Plateau in the northeast and the Okanagan Highlands in the southeast. In the northwest and southwest portions of the ecoregion, the Chilcotin, Interior Transition, and Okanagan Ranges are characterized by rugged mountains and deep valleys. To the east, the mountains are more rounded, particularly the Kettle Range and Huckleberry Mountains in Washington (WDNR 2003). The south-central portion of the ecoregion contains the northern extent of Palouse grasslands—an area characterized by rolling, highly fertile loess hills, and scattered wetlands. The Sawtooth Ridge northeast of Lake Chelan marks the southwestern border of the ecoregion. In Washington, the ecoregion includes the Methow and Okanogan valleys and the Okanogan Highlands east to the Colville and Spokane valleys.

Elevations within the ecoregion range from below 300 m (1,000 ft) to peaks in the Interior Transition Ranges that are over 3,000 m (10,000 ft). Glaciation has left its imprint in the form of hummocky moraines, drumlinoid features, terraces, esker complexes, and glacial lake deposits.

Major water bodies in the western and northern portions of the ecoregion in British Columbia include the Thompson River and its lakes and tributaries which join the Fraser River at Lytton. To the east and south lie Okanagan Lake and the Similkameen River, which flows south into Washington State.

Development is concentrated in the Okanagan and Thompson valleys in British Columbia and in the Spokane, Colville, Methow and Okanogan valleys in Washington. In British Columbia, the ecoregion encompasses the Central-Okanagan and Okanagan-Similkameen, and part of the Squamish-Lillooet, Thompson-Nicola, North Okanagan, and Kootenay-Boundary, Columbia Shuswap and Fraser Valley Regional Districts. In Washington State, the ecoregion includes Okanogan, Ferry, Stevens counties, parts of Pend Oreille and Spokane counties, and the Colville Indian and Spokane Indian Reservations. Approximately 24% of historical grasslands in the British Columbia portion of the ecoregion have been lost to agriculture, urban and industrial development (Grasslands Conservation Council of British Columbia 2004). Ten percent of the Washington portion had been converted to agricultural or urban use as of 1991 (Washington GAP 1997).

1.1.1 Biogeographical Setting

Geologic and Glacial History

Continental and alpine glaciers played a major role in shaping the landforms of the Okanagan Ecoregion. The entire area was glaciated during the Pleistocene epoch. Extensive surficial moraines were deposited as the glaciers retreated, and lakes, such as Kamloops and Okanagan Lake, formed in the ice-carved depressions. Streams and rivers cut through the surficial moraines and created steeply incised gullies with exposed bedrock in transition areas between the headwaters and the lower-lying valleys. With the exception of the Cascades, bedrock is composed mainly of lava flows that extend southward from central interior British Columbia. The Cascades are composed of sedimentary rocks with some volcanics mixed with granites (Perrin and Blyth 1998).

Climate

The ecoregion has both the coldest climate in Washington and some of the hottest and driest weather recorded in British Columbia. The ecoregion is influenced by the extremes of hot, dry air from the Columbia Basin in the summer and cold, dense arctic air in the winter. The western part of the ecoregion is dry because it is within the rain shadow of the Coast and Cascade Mountains; however, precipitation increases to the east as air masses rise, cool, and drop moisture over the Rocky Mountains. Annual precipitation varies from less than 31 cm (12 in) in the greater Okanogan valley of Washington and British Columbia to 127–229 cm (50–90 in) in the Cascades. Most of the ecoregion lies within a 36–61 cm (14 to 24 in) precipitation zone. Throughout the region, fairly steep temperature and precipitation gradients occur from the mountains to the valleys (WDNR 2003; Scudder and Smith 1998; Environment Canada 2006).

Biotic Communities

The Okanagan Ecoregion can be described as transitional, with portions having characteristics of adjacent ecoregions; however, in British Columbia, the climate has created ecosystems that are not found elsewhere in Canada. Vegetation is dominated by three zones: the Bunchgrass Zone in the lower slopes of the large basins, the Interior Douglas-fir Zone on the lower elevations of the plateaus, and the Montane Spruce Zone on the higher elevations of the plateaus. Also present are the Engelmann Spruce - Subalpine Fir Zone on the higher elevations of the plateaus and highlands; the Alpine Tundra Zone on the highest slopes of the Okanagan and Clear Ranges; the Ponderosa Pine Zone sporadically on middle slopes of the large, dry basins; and the Interior Cedar - Hemlock Zone on the upper slopes in the northeastern area of the ecoregion.

Conifer forests dominate mountain ridges and low hills in the ecoregion, while valleys and lowlands are often non-forested. The conifer forests are more open and less continuous, consisting of smaller stands, than are forests west of the Cascade crest and in the Canadian Rocky Mountains. Douglas-fir–ponderosa pine (*Pseudotsuga menziesii–Pinus ponderosa*) forests characterize the ecoregion and grade to shrub-steppe in the low broad valleys in the eastern part of the ecoregion and to grasslands in the western part. Whitebark pine (*Pinus albicaulis*), lodgepole pine (*Pinus contorta* var. *latifolia*), and subalpine larch (*Larix lyallii*) form parklands in the highest elevations of the ecoregion and are often associated with dry alpine or subalpine meadows. Moister forests are dominated by Douglas-fir, with western larch (*Larix occidentalis*), western white pine (*Pinus monticola*) or trembling aspen (*Populus tremuloides*) as common components.

Historically, stand replacement fires occurred at irregular intervals from 10 years in the lowland foothills to 150 years or more at high elevations. Decades of fire suppression have resulted in a landscape composed of dense, fire-prone forests (WDNR 2003).

1.1.2 Socio-economic Environment

Approximately 925,000 people live in the Okanagan Ecoregion. Population levels have increased dramatically over the past 30 years, a trend that is particularly notable within the Thompson and Okanagan valleys of British Columbia and the Okanogan and Colville valleys of Washington. In the British Columbia portion of the ecoregion, there are more than 45 communities, and the five largest cities and towns had a total population of 266,560 in 2001 (Statistics Canada 2005). The northwestern portion of the ecoregion is less populated than the central and southern portions. The Okanagan-Similkameen Regional District, which encompasses Penticton, Princeton and Osoyoos, is predicted to undergo a 46% increase in population, growing from 78,100 in 1996 to an estimated 114,000 in 2026 (RDOS 2003). The Central Okanagan Regional District has the second highest rate of population growth in British Columbia (Statistics Canada 2005).

British Columbia's economy in 2006 is expanding at unprecedented rates. Residential and commercial development is flourishing, and the rate of job growth in British Columbia is Canada's highest at 8.3% (Government of British Columbia 2006).

In Washington, rural areas have generally been growing as fast as or faster than urban areas over the past 30 years, especially those which have access to major highways and airports. Population growth in the Ferry, Stevens and Pend Oreille County region grew from 27,085 to 59,058, or 118%, from 1970 to 2000. Most of this growth occurred in Stevens County due to people moving into the region, but Ferry and Pend Oreille counties also grew by 99 and 95%, respectively, due to immigration. During this same time period, Spokane County's population more than doubled from 1969 to 2002. Okanogan County grew from 24,701 in 1969 to 39,236 by 2002. The population on the Colville Indian Reservation in 2006 is approximately 7587; Tribal memberships on and off the reservation increased from 1970 in 1960 to 9082 in 2006 (U.S. Census Bureau 2000; Colville Confederated Tribes 2006).

The boom in urban and industrial development throughout the ecoregion is attributed to increasing population growth. Many communities are working to diversify their economies, particularly by expanding the small business sector and the accompanying infrastructure, training and partnerships needed to support that growth. Increasing development of nature heritage tourism, recreation, and other value-added natural resource businesses is also motivating communities to assess how they can balance rural values with dependency on economic change (Tri-County Economic Development District 2004; Children First 2004). High-tech and manufacturing sectors also continue to expand in communities in British Columbia (Statistics Canada 2005). Employment in farm and agricultural services dropped more than 9% across the region between 1970 and 2000 reflecting a general decline in livestock business, whereas the number of small businesses, particularly in retail and construction, increased mainly in Okanogan and Stevens counties (Sonoran Institute 2004).

Unemployment levels and long-term poverty rates are high across rural counties in the Washington portion of the ecoregion;,three counties are listed among the top ten stressed (a measure of socio-economic performance) counties in the Inland Northwest (Alexander et al. 2005). Conversely, unemployment and poverty rates in the British Columbia portion of the ecoregion are comparable to those in the rest of the province (Statistics Canada 2005).

People moving into the ecoregion generally have larger incomes than those moving out. Much of that income is in the form of investments, retirement income, and other non-labor sources (U.S. Census Bureau 2000; Statistics Canada 2005).

1.1.3 Land Ownership and Management

Approximately 44% of the Washington portion of the ecoregion is in federal or state ownership (Map 2, Table 1.1). The largest federal landowner is the U.S. Forest Service whose holdings include almost 947,000 ha (2,338,791 ac) or 32% of the Washington portion of the ecoregion. The holdings of the Washington Department of Natural Resources total 198,000 ha (489,700 ac) or 8% of the Washington portion of the ecoregion.

The Colville and Spokane Indian Reservations comprise approximately 19% of the Washington portion of the ecoregion. The Colville Indian Reservation is located in southern Okanogan and Ferry counties and consists of approximately 550,600 ha (1.36 million ac).

The 61,100 ha (151,100 ac) Spokane Indian Reservation lies in the southern part of Stevens County. The interests of these tribes extend well beyond their reservations; the Colville Tribes and the Spokane Tribe are sometimes actively involved in natural resource management and conservation issues on their historic tribal lands outside the reservations.

Approximately 95% of land in British Columbia is owned by the Crown, meaning that the provincial government retains ownership on behalf of its citizens. Similarly, within the British Columbia portion of the Okanagan Ecoregion, approximately 87% or 4.3 million ha (10.6 million ac) is Crown land (Table 1.1, derived from this Ecoregional Assessment). This includes provincial parks and protected areas which total about 6.5% of the ecoregion in British Columbia. This provincial land base is heavily encumbered by various tenured and untenured land and resource uses. Forest, range, guide-outfitting and trapping tenures cover most of the Crown land within the ecoregion. Recreation tenures apply to specific areas, whereas mineral claims are prevalent throughout the ecoregion.

Because most of the land in British Columbia is owned by the Crown, the provincial government is the major decision maker on how land and resources are allocated and managed. Several provincial government agencies have legislated mandates to ensure that Crown lands are used for the benefit of all British Columbians.

Approximately 11% of British Columbia portion of the ecoregion is privately owned. This represents a significant portion of valley bottom wetlands, grasslands and lower elevation slopes which have been converted to residential, urban and agricultural uses.

Table 1.1. Okanagan Ecoregion Land Ownership

Managed Land, Washington	% of the Washington Portion of the Ecoregion	% of the Okanagan Ecoregion
Federal Lands		
Forest Service: National Forest	23.6%	7.3%
Forest Service: Wilderness	8.3%	2.6%
Bureau of Land Management	1.4%	0.4%
National Park Service	1.6%	0.5%
Fish and Wildlife Service	0.6%	0.2%
Other Federal	1.4%	0.4%
State Lands		
Department of Natural Resources: Trust Lands	6.3%	1.9%
Department of Fish and Wildlife	1.0%	0.3%
Department of Natural Resources: NRCA and NAP	0.4%	0.1%
Parks and Recreation	0.2%	0.1%
Other State	< 0.1%	

Managed Land, British Columbia	% of the BC Portion of the Ecoregion	% of the Okanagan Ecoregion
Provincial Crown Land*	77.2%	53.3%
Private Land	10.8%	7.4%
Provincial Park or Protected Area	9.4%	6.5%
Indian Reserve	2.5%	1.7%
Federal Land	<0.1%	<0.1%
Conservation Trust Land	<0.1%	<0.1%

* includes land managed under a Tree Farm License

Managed Land, Washington	% of the Washington Portion of the Ecoregion	% of the Okanagan Ecoregion
Other Lands		
Private Land	36.1%	11.2%
Tribal Land	19.1%	5.9%
County or Municipal	< 0.1%	< 0.1%
Conservation Land	< 0.1%	< 0.1%

1.1.4 Land Use History of the Okanagan Ecoregion

Historically, native peoples moved between the valleys and mountains in the ecoregion and traded with other tribes to meet their seasonal and year-round needs. The traditional economy of these peoples consisted of seasonal hunting, fishing and gathering, and trading with other families and tribes. Resources from roots and game to fish and berries were geographically scattered; therefore, the native peoples lived a generally nomadic lifestyle based on gathering these resources, but they did establish more permanent winter settlements that were used as storage and field camps and were located near important gathering and processing areas (Wilson 1990; Thomson 1994).

The acquisition of horses from native peoples to the south and later contact with Europeans vastly changed the traditional way of life of aboriginal people in the region (Mather, no date). In 1811, explorer David Thompson of the Northwest Fur Company traveled down the Columbia River through Kettle Falls and initiated the fur trade era in the region (Wilson 1990). Fur traders established posts on the Spokane River and at the confluence of the Columbia and Okanogan Rivers, which accelerated cultural changes among native people by introducing them to fur trapping and European agricultural practices. The establishment of Fort Okanagan at the confluence of the Columbia and Okanogan Rivers in 1811 supported the northward expansion of the fur trade through the Okanagan valley to the present city of Kamloops (Mather, no date). As the Hudson's Bay Company established forts to supply goods to trappers who collected beaver pelts for the fur trade (Mather, no date), the native peoples developed more sedentary ways of life.

In the 1830s, missionaries arrived and began teaching English and agriculture as part of a broader strategy for converting the semi-nomadic native people into sedentary farmers. Prospectors and homesteaders anxious to claim new lives and lands in the West arrived soon thereafter. This expansion created the need for recognized boundaries. In 1848, the Oregon Treaty was established and the 49th parallel was designated as the boundary between British and American continental territories west of the Rocky Mountains. The British and American Joint Boundary commission began to survey and mark the 49th parallel in 1856. It was also during this time that native people began to struggle with the emerging governments about their rights to land. In British Columbia, native people believed their 1858 agreement with the new Colonial Government would be followed by full negotiations. Further negotiations did not occur, and the Imperial Agreement was used to establish Crown lands, ensure greater access to land throughout the Okanagan for settlers, and restrict native people to reserves.

The discovery of gold in the Lower Fraser River in 1858 sparked a gold rush that attracted prospectors across the border. In 1860, the Land Ordinance was developed to provide for the acquisition of 160-acre parcels of land by British citizens for a low price with the conditions that they must continuously occupy the land and make improvements. By the 1870s, the economy of the Okanagan in British Columbia was diversifying as ranchers, miners, and other settlers began to develop timber and other natural resources on their lands (Mather, no date).

While the Gold Rush brought thousands of people through the Okanagan to the Cariboo region of British Columbia, some stopped short in present day Washington State and began prospecting the lands and waters around the Pend Oreille, Columbia and Kettle Rivers. As in Canada, tension and conflicts grew as these miners and other homesteaders began to encroach onto the lands of the native peoples. In an attempt to reduce these conflicts, the Colville Reservation was created by presidential order in 1872. Changes to the boundaries of this initial reservation began only three months after being established when the Spokane and Kalispel Reservations were split off to accommodate the expanding populations of European settlers east of the Columbia River. Then, in 1892, the U.S. government declared the North Half of the reservation public domain, and it was opened for mining, timber cutting, and homesteading. By 1900, the native people had been allotted about one third of the lands, and the South Half of the reservation was opened for homesteading (Colville Confederated Tribes 2004; Kirk and Alexander 1990).

Work on the National Railway in British Columbia began in 1880, which stimulated growth in the beef and lumber industries. This lead to an increase in the number and size of settlements across the land. Over time, as agricultural and timber operations expanded and farmers and loggers were better able to transport their products to markets, agriculture and forestry grew into important industries (Kirk and Alexander 1990; Wilson 1990).

Around 1867, fruit growing added to the economic base of the Okanagan region (Fisher 1978). Orchardists used water from nearby rivers and lakes for irrigation, and advances in irrigation and pest control technology stimulated a shift from cattle ranching to crop farming on both sides of the border in the 1920s.

Lumber, livestock, apple growing and other related industries such as packing warehouses and shipping businesses created many new jobs throughout the 20th century. In Washington, the construction of the Grand Coulee Dam in 1938 and the filling of Lake Roosevelt flooded sacred Indian burial grounds, destroyed salmon spawning areas and inundated some productive agricultural lands. It also expanded the types of jobs available and opportunities for further development as electricity and irrigation were extended to additional parts of the region (Colville Confederated Tribes 2004; Kirk and Alexander 1990).

In British Columbia, 26% of farmland in the Okanagan valley was converted to non-agricultural uses between 1971 and 1986. New technologies supported a shift from the small timber operations in the lowlands to large-scale harvest of trees at high elevations. Forestry dominated the economy of the South Okanagan and Similkameen areas of British Columbia and portions of the Okanagan Ecoregion in Washington during this time. However, in recent years, prices as well as restructuring of the industry have made it less economically viable. In British Columbia, forest industry facilities and operations continue to support local economies throughout the ecoregion. In Washington, sawmills at Oroville, Omak and Colville continue to play a role in supporting the forest industry.

1.2 Biodiversity Status of the Okanagan Ecoregion

The Okanagan Ecoregion is considered unique because it is an ecosystem that contains elements of a number of biomes within British Columbia and Washington, which has resulted in unusually high species richness. The rain shadow effect of the Cascade Mountains on the southern interior of British Columbia and the Columbia Basin of Washington creates dry conditions that result in a number of rare habitats (e.g., grasslands, shrub-steppe and lowland dry forests) and unique assemblages of these habitats with wetland, riparian, mesic forest, cliff and talus habitats. Not surprisingly, these habitat characteristics result in rare and unique communities of flora and fauna.

The ecoregion has one of the largest assemblages of nationally rare plant species in Canada, probably surpassed only by the Carolinian forests of southwest Ontario and the Garry oak (*Quercus garryana*) and associated ecosystems of southeast Vancouver Island. This may be attributed to the hot, dry summer climate of the region, which provides suitable growing conditions for many species that are typically restricted to the arid intermontane regions of the United States. Many of these species are restricted to valley bottom environments and have probably declined significantly as lowland ecosystems have been depleted by agricultural and urban development. The Okanagan Ecoregion is less unique in the United States. Its flora is largely typical of other intermontane areas of Washington, Idaho and Oregon.

The Okanagan Ecoregion supports some of the greatest diversity and largest number of breeding bird species in British Columbia. It is home to 74% of all bird species known to occur and 70% of all species known to breed in the province. The greater sage-grouse (*Centrocercus urophasianus*) and the burrowing owl (*Athene cunicularia*) have been extirpated from the BC portion of the ecoregion. Burrowing owl reintroduction and recovery efforts in British Columbia are ongoing, and success will be monitored over time (John Surgenor, 2006, pers. comm.). There have been no recent greater sage-grouse reintroduction efforts in British Columbia. Fifteen other red-listed bird species occur within the British Columbia portion of the ecoregion, and more than four species are listed as threatened or endangered within the Washington portion. The Similkameen River Slough, which includes part of Washington's Palmer Lake, has the highest breeding bird diversity recorded in the Washington Gap Analysis (Cassidy et al. 1997). Conservation of grassland, wetland and riparian habitats is critical for protecting many of the bird species that occur within the ecoregion.

Mammal occurrences also reflect the wide variety of habitats available within the ecoregion. It supports a wide variety of bats, with 14 of the 20 species that occur in British Columbia occurring in the South Okanagan (Harper et al. 1993). The ecoregion also supports many ungulate species including mule deer (*Odocoileus hemionus*), white-tailed deer (*Odocoileus virginianus*), elk (*Cervus canadensis*), moose (*Alces alces*), bighorn sheep (*Ovis canadensis*), and mountain goats (*Oreamnos americanus*). Three of the four red-listed mammal species of the ecoregion are associated with grassland habitats; they include the pallid bat (*Antrozous pallidus*), white-tailed jackrabbit (*Lepus townsendii*) (now extirpated), badger (*Taxidea taxus*) and western red bat (*Lasiurus blossevillii*), the latter of which is associated with diminishing riparian habitats (BC Ministry of Environment 1998). Wide-ranging carnivores occurred throughout much of the ecoregion, but some are now thought to be extirpated and those that remain have greatly declined in abundance. While grizzly bears and fishers (*Martes pennanti*) still occur in the northernmost portions of the ecoregion, they once occurred in larger numbers in Washington where they are now listed as endangered. Wolverines, grey wolves, and lynx still occur in the ecoregion, but wolves may only occasionally travel south into the Cascades of Washington.

The ecoregion is the only place in British Columbia where the red-listed tiger salamander (*Ambystoma tigrinum*) (Hallock 2005a) and night snake (St. John 2002) and the blue-listed Great Basin spadefoot (*Spea intermontana*) (Hallock 2005b) can be found. The northern leopard frog (*Rana pipiens*) (red-listed) historically occurred within the ecoregion but is now extirpated (BC Ministry of Environment 1998; McAllister 2005). The pygmy short-horned lizard is also red-listed and is presumed to be extirpated from the ecoregion (St. John 2002).

The mormon metalmark (*Apodemia mormo*) and Behr's hairstreak (*Satyrium behrii*) are two red-listed butterflies that are associated with grassland habitats in the southern Okanagan area of British Columbia. Extensive surveys have been conducted to identify locations where they and other rare invertebrates occur within this portion of the ecoregion. While a great number of invertebrate species are likely to be at risk within the ecoregion, attention to the conservation status of invertebrates has focused on butterflies, dragonflies and mollusks.

A number of anadromous and freshwater fish species occur within the ecoregion. Anadromous species include the Pacific lamprey (*Lampetra tridentata*), steelhead (*Oncorhynchus mykiss*), chinook salmon (*Oncorhynchus tshawytscha*), sockeye salmon (*Oncorhynchus nerka*), and white sturgeon (*Acipenser transmontanus*). Freshwater fish species include native and transplanted populations of rainbow trout (*Oncorhynchus mykiss*), introduced brook trout (*Salvelinus fontinalis*), and native populations of Dolly Varden (*Salvelinus malma*), mountain whitefish (*Prosopium williamsoni*), lake chub (*Couesius plumbeus*), redside shiner (*Richardsonius balteatus*), and pikeminnow (*Ptychocheilus oregonensis*) (Demarchi 1996).

The southern portion of the Okanagan valley in British Columbia has become a focal point within the ecoregion because it supports most of the remaining grasslands, shrub-steppe, and low-elevation dry forests in British Columbia. The continuing loss of these habitats has placed many species at risk of extirpation or extinction in British Columbia and Canada. For example, the South Okanagan provides habitat for 30% of the vertebrate species that are red-listed in British Columbia, including 15 bird, 4 mammal, 2 reptile, and 2 amphibian species. Many more species would be added to this list if invertebrate and plant species at risk were included. The lowland habitats these species require are being threatened by housing and commercial development, road building, golf course development, agricultural development (especially orchards and vineyards), livestock grazing, logging and other silviculture activities, human recreation, and other human activities (Lea and Douglas 1991; Harper et al. 1993; BC Ministry of Environment 1998). Sixty percent of the original grassland and shrub-steppe habitat in this portion of the ecoregion has been altered by development; only 9% has not been disturbed in some way (BC Ministry of Environment 1998). Additionally, 85% of the wetland and stream-side habitats have been lost (BC Ministry of Environment 1998). Urban and industrial development in the British Columbia portion of the Okanagan Ecoregion has led to the disappearance of approximately 25,000 ha (61,750 ac) of the region's grasslands, with most of this loss having occurred around towns and cities in the Okanagan and Thompson Pavilion Grassland Regions. Towns such as Armstrong, Keremeos and Oliver have lost over 95% of their historic grasslands. In total, over 69,000 ha (170,430 ac) of native grasslands have been converted to agriculture in these Grasslands Regions (Grasslands Conservation Council of British Columbia 2004).

Ecoregional assessments are used to develop conservation strategies for species and habitats without regard to jurisdictions; however, they do take into account the fact that management activities within political borders can affect the status of species, habitats and ecological communities.

The international border has divided the landscape so that only a small area of British Columbia and Canada supports grasslands, shrub-steppe, and low-elevation dry forest habitats. Consequently, species associated with these habitats are likely to be listed as vulnerable to extirpation or extinction in the province and country. However, because some of these habitats and species are more abundant in Washington, they cannot officially be considered in species evaluation risks in British Columbia. While the larger habitat reserves in Washington are valuable to species and help ameliorate losses of species at the periphery of their range (i.e., in the South Okanagan), there is great value in conserving the broadest extent of species and habitats to protect against random and catastrophic population and environmental events (e.g., disease epidemics, genetic drift, climate change, fire, deforestation) that can decimate populations. The unique array of rare habitats and species that make up British Columbia's South Okanagan is an important part of the Okanagan Ecoregion and is an important link between the larger Columbia Basin in Washington and the grassland habitats of the Thompson and Nicola drainages in the northern and northwestern portions of the ecoregion.

The international border presents another consequence to biodiversity conservation within the ecoregion. Washington has historically supported populations of wide-ranging carnivores, including grizzly bears, grey wolves, wolverines, fishers, and lynx. However, only a small population of lynx (<40 individuals) and an even smaller population of wolverines (<10) are thought to exist in the state. Populations of wide-ranging carnivores in Washington depend on demographic support from larger populations in British Columbia to sustain them. All of these species are protected in Washington; however, only grizzly bears are protected in some areas of British Columbia. Whereas British Columbia may benefit from demographic support from Washington for species that use grasslands, shrub-steppe, and lowland dry forests, Washington depends on British Columbia to retain habitat connectivity within high-elevation forests and mountain ranges so that populations of wide-ranging carnivores can be sustained.

1.3 Ecoregion Boundary

The study area boundary for this Okanagan Ecoregional Assessment corresponds very closely with the British Columbia Ecoregion Classification system delineation of the Southern Interior Ecoprovince (SIR) (Demarchi 1996). The boundary for the SIR was extended into Washington State as part of the Shining Mountains Project, which was developed in the 1990s by the provincial government with numerous federal, provincial and state government, academic, and First Nations/Tribal partners in British Columbia, Alberta, Yukon, Alaska, Washington, Idaho and Montana. The purpose of the Shining Mountains Project was to determine the extent and distribution of regional and zonal ecosystems that British Columbia shared with its neighbouring jurisdictions (BC Ministry of Sustainable Resource Management 2005). In Washington, the boundary also corresponds with an ecoregion framework that was based on Bailey's ecoregion map for the United States (Bailey et al. 1994) and was further refined by agencies and other organizations in Washington and Oregon (Pater et al. 1998).

The British Columbia Ecoregion Classification system and its extension into Washington through the Shining Mountains Project, stratifies terrestrial ecosystem complexity into discrete geographical units at five levels. At the two broadest levels (ecodomain and ecodivision), British Columbia's ecosystems are placed in a global context. The three lower levels (ecoprovince, ecoregion and ecosection) become progressively more detailed and relate ecosystems to each other on a provincial and state scale. The three lowest levels describe areas of similar climate, physiography, hydrology, and vegetation (Demarchi 1996). Map 3 shows the Okanagan ecosections, and their descriptions are found in Appendix 7.

For the purposes of this ecoregional assessment, the Okanagan Ecoregion boundary was modified to reflect the improved terrestrial ecosystems mapping in the ecoregion. The southwestern boundary was moved west to include all of the Hozameen Range and Leeward Pacific Ranges; the boundary was modified in the north/northeast to include the Tranquille Upland and Northern Okanagan Highland and to exclude the Selkirk Foothills in the east.

The southern boundary of the Okanagan Ecoregion, which is shared with the Columbia Plateau Ecoregion, was modified to follow the boundary delineated by the British Columbia Ecoregion Classification except for the segment from the Little Spokane/Spokane Rivers confluence to the Canadian Rocky Mountains Ecoregion boundary. By excluding the southerly aspects of the Columbia River Canyon from the Okanagan, the SIR boundary better depicts the floristic/vegetation/ecological system affinities between the Okanagan and Columbia Plateau Ecoregions. The Little Spokane/Spokane Rivers confluence to the Canadian Rocky Mountains ecoregion segment (Bailey ecoregion delineation) was retained because it includes a vegetation pattern that is more similar to the Okanagan than the Columbia Plateau.

The boundary between the Okanagan and the neighbouring East Cascades ecoregion follows a watershed boundary, which is consistent with the rationale used by TNC in delineating the East Cascades and West Cascades Ecoregions. The boundary shared by the Okanagan and North Cascades ecoregions in Washington follows watershed boundaries, which is consistent with the rationale used in delineating the Cascades ecoregions. The northwestern-most segment of the Okanagan follows the southern-most boundary of an ecoregion section located primarily in British Columbia.

The SIR boundary generally corresponds to vegetation zones with the exception of the Ponderosa Pine Zone south of Spokane. This zone does not extend as far south as is depicted in the Shining Mountains Project. The final ecoregion boundary incorporates both the original ecoregion boundary and the SIR boundary. Figure 1.1 provides a graphical representation of the ecoregion boundaries and subsequent modifications.

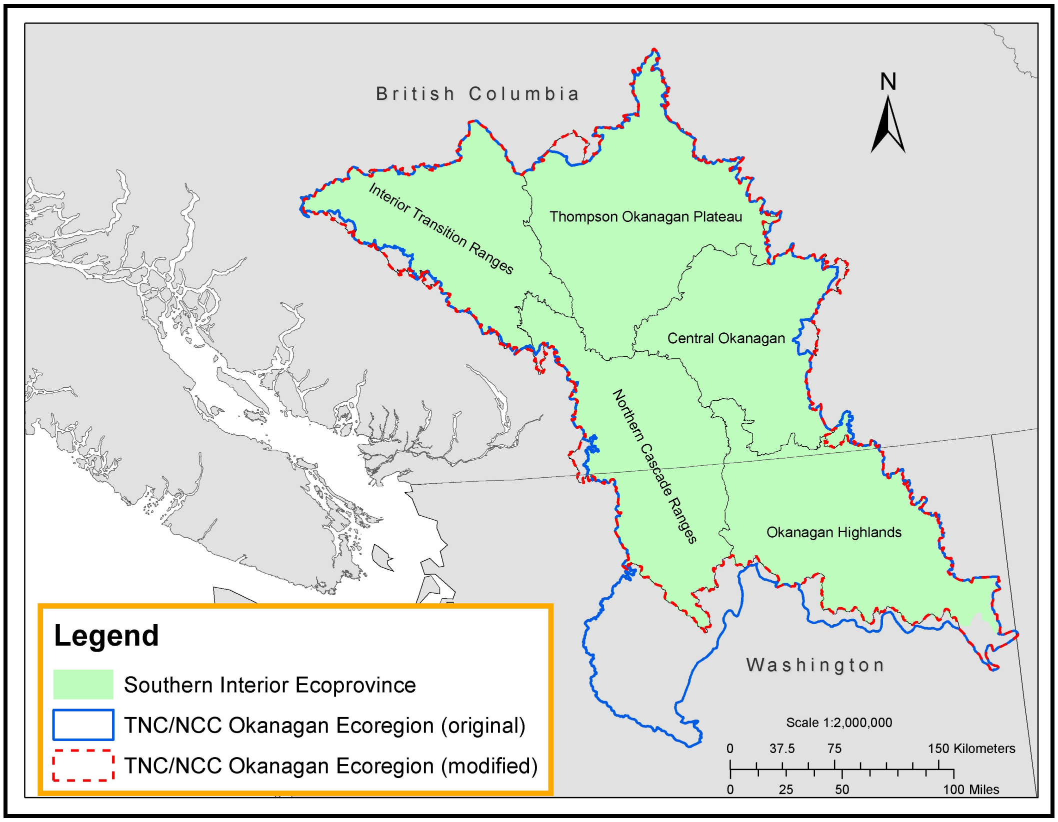

Figure 1.1. Okanagan Ecoregion Boundary Modifications

1.3.1 *Terrestrial Ecosections*

The Okanagan Ecoregion is divided into five ecosections that generally correspond to the British Columbia ecoregion delineation described in the Shining Mountains Project (except for the Thompson Okanagan Plateau, which was split into two sections as shown in Map 3). The ecosections are

- Interior Transition Ranges—entirely in British Columbia and covers the north-western portion of the ecoregion in the Lytton and Lillooet areas
- Thompson Okanagan Plateau—entirely in British Columbia and covers the northern portion of the ecoregion in the Merritt, Kamloops and Salmon Arm areas
- Central Okanagan—entirely in British Columbia and covers the eastern portion of the ecoregion in the Okanagan Lake, Penticton, Kelowna, and Vernon areas
- Okanagan Highlands—mostly in Washington and covers the south-eastern portion of the ecoregion from Skaha Lake and Osoyoos, British Columbia and into the Oroville, Tonasket, Omak areas of Washington, then east to the Inchelium, Colville, and Spokane areas
- North Cascades Ranges—shared by British Columbia and Washington in the south-western portion of the ecoregion and covers the Princeton area in British Columbia and the Winthrop and Twisp areas in Washington

Ecosections are an essential element of the assessment as they are used to stratify the ecoregion along ecological lines. Stratification ensures that the distribution of priority conservation areas reflects the distribution of biodiversity attributes that characterize the ecoregion and thus captures the genetic diversity of species and the varied composition of habitats in the ecoregion. The resulting conservation portfolio will be highly representative of biodiversity across the ecoregion. Appendix 7 provides detailed descriptions of terrestrial ecosections in the Okanagan Ecoregion.

1.3.2 *Freshwater Ecological Drainage Units*

Ecological Drainage Units (EDUs) are groups of watersheds that share a common zoogeographic history and physiographic and climatic characteristics (Map 4). We expect that each EDU will contain sets of freshwater systems with similar patterns of drainage density, gradient, hydrologic characteristics, and connectivity. This assumption is based on a large body of research that indicates that drainage basin and physiography strongly influence freshwater biodiversity patterns (Pflieger 1989; Maxwell et al. 1995; Angermeier and Winston 1999; Angermeier et al. 2000; Oswood et al. 2000; Rabeni and Doisy 2000). EDUs can be equated to terrestrial ecoregions largely because their biogeographic patterns and spatial extent are comparable. For our ecoregional assessment purposes, EDUs provide a means of stratifying freshwater systems and species in order to set appropriate goals for freshwater biodiversity conservation. The EDUs that intersect the Okanagan Ecoregion are the Middle Fraser, Thompson, and Okanagan (Map 5). The Upper Fraser EDU does not intersect the ecoregion, but it is part of the whole Fraser system, so it was included in the analysis. The Lower Fraser and Fraser Canyon and Puget Sound EDUs were assessed as part of the North Cascades and Pacific Ranges Ecoregional Assessment (Iachetti et al. 2006). The description of ecosections in Appendix 7 summarizes the physiography and climate of these EDUs. Appendix 7 also summarizes the zoogeographic history of these units.

1.3.3 Assessment Units

In order to address the complexity and large amount of data used in the analyses, the assessment team chose to use the optimal reserve selection algorithm MARXAN (Ball and Possingham 2000; Possingham, et al. 2000), which has been used in a variety of terrestrial and aquatic conservation assessments around the world. It uses an optimization algorithm to select a system of spatially cohesive reserves that meet a suite of ecological and site suitability criteria.

Assessment units (AUs) are used in MARXAN. They provide the framework for compiling data on the distribution of biodiversity features within the ecoregion (Warman et al. 2004). Assessment units are attributed with the target data located within their boundaries (Appendix 12). They are also attributed with data used in the Suitability Index (Chapter 4.0). Determining the type and size of assessment unit involves making a number of tradeoffs such as consistency in size, spatial resolution, natural versus geometric shapes and others. The size of the assessment unit will determine the spatial resolution of the analysis (Floberg et al. 2004). A more complete discussion of the rationale for selecting assessment units in the Okanagan Ecoregional Assessment is given in Appendix 8.

Our assessment used two types of assessment units. For the terrestrial analysis, we used 500-ha (1,236 ac) hexagons as assessment units (Map 6). For the freshwater analysis, we used third-order watersheds in British Columbia and watershed units from the Interior Columbia Basin Ecosystem Management Project[1] for the Washington portion of the ecoregion.

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[1] URL: http://www.icbemp.gov/

Chapter 2 – The Assessment Process

This section provides a brief overview of the main steps used to develop this ecoregional assessment. More detail on methods can be found in later chapters and appendices.

Six technical teams followed a methodological framework developed by Groves et al. (2000, 2002). The teams were as follows: terrestrial plant associations and ecological systems; freshwater ecological systems; plant species; animal species; assessment of impacts on biodiversity; and GIS/data management. Each technical team contributed to the steps described below and adopted innovations where necessary to address specific data limitations and other challenges.

In addition to the technical teams, a field team was assembled to conduct outreach to Okanagan communities, organizations, and individuals that were needed to effectively link the ecoregional assessment process to conservation program development in British Columbia and Washington. The efforts of all subteams were coordinated by the Core Team. Appendices 2 and 3 list assessment team members.

2.1 Identifying Conservation Targets

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

Robert Jenkins, who worked 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). The coarse-filter approach hypothesizes that conservation of multiple examples of all communities and ecological systems will also conserve the majority of species that inhabit them. This approach is a way to compensate for the lack of information on poorly studied species and species that are still unknown to science.

Fine-filter targets are species that cannot be assumed to be captured by coarse-filter targets. Fine-filter targets warrant special effort to ensure they are represented in the conservation assessment. They are typically rare or imperiled species but can include wide-ranging species that require special representation or species that occur in other ecoregions but have genetically important disjunct populations. The plant and animal species teams each developed criteria to guide their selection of fine-filter targets.

Before coarse-filter targets (e.g., ecological systems, plant associations, habitat types) can be selected, they must first be defined. There are many different classifications for ecological systems and plant associations. The communities and systems teams had to develop classifications that could be used throughout the ecoregion before they could decide which systems and associations should be targets. The list of targets is provided in Appendix 5.

2.2 Assembling Information on Target Locations

Data for target "occurrences" (e.g., location, spatial extent of a separate population, or example of a species or community) were assembled from a variety of sources. Although existing agency databases comprised most of this dataset, the teams filled in data gaps by gathering all available information and consulting specialists for specific target groups.

One of the challenges of conducting an ecoregional assessment is to find data that cover the whole ecoregion. This is typically done by combining datasets from different jurisdictions to create a complete coverage.

The assembled target data for plants and animals were screened by examining the dates and locations of each record. Records that were considered out of date or spatially inaccurate were not used in the analysis.

Decisions were made about 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 spatial extent of fine- or coarse-filter targets. The data were stored in a geographical information system (GIS). Appendix 4 lists data used in this assessment. Appendix 12 discusses how occurrence data was added to terrestrial assessment units.

2.3 Setting Target Goals

Conservation goals define the abundance and spatial distribution of viable target occurrences needed to adequately conserve the targets in the ecoregion. The goals also provide an estimate of how much effort will be needed to sustain those targets well into the future. For assessment purposes, “goal” is defined as a numerical value associated with a species or system that describes how many populations, nest sites, or breeding sites (for species targets) or how much area (for systems targets) the portfolio should include to represent each target. The goal also describes how those target occurrences should be distributed across the ecoregion to represent environmental variation and hedge against local extirpations. Further discussion on setting goals can be found in Appendix 6.

In setting goals for species targets, the Okanagan teams used goals developed by NatureServe (Comer 2003a; Appendix 19). Targets were grouped according to geographic range relative to the ecoregion. Goals decrease as endemism decreases, in rough proportion to the ecoregion’s share of the global distribution.

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 teams and Natural Heritage Programs. These scientists have settled on a generic goal for matrix-forming, large-patch, and linear terrestrial ecological systems: 30% of the historical extent of the system (Neely et al. 2001, Rumsey et al. 2003). Historical was defined as circa 1850. In cases where there was significant change from historical extent, either an increase or decrease in the area of the system, the default goal was adjusted. Appendix 5 lists the goals set for all targets.

The terrestrial systems team conducted a literature review to determine the minimum dynamic area (MDA) terrestrial systems historically required to ensure survival or re-colonization of the ecological system following a natural disturbance that removes most or all individuals. This is determined by the ability of some number of individuals or patches to survive, and the size and severity of stochastic events (Pickett and Thompson 1978). MDAs were used to determine the minimum patch size of each terrestrial system to be captured by the MARXAN site selection algorithm. These goals were later adjusted by the team based on how the algorithm performed in meeting the goals when capturing terrestrial systems. Goals for freshwater ecological systems were set at 30% of current extent.

2.4 Rating Conservation Suitability of Different Portions of the Ecoregion

The ecoregion was divided into thousands of assessment units (AUs). These are described in Section 1.3.3 and shown in Map 6. Assessment units consisted of 19,210 500-ha hexagons for the terrestrial analysis and 4,307 watershed units for the freshwater analysis. Watershed units ranged in size from 302 ha (747 ac) to combined watershed areas of 469,163 ha (1,159,326 ac). AUs were compared to each other using a set of factors the team and other experts selected to determine the suitability of each AU for conservation. These include factors that are likely to impact native species habitat quality, such as the extent of roads or developed areas or the presence of dams. They also include factors that are likely to impact the cost of managing the area for conservation, such as proximity to urban areas, percent of public versus private lands, or existence of established conservation areas. The A suitability index intended to indicate the relative likelihood of conservation success across the ecoregion was developed.

2.5 Assembling Terrestrial and Freshwater Portfolios

An ecoregional assessment incorporates hundreds of different targets at thousands of locations. The relative biodiversity value and conservation suitability of thousands of potential conservation areas must be evaluated in order to identify a network of sites (i.e., the portfolio) that best represents viable occurrences of coarse- and fine-filter biodiversity targets that meet our goals. The complexity of such analysis precludes experts from selecting the most efficient and complementary set of conservation areas through simple inspection alone.

MARXAN is designed to meet conservation target goals in the smallest area possible while maximizing AU suitability. It begins by selecting a random set of assessment units—i.e., a random conservation portfolio. It then explores improvements to this first 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, and thus greatly increases the chances of converging on the most efficient portfolio. Typically, one run of the algorithm consists of 2 million iterations, and each output scenario (portfolio) is the result of 10 runs.

2.6 Creating the Portfolios

Results of MARXAN analyses for freshwater and terrestrial conservation portfolios were then reviewed and refined by the Core Team and other experts who are familiar with the ecoregion. This compensates for gaps in the input data or other limitations of automated portfolio development.

The terrestrial and freshwater portfolios were then overlaid so we could readily see where selected units overlap. The combined portfolio is rather extensive; hence, all sites within the portfolio were prioritized based on their relative conservation value and vulnerability. Overlap between terrestrial and freshwater portfolio sites may confer greater importance to individual priority conservation areas.

2.7 Expert Review

Throughout the planning process, each of the six subteams solicited expert input at workshops and through personal interviews (see list of experts in Appendix 3). Experts were asked to (1) review draft target selection criteria, target lists and data on target distributions, and provide recommendations for additions and deletions to the lists; (2) provide spatially-explicit additions and deletions to the freshwater and terrestrial portfolios regarding occurrence of species, communities or ecological systems; and (3) provide available datasets for species, communities or ecological systems. Members of the Core Team then reviewed expert comments and made final changes to the portfolios.

Expert input addressed the need to (1) verify the results of our MARXAN model, (2) improve results of the portfolios with knowledge of the ecoregion, and (3) reveal shortcomings in the modeling approach due to data errors and gaps (Data gaps are discussed in Chapter 8.0). The net benefits of finding and fixing errors in the modeling process exceeded potential drawbacks of expert bias (Cleaves 1994; Coughlin and Armour 1992; Saaty 1980; Tversky and Kahneman 1974).

2.8 Prioritization of Portfolios

The conservation portfolios are intended to serve as the conservation blueprint for protection of the ecoregion's native biodiversity. Prioritizing conservation areas within the portfolios informs decision makers about their options for conservation.

To facilitate prioritization, we used MARXAN to generate two indices that reflect the relative importance of every assessment unit: irreplaceability and conservation utility. The irreplaceability index was also incorporated into an irreplaceability versus vulnerability scatterplot that was used to establish priorities within the portfolio. Prioritization methodology is detailed in Chapter 7.0.

Chapter 3 – Targets

The ecoregional assessment process identifies all native species and communities as the elements to be represented in an ecoregional portfolio of sites (Groves et al. 2000; Groves 2003). As previously noted, this represents the coarse-filter/fine-filter approach to biodiversity conservation developed by The Nature Conservancy and partners and refined through experience and planning. Both terrestrial and freshwater coarse-filter targets were used to design the portfolio of conservation sites for the Okanagan Ecoregion. The planning team's strategy with coarse-filter conservation was to develop a landscape portfolio of sites that captured the size and extent of natural communities and terrestrial habitats so that natural processes such as fires and floods could continue to function across the ecoregion.

All teams incorporated expert review into the target selection process. The experts solicited are listed in Appendix 3. Appendix 5 lists all targets selected and goals summaries.

3.1 Terrestrial Ecological Systems and Species

Four types of conservation targets were selected for the terrestrial analysis. Two scales of coarse-filter targets were used to describe the ecoregion's biodiversity: plant associations—typically the finest scale defined in a classification system, and ecological systems—a more general categorization of communities based on plant associations and environmental substrates. Certain animal and plant species were selected as fine-filter targets.

This section briefly describes how the targets for each target type were selected and the principal data sources used during the selection process. Summary tables are also included.

3.1.1 Terrestrial Plant Associations

The terrestrial plant associations and ecosystems team included the following people:

- Carmen Cadrin—Ecologist, British Columbia Conservation Data Centre, Ministry of Environment
- Rex C. Crawford—Natural Heritage Ecologist, Washington State Department of Natural Resources, Subteam Lead
- Mike Heiner—GIS Analyst/Ecologist, The Nature Conservancy of Washington
- Gwen Kittel—Vegetation Ecologist, NatureServe

Definition

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). Plant associations are the basic coarse filter tracked by NatureServe programs (http://www.natureserve.org/). These plant communities are typically less than 1,000 ha (2,471 ac). An example is "Ponderosa pine / bluebunch wheatgrass".

Selecting Plant Association Targets

There are several plant classifications in use, but there is no single, agreed-upon list of plant association targets. In order to develop one classification for the whole ecoregion, the team compared and resolved differences among (cross-walked) published plant association classifications from across Washington and British Columbia.

The International Vegetation Classification (IVC) (Grossman et al. 1998) provides a relatively comprehensive classification of plant associations across the ecoregion. This was used as the basis for the ecoregional list used in this assessment. Plant associations from the British Columbia Conservation Data Centre's and Washington Natural Heritage Program's databases, which have not yet been included in the IVC, were cross-walked. The resulting list contained 531 plant associations for the Okanagan Ecoregion. From this list, 66 globally imperiled or critically imperiled associations were selected to serve as conservation targets for the assessment. 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 they consist of relatively few or small occurrences in a particular landscape due to habitat loss. Therefore, they need specific attention to ensure inclusion in the portfolio. More common plant associations can be assumed to be captured by the broader ecological systems.

Data Sources

Data for plant associations were obtained from the British Columbia Conservation Data Centre and the Washington Natural Heritage Program. There were 25 records in total for 12 of the 66 selected associations..

Okanagan Plant Association Targets

Due to the lack of data for plant associations, occurrence information was not used in developing the automated portfolio. It was, however, used to evaluate the automated portfolio retrospectively and is included in the Site Summary Reports for mid-risk portfolio sites. Table 3.1 lists all plant associations (plant communities) used in the retrospective analysis. Section 6.6 documents how this analysis was completed.

Table 3.1. Okanagan Plant Association Targets

Common Name (where applicable)	**Scientific Name**	**GEL Code**	**Global Rank**	**S Rank (BC)**
	Abies grandis / *Taxus brevifolia* Forest	CEGL000283	G2	S2
	Alnus incana / *Carex scopulorum* var. *prionophylla* Shrubland	CEGL000122	G1	
	Artemisia tridentata (ssp. *tridentata*, ssp. *xericensis*) / *Pseudoroegneria spicata* Shrub Herbaceous Vegetation	CEGL001018	G2G4	S1
	Artemisia tridentata ssp. *tridentata* / *Leymus cinereus* Shrubland	CEGL001016	G2	S1
Bitterbrush / needle-and-thread Shrub Herbaceous Vegetation	*Purshia tridentata* / *Hesperostipa comata* Shrub Herbaceous Vegetation	CEGL001498	G2	S1
Black cottonwood / common snowberry - red-osier dogwood Forest	*Populus balsamifera* ssp. *trichocarpa* / *Symphoricarpos albus* Forest	CEGL000677	G2	S2
Bluebunch wheatgrass - balsamroot	*Pseudoroegneria spicata* - *Balsamorhiza sagittata*	C5B2CASBS1	G2	

Common Name (where applicable)	**Scientific Name**	**GEL Code**	**Global Rank**	**S Rank (BC)**
Bluebunch wheatgrass - junegrass	*Pseudoroegneria spicata - Koeleria macrantha*	CEBC000001	G2	
	Calamagrostis purpurascens Herbaceous Vegetation	CEGL001850	G2	
	Carex aperta Herbaceous Vegetation	CEGL001801	G1	
	Carex lanuginosa – Juncus arcticus	CEBC001014	G2	
	Carex limosa Herbaceous Vegetation	CEGL001811	G2	S1
Drummond's willow / Holm's Rocky Mountain Sedge Shrubland	*Salix drummondiana / Carex scopulorum* var. *prionophylla* Shrubland	CEGL001584	G2	S2
Drummond's Willow / Holm's Rocky Mountain sedge Shrubland	*Salix drummondiana / Carex scopulorum* var. *prionophylla* Shrubland	CWWA000024	G2	
	Festuca viridula - Festuca idahoensis Herbaceous Vegetation	CEGL001633	G2?Q	
Giant wildrye Bottomland Herbaceous Vegetation	*Leymus cinereus* Bottomland Herbaceous Vegetation	CEGL001480	G1	S1
	Glyceria grandis Herbaceous Vegetation	CEGL003429	G2	S1?
Idaho fescue - bluebunch wheatgrass	*Festuca idahoensis - Pseudoroegneria spicata*	CEBC000268	G2	
Idaho fescue - parsnip-flower buckwheat Herbaceous Vegetation	*Festuca idahoensis - Eriogonum heracleoides* Herbaceous Vegetation	CEGL001616	G2	
	Larix lyallii / Vaccinium scoparium / Luzula glabrata var. *hitchcockii* Woodland	CEGL000951	G2G3	
	Leymus cinereus Herbaceous Vegetation	CEGL001479	G2	S2S3
	Marsilea vestita – Schoenoplectus americanus	C7C1CMVSA1	G1	
	Philadelphus lewisii Intermittently Flooded Shrubland	CEGL001170	G2	S2
	Picea engelmannii x *glauca – Betula occidentalis / Ribes oxyacanthoides*	C2A2BSXBO1	G2	
	Picea engelmannii x *glauca / Ribes lacustre - Oplopanax horridus*	CEBC000313	G2G3	

Common Name (where applicable)	**Scientific Name**	**GEL Code**	**Global Rank**	**S Rank (BC)**
	Picea engelmannii x *glauca* / *Rosa acicularis* / *Petasites frigidus* var. *palmatus*	C2A2BSXPP1	G2	
	Pinus albicaulis / *Calamagrostis rubescens* Woodland	CEGL000753	G2	
	Pinus contorta / *Vaccinium caespitosum* / Sphagnum spp.	CEBC000221	G1	
	Pinus ponderosa – Populus balsamifera ssp. *trichocarpa* / *Rhus radicans*	C2B2CPPPB1	G1	
	Pinus ponderosa - Pseudotsuga menziesii / *Penstemon fruticosus* Woodland	CEGL000212	G2G3	
	Pinus ponderosa / *Crataegus douglasii* Woodland	CEGL000855	G1	S1
	Pinus ponderosa / *Hesperostipa comata* Woodland	CEGL000879	G1	S1
	Pinus ponderosa / *Symphoricarpos albus* Temporarily Flooded Woodland	CEGL000866	G2	S2
Ponderosa pine / common snowberry / Kentucky bluegrass	*Pinus ponderosa* / *Symphoricarpos albus* / *Poa pratensis*	CEBC000416	G2	
Ponderosa pine / mallow-leaf Ninebark Forest	*Pinus ponderosa* / *Physocarpus malvaceus* Forest	CEGL000189	G2	S1S2
Ponderosa pine / pinegrass Forest	*Pinus ponderosa* / *Calamagrostis rubescens* Forest	CEGL000181	G2	
Ponderosa pine / rough fescue Woodland	*Pinus ponderosa / Festuca campestris* Woodland	CEGL000185	G4	S1
	Populus balsamifera ssp. *trichocarpa* / *Salix sitchensis – Rubus parviflorus*	C3B4CPBSS2	G2	
	Populus balsamifera ssp. *trichocarpa – Psuedotsuga menziesii* / *Symphoricarpos albus – Cornus stolonifera*	CEBC001052	G1	
	Populus balsamifera ssp. *trichocarpa / Betula occidentalis*	C1B3DPBBO1	G1	
	Populus balsamifera ssp. *trichocarpa* / *Oplopanax horridus - Acer glabrum* Forest	CEGL000482	G2	

Common Name (where applicable)	**Scientific Name**	**GEL Code**	**Global Rank**	**S Rank (BC)**
	Populus balsamifera ssp. *trichocarpa / Salix exigua* Forest	CEGL000676	G1	
	Populus balsamifera ssp. *trichocarpa / Salix* spp. Dry Submaritime	C2A2BPTSS1	G2	
	Populus tremuloides – Populus balsamifera ssp. *trichocarpa / Symphoricarpos albus / Equisetum arvense*	CEBC000417	G1	
	Populus tremuloides / Achnatherum richardsonii – Geum triflorum	CEBC000878	G2	
	Populus tremuloides / Carex pellita Forest	CEGL000577	G2	
	Populus tremuloides / Philadelphus lewisii	CEBC001051	G1	
	Pseudoroegneria spicata – Anemone occidentalis	C5B2CASPO1	G1	
	Pseudoroegneria spicata - Eriogonum heracleoides Herbaceous Vegetation	CEGL001668	G2	S1
	Pseudotsuga menziesii – Thuja plicata / Corylus cornuta	C1A9BPMCC1	G2	
	Pseudotsuga menziesii / Acer glabrum / Prosartes hookeri	C1A9CPMDH1	G2	
	Purshia tridentata / Achnatherum hymenoides Shrubland	CEGL001058	G1	S1
	Cornus stolonifera / Carex spp.	CEBC001018	G2	
	Rhus glabra / Aristida purpurea var. *longiseta* Shrub Herbaceous Vegetation	CEGL001507	G1	
	Salix farriae / Eleocharis quinqueflora Saturated Shrubland	CEGL000229	G2	
Smooth sumac / bluebunch wheatgrass Shrub Herbaceous Vegetation	*Rhus glabra / Pseudoroegneria spicata* Shrub Herbaceous Vegetation	CEGL001122	G2	S2
Threetip sagebrush / bluebunch wheatgrass – balsamroot Shrub Herbaceous Vegetation	*Artemisia tripartita* ssp. *tripartita / Pseudoroegneria spicata* Shrub Herbaceous Vegetation	CEGL001538	G2	S2S3
Threetip sagebrush / needle-and-thread Shrub Herbaceous Vegetation	*Artemisia tripartita ssp. tripartita / Hesperostipa comata* Shrub Herbaceous Vegetation	CEGL001539	G1	

Common Name (where applicable)	**Scientific Name**	**GEL Code**	**Global Rank**	**S Rank (BC)**
Timber oatgrass Herbaceous Vegetation	*Danthonia intermedia* Herbaceous Vegetation	CEGL001794	G2	
Trembling aspen / common snowberry / mountain sweet-cicely	*Populus tremuloides / Symphoricarpos albus / Osmorhiza berteroi*	CEBC001050	G3	
Trembling aspen / snowberry / Kentucky bluegrass	*Populus tremuloides / Symphoricarpos albus / Poa pratensis*	CEBC000882	G3	
Western hemlock - Douglas-fir / electrified cat's-tail moss Dry Submaritime 1	*Tsuga heterophylla - Pseudotsuga menziesii / Rhytidiadelphus triquetrus* Dry Submaritime 1	C1A9CTHRT2	G2	
Western hemlock / queen's cup	*Tsuga heterophylla / Clintonia uniflora*	C1A9CTHCU1	G2	
Western hemlock / vine maple - falsebox	*Tsuga heterophylla / Acer circinatum - Paxistima myrsinites*	CEBC000866	G2	
Western redcedar / wild sarsparilla Forest	*Thuja plicata / Aralia nudicaulis* Forest	CEGL000471	G2	
Wyoming big sagebrush / needle-and-thread Shrubland	*Artemisia tridentata* ssp. *wyomingensis / Hesperostipa comata* Shrubland	CEGL001051	G2	S2

3.1.2 Terrestrial Ecological Systems

Definition

A terrestrial ecological system is defined as a group of plant associations that tend to co-occur within landscapes that have similar ecological processes, substrates, and/or environmental gradients (Comer et al. 2003). This emphasis on both the biotic component and the physical setting provides cohesive, enduring units that represent processes important to the persistence of natural communities and that are readily mapped across broad regions using available GIS data.

A given terrestrial ecological system will typically occur on a landscape at intermediate geographic scales of tens to thousands of hectares and will persist for 50 or more years. Ecological systems are intended to provide “meso-scale” classification units for resource management and conservation applications. They may serve as practical units on their own or in combination with classification units defined at different conceptual and spatial scales (Comer et al. 2003). An example would be “Rocky Mountain Ponderosa Pine Woodland”.

Selecting Ecological System Targets

As with the plant associations, the first task was to create a list of ecological systems that occur in the ecoregion. The team began with the list compiled and developed by NatureServe (Comer et al. 2003). Modifications were made to these ecological systems and their definitions using experience and information gained from other projects and ongoing ecoregional assessments. This was the basis for an initial list of 325 ecological systems that occur or possibly occur in the Okanagan Ecoregion.

This list was then reviewed and pared down to 41 ecological systems that are most likely to occur in the ecoregion. In cases where there were groups of plant associations that were outside the variation of existing ecological systems, especially in British Columbia, new systems were recognized. This resulted in 52 terrestrial ecological systems defined for the Okanagan Ecoregion. Full descriptions of the terrestrial ecological systems are provided in Appendix 10.

Many of these systems could not be mapped either due to inconsistencies in data across the border or because the small size of the system meant it was not well represented and had limited data. This required merging the 52 defined systems into 24 ecological system targets that could be represented spatially (Map 7). Appendix 10 shows the relationship between defined terrestrial ecological systems and system targets used in mapping and in the MARXAN analysis. Ecological system clusters were created through an iterative approach between efforts to spatially represent defined systems and on the ground knowledge of ecological and distribution relationships among defined systems. In general, riparian types were clustered into broader units, similar yet spatially indistinguishable systems are clustered (for example, Inter-Mountain Basins Montane Grassland and Sagebrush Steppe in Appendix 10),small patch types are grouped into their surrounding matrix types (for example, Inter-Mountain Basins Big Sagebrush Steppe), and peripheral types are grouped (for example, North Pacific Western Hemlock-Silver Fir Forest).

For terrestrial systems, MDAs were set for four ecological system targets. Two of these were aggregates of multiple system targets. The first aggregate target for MDA included five Interior and Rocky Mountain Subalpine and Montane Forests targets; the second included the Ponderosa Pine and Sagebrush Steppe targets. If the mapped area of a system was smaller than this MDA, then it would not be selected to be part of the portfolio. We assume that the MDA size and the landform selection in MARXAN capture enough variation to capture all the systems.

Riparian systems are difficult to map at the ecoregional level. Since they provide important habitat, have been widely converted, and are typically highly threatened, an alternate method was used to define and map them. Appendix 9, Section 2.2 provides details on the riparian delineation methods. Four riparian systems were defined for the Okanagan Ecoregion resulting in a total of 24 ecological systems used as targets in the assessment (Table 3.2).

Data Sources

The Okanagan is a highly transitional ecoregion, climatically and biogeographically, and available datasets vary widely across the international border in terms of spatial and thematic resolution. This presents a familiar challenge to conservation planning and to mapping the ecoregion’s characteristic ecosystems. Four datasets were chosen to define and depict the ecological systems. For the British Columbia portion of the ecoregion, the Biogeoclimatic Ecosystem Classification (BEC) and the Broad Ecosystem Inventory and Mapping (BEU) datasets were used. The BEC system delineates terrestrial ecosystems based on dominant vegetation species, climax zones, and site characteristics (local vegetation, soils, history, successional status). At the broadest scale, units are classified according to their zone, then subzone, down in scale to variant and then site series. This system was first developed by Dr. V.J. Krajina, Department of Botany at the University of British Columbia, and is used by the BC Ministry of Forests and Range to classify and manage sites. For the Washington portion of the ecoregion, the Shining Mountains mapping and Vegetation Mapping of the Okanogan and Colville National Forests datasets were utilized. The Shining Mountains mapping was developed by the British Columbia government for the purpose of determining the distribution and extent of regional and zonal ecosystems the province shares with surrounding jurisdictions. It is based on two ecosystem classifications used in the province: the British Columbia Ecoregion Classification and the BEC zonation.

Appendix 4 provides a list of datasets used to map terrestrial systems. These datasets were intersected, and the resulting combinations of attributes were examined by the team to determine which ecological system definitions matched most closely. The systems were mapped as individual combinations of climate zone, physiography, and vegetation structure.

The riparian systems were mapped using a Digital Elevation Model (DEM)-derived GIS model. This model enables mapping of riparian areas consistently and quickly across large areas using GIS data that are widely available. The model identifies areas that are (1) influenced by fluvial processes (transport and deposition of alluvial materials and soils), (2) periodically inundated during floods, and (3) likely to exhibit hydrologic conditions that are the principal controls of spatial pattern of riparian vegetation. Appendix 4 provides a list of the datasets used to delineate riparian systems.

Of the 24 ecological systems mapped, the 8 matrix-forming systems cover the largest total area, spanning broad physical gradients and thereby encompassing significant ecological and genetic variability. To represent this variability, the team conducted a cluster analysis to classify the landscape using four topographic indices known to correspond to vegetation patterns and that are readily mapped from a digital elevation model. The four topographic indices were topographic position measured by a moving window of 300-m radius, topographic position measured by a moving window of 2,000-m radius, an index of annual clear-sky insolation (SolarFlux, Rich et al. 1995) and slope. The resulting clusters, or ecological land units (ELUs), provide map units that function to stratify the matrix-forming systems and thereby influence the automated selection of potential conservation areas. Appendix 9 provides details on the riparian model and ecological land unit classification. Full descriptions of the terrestrial ecological systems are provided in Appendix 10.

Okanagan Terrestrial Ecological System Targets

Table 3.2. Okanagan Terrestrial Ecological System Targets

Ecological Grouping	Coarse-filter Terrestrial System Target *	ScientificName	GELCODE
ALPINE	North American Alpine Ice Field	• North American Alpine Ice Field	CES300.728
	Rocky Mountain Alpine Composite	• North Pacific Alpine and Subalpine Bedrock and Scree	CES204.853
		• North Pacific Dry and Mesic Alpine Dwarf-Shrubland, Fell-field and Meadow	CES204.862
		• Rocky Mountain Alpine Bedrock and Scree	CES306.809
		• Rocky Mountain Alpine Dwarf-Shrubland	CES306.810
		• Rocky Mountain Alpine Fell-Field	CES306.811
		• Rocky Mountain Dry Tundra	CES306.816

Ecological Grouping	Coarse-filter Terrestrial System Target *	ScientificName	GELCODE
SUBALPINE PARKLAND	North Pacific Maritime Mesic Parkland	• North Pacific Maritime Mesic Subalpine Parkland	CES204.837
	Northern Rocky Mountain Subalpine Dry Parkland	• North Pacific Alpine and Subalpine Dry Grassland	CES204.099
		• Northern Rocky Mountain Subalpine-Upper Montane Grassland	CES306.806
		• Northern Rocky Mountain Subalpine Woodland and Parkland	CES306.807
		• Northern Rocky Mountain Subalpine Larch Woodland	CES306.808
SUBALPINE FORESTS	Northern Interior Lodgepole Pine-Douglas- fir Woodland and Forest	• Northern Interior Lodgepole Pine-Douglas-fir Woodland and Forest	CES306.New3
	Northern Interior Spruce-Fir Woodland and Forest	• Northern Interior Spruce-Fir Woodland and Forest	CES306.New1
	Rocky Mountain Subalpine Dry-Mesic Spruce-Fir Forest and Woodland	• Rocky Mountain Lodgepole Pine Forest	CES306.820
		• Rocky Mountain Subalpine Dry-Mesic Spruce-Fir Forest and Woodland	CES306.828
	Rocky Mountain Subalpine Mesic Spruce-Fir Forest and Woodland	• North Pacific Mountain Hemlock Forest	CES204.838
		• Rocky Mountain Subalpine Mesic Spruce-Fir Forest and Woodland	CES306.830
MID-MONTANE FORESTS and SHRUBLANDS	East Cascades Mesic Montane Mixed-Conifer Forest and Woodland	• East Cascades Mesic Montane Mixed-Conifer Forest and Woodland	CES204.086

Ecological Grouping	Coarse-filter Terrestrial System Target *	ScientificName	GELCODE
	Inter-Mountain Basins Montane Grassland and Sagebrush Steppe	• Inter-Mountain Basins Montane Sagebrush Steppe	CES304.785
		• Northern Rocky Mountain Montane Grassland	CES306.836
	North Pacific Western Hemlock-Silver Fir Forest	• North Pacific Dry-Mesic Silver Fir-Western Hemlock-Douglas-fir Forest	CES204.098
		• North Pacific Maritime Dry-Mesic Douglas-fir-Western Hemlock Forest	CES204.001
		• North Pacific Maritime Mesic-Wet Douglas-fir-Western Hemlock Forest	CES204.002
	Northern Interior Dry-Mesic Mixed Conifer Forest and Woodland	• Northern Interior Dry-Mesic Mixed Conifer Forest and Woodland	CES306.New2
	Northern Rocky Mountain Montane Mixed Conifer Forest	• North Pacific Montane Shrubland	CES204.087
		• Northern Rocky Mountain Dry-Mesic Montane Mixed Conifer Forest	CES306.805
		• Northern Rocky Mountain Lower Montane-Foothill Deciduous Shrubland	CES306.994
		• Northern Rocky Mountain Western Larch Savanna	CES306.837
		• Rocky Mountain Aspen Forest and Woodland	CES306.813
	Northern Rocky Mountain Western Redcedar-Hemlock Forest	• Northern Rocky Mountain Western Hemlock-Western Redcedar Forest	CES306.802
	Rocky Mountain Cliff, Canyon and Massive Bedrock	• North Pacific Montane Massive Bedrock, Cliff and Talus	CES204.093
		• Rocky Mountain Cliff, Canyon and Massive Bedrock	CES306.815

Ecological Grouping	Coarse-filter Terrestrial System Target *	ScientificName	GELCODE
	Not mapped individually, modeled as steep slopes in several Forested Systems	• North Pacific Avalanche Chute Shrubland	CES204.854
		• Northern Rocky Mountain Avalanche Chute Shrubland	CES306.801
LOWER TREELINE FORESTS	Rocky Mountain Ponderosa Pine Woodland and Savanna	Northern Rocky Mountain Ponderosa Pine Savanna	CES306.030
STEPPE and SHRUB STEPPE	Inter-Mountain Basins Big Sagebrush Steppe	• Columbia Plateau Scabland Shrubland	CES304.770
		• Inter-Mountain Basins Big Sagebrush Steppe	CES304.778
	Inter-Mountain Basins Cliff and Canyon	• Inter-Mountain Basins Cliff and Canyon	CES304.779
	Northern Interior Plateau Grassland	• Northern Rocky Mountain Lower Montane, Foothill and Valley Grassland	CES306.040
WETLAND and RIPARIAN	Columbia Basin Foothill Riparian Woodland and Shrubland	• Columbia Basin Foothill Riparian Woodland and Shrubland	CES304.768
		• Inter-Mountain Basins Greasewood Flat	CES304.780
		• Inter-Mountain Basins Playa	CES304.786
		• North American Arid West Emergent Marsh	CES300.729
	North Pacific Montane Riparian Woodland and Shrubland	• North Pacific Montane Riparian Woodland and Shrubland	CES204.866
	Northern Rocky Mountain Lower Montane Riparian Woodland and Shrubland	• Northern Rocky Mountain Conifer Swamp	CES306.803
		• Northern Rocky Mountain Lower Montane Riparian Woodland and Shrubland	CES306.804

Ecological Grouping	Coarse-filter Terrestrial System Target *	ScientificName	GELCODE
	Rocky Mountain Alpine-Subalpine Wetlands	• Rocky Mountain Alpine-Montane Wet Meadow	CES306.812
		• Rocky Mountain Subalpine-Montane Mesic Meadow	CES306.829
		• Rocky Mountain Subalpine-Montane Fen	CES306.831
	Rocky Mountain Subalpine-Montane Riparian Woodland and Shrubland	• Rocky Mountain Subalpine-Montane Riparian Shrubland	CES306.832
		• Rocky Mountain Subalpine-Montane Riparian Woodland	CES306.833

* All coarse-filter terrestrial ecological systems were MARXAN targets.

3.1.3 Terrestrial Plant Species

The team that developed the plant species data for the assessment included

- Florence Caplow—Rare Plant Botanist, Washington Natural Heritage Program
- Robin Dye—Conservation Planner, The Nature Conservancy
- Matt Fairbarns—Ecologist, British Columbia Conservation Data Centre (now Aruncus Consulting), Subteam Lead

Selecting Plant Species Targets

Two groups of targets were identified: primary targets—those species of top conservation concern whose data would be used to develop the automated portfolio; and secondary targets—those species considered to be of lower conservation concern whose data would be used to evaluate and refine the portfolio.

Criteria for selecting vascular plant species as primary conservation targets were developed by the team based on the guidelines provided in Groves et al. (2000). Lists of tracked vascular plant species that occur in the ecoregion were obtained from the Washington Natural Heritage Program and the British Columbia Conservation Data Centre. Species from those lists were selected as primary targets if they met one of more of the following criteria:

- listed by NatureServe as G1–G2 for species or T1–T2 for intraspecific taxa
- listed by the U.S. Endangered Species Act and/or the Canadian Species at Risk Act
- strong candidates for listing by the Canadian Species at Risk Act (Fairbarns 2003) and/or the U.S. Endangered Species Act

- endemic to the Okanagan Ecoregion (using definition in Groves et al. 2000) and tracked by the British Columbia Conservation Data Centre and/or the Washington Natural Heritage Program

Other species were selected as secondary targets if they were listed as S1 to S3 in British Columbia and/or Washington.

These criteria and a draft target list were sent to experts to review and provide recommendations for additions and deletions. Additional species were added to the secondary target list if expert reviewers determined that they exhibit significant, long-term declines in habitat/and or numbers, are subject to a high degree of threat, or may have unique habitat requirements that expose them to great risk. Expert reviewers also added species to the secondary target list if they occur as disjuncts in the ecoregion (i.e., are absent from all adjacent ecoregions).

The British Columbia Conservation Data Centre and the Washington Natural Heritage Program rank and track all vascular plant taxa within their respective jurisdictions. However, at present, neither of these organizations comprehensively rank or track non-vascular taxa. Expert lichenologists and bryologists familiar with the region were asked to provide candidate lists of non-vascular plants that appeared to meet one or more of the primary target criteria.

Comments from expert review of the vascular list were evaluated by the team and incorporated, and the lichens and bryophytes nominated by experts were added to produce a final targets list.

In total, 332 vascular plant species were identified as potential targets for the ecoregion. Of these, 106 were primary targets, including 16 species in Washington and 88 in British Columbia (2 species were primary targets in both). The large number of primary targets from British Columbia is an indication of how unique the Okanagan valley is within a Canadian context. In contrast, the Washington portion of the ecoregion is more closely allied to other ecoregions across the northern portion of the state. Twenty-two species of lichens were identified as potential targets for the ecoregion; 11 of these were identified as primary targets. Primary plant targets are listed in Table 3.3. The entire list including secondary plant targets can be found in Appendix 5.

Data Sources

The team collected data on vascular plants from the British Columbia Conservation Data Centre and the Washington Natural Heritage Program. These data are gathered and managed systematically and are already in a format that is usable in the ecoregional assessment process. Map 8 represents terrestrial fine-filter target locations.

Since the heritage programs do not yet systematically track non-vascular plants, Dr. Katherine Glew, University of Washington herbarium, was contracted to visit a limited number of herbariums and contact expert lichenologists familiar with the ecoregion to gather lichen occurrence information. Dr. Glew recorded herbaria label information, and the team created records for these occurrences. Dr. Glew's report on lichens is provided in Appendix 11. The team did not have the resources or time to search for records of bryophytes.

To prepare the data for use in the assessment process, the team decided that only records more recent than 1977 and those with enough locational certainty (generally the location known within one mile) would be used.

Okanagan Plant Targets

Table 3.3. Okanagan Plant Targets

Common Name (where applicable)	Scientific Name	GEL Code	Global Rank	S Rank (BC)	S Rank (WA)
Vascular Plants					
Andean Evening-primrose	*Camissonia andina*	PDONA03010	G4	S1	SR
Annual Paintbrush	*Castilleja minor ssp. minor*	PDSCR0D221	G5T5	S1	S?
Beaked Sedge	*Carex rostrata*	PMCYP03BP0	G5	S2S3	S1
Blue-eyed Grass	*Sisyrinchium septentrionale*	PMIRI0D180	G3G4	S3S4	S2S3
Branched Phacelia	*Phacelia ramosissima*	PDHYD0C410	G4	S1	SR
Bristly Mousetail	*Myosurus apetalus var. borealis*	PDRAN0H051	G5TNR	S2	S?
Cliff Paintbrush	*Castilleja rupicola*	PDSCR0D2U0	G2G3	S2	SR
Cockscomb Cryptantha	*Cryptantha celosioides*	PDBOR0A0F0	G5	S1	SR
Columbian Goldenweed	*Pyrrocoma carthamoides var. carthamoides*	PDASTDT021	G4G5T4	S2	SR
Cup Clover	*Trifolium cyathiferum*	PDFAB400N0	G4	S1	SR
Dwarf Woolly-heads	*Psilocarphus brevissimus var. brevissimus*	PDAST7R011	G4T4	S1	SR
Engelmann's Knotweed	*Polygonum douglasii ssp. engelmannii*	PDPGN0L0X5	G5T3T5	S2S3	XX
Flat-topped Broomrape	*Orobanche corymbosa ssp. mutabilis*	PDORO04042	G4T3?	S2	SR
Freckled Milk-vetch	*Astragalus lentiginosus*	PDFAB0FB90	G5	S2	SR
Giant Helleborine	*Epipactis gigantea*	PMORC11010	G3	S2S3	S3
Grand Coulee Owl-clover	*Orthocarpus barbatus*	PDSCR1H020	G2G4	S1	S?
Gray Stickseed	*Hackelia cinerea*	PDBOR0G070	G4?	XX	S1
Hairgrass Dropseed	*Sporobolus airoides*	PMPOA5V020	G5	S1	SR
Hairy Water-clover	*Marsilea vestita*	PPMAR01080	G5	S1	SR
Howellia	*Howellia aquatilis*	PDCAM0A010	G3	XX	S2S3
Hutchinsia	*Hutchinsia procumbens*	PDBRA2Z010	G5	S1	SR
Lance-leaved Draba	*Draba cana*	PDBRA110M0	G5	S4	S1S2
Leiberg's Fleabane	*Erigeron leibergii*	PDAST3M280	G3?	S1	S?
Lemmon's Holly Fern	*Polystichum lemmonii*	PPDRY0R0E0	G4	S1	SR
Low Hawksbeard	*Crepis modocensis ssp. modocensis*	PDAST2R0A2	G4G5T4	S1	SR
Lyall's Mariposa Lily	*Calochortus lyallii*	PMLIL0D0T0	G3	S2	S?
Mexican Mosquito Fern	*Azolla mexicana*	PPAZO01030	G5	S2	SR
Moss Grass	*Coleanthus subtilis*	PMPOA1L010	GNR	S1	SR
Mountain Holly Fern	*Polystichum scopulinum*	PPDRY0R0N0	G5	S1	SR

Common Name (where applicable)	**Scientific Name**	**GEL Code**	**Global Rank**	**S Rank (BC)**	**S Rank (WA)**
Mutton Grass	*Poa fendleriana ssp. fendleriana*	PMPOA4Z0V1	G5T5	S1	XX
Narrowleaf Skullcap	*Scutellaria angustifolia ssp. micrantha*	PDLAM1U042	G5T3T5	XX	S2S3
Narrow-leaved Brickellia	*Brickellia oblongifolia ssp. oblongifolia*	PDAST1H0Z2	G5T5	S2	SR
Needle-leaved Navarretia	*Navarretia intertexta*	PDPLM0C0C0	G5?	S2	SR
Obscure Cryptantha	*Cryptantha ambigua*	PDBOR0A040	G4	S2	SR
Okanogan Stickseed	*Hackelia ciliata*	PDBOR0G060	G3?	S1	S?
Oniongrass	*Melica bulbosa var. bulbosa*	PMPOA3X030	G5T5	S2	SR
Oregon Checker-mallow	*Sidalcea oregana var. procera*	PDMAL110K8	G5T4	S1	SR
Pale Alpine-forget-me-not	*Eritrichium nanum var. elongatum*	PDBOR0F033	G5T4	XX	S1
Pulsifer's Monkey-flower	*Mimulus pulsiferae*	PDSCR1B290	G4?	XX	S2
Rigid Fiddleneck	*Amsinckia retrorsa*	PDBOR010A0	G5	S1	S4
Rocky Mountain Clubrush	*Schoenoplectus saximontanus*	PMCYP0Q1D0	G5	S1	XX
Rough Dropseed	*Sporobolus compositus var. compositus*	PMPOA5V161	G5T5	S1	SR
Salish fleabane	*Erigeron salishii*	PDAST3M4U0	G2	S1	S2S3
Scalepod	*Idahoa scapigera*	PDBRA1G010	G5	S2	SR
Scarlet Ammannia	*Ammannia robusta*	PDLYT01050	G5	S1	S?
Short-rayed Aster	*Aster frondosus*	PDASTD8020	G4	S1	SR
Showy Phlox	*Phlox speciosa ssp. occidentalis*	PDPLM0D1Q4	G5TNR	S1	SR
Silvercrown	*Cacaliopsis nardosmia*	PDAST1L010	G4G5	S1	SR
Skinny Moonwort	*Botrychium lineare*	PPOPH01120	G1	XX	S1
Slender Collomia	*Collomia tenella*	PDPLM02090	G4?	S1	SR
Slender Crazyweed	*Oxytropis campestris var. gracilis*	PDFAB2X0X0	G5?		S2
Slender Gilia	*Gilia tenerrima*	PDPLM041N0	G5	S1	XX
Slender Hawksbeard	*Crepis atribarba ssp. atribarba*	PDAST2R021	G5T5	S1	SR
Small-flowered Ipomopsis	*Ipomopsis minutiflora*	PDPLM060A0	G2G3	S2	SR
Small-flowered Lipocarpha	*Lipocarpha micrantha*	PMCYP0H040	G4	S1	S4
Spalding's Milk-vetch	*Astragalus spaldingii var. spaldingii*	PDFAB0F8D0	G3?T3?	S1	SR
Stoloniferous Pussytoes	*Antennaria flagellaris*	PDAST0H0W0	G5?	S1	SR
Strict Buckwheat	*Eriogonum strictum var. proliferum*	PDPGN085L9	G5TNR	S1	SR
The Dalles Milk-vetch	*Astragalus sclerocarpus*	PDFAB0F7X0	G5	S2	SR
Toothcup Meadow-foam	*Rotala ramosior*	PDLYT0B030	G5	S1	S1

Common Name (where applicable)	**Scientific Name**	**GEL Code**	**Global Rank**	**S Rank (BC)**	**S Rank (WA)**
Tweedy's Lewisia	*Lewisia tweedyi*	PDPOR090A0	G2G3	S1	S?
Tweedy's Willow	*Salix tweedyi*	PDSAL022Z0	G3G4	S2S3	S3
Two-spiked Moonwort	*Botrychium paradoxum*	PPOPH010J0	G2	S1	S2
Ute Ladies' Tresses	*Spiranthes diluvialis*	PMORC2B100	G2	XX	S1
Velvet-leaf Blueberry	*Vaccinium myrtilloides*	PDERI180M0	G5	S4	S1
Watson's Cryptantha	*Cryptantha watsonii*	PDBOR0A3C0	G5	S1	SR
Western Centaury	*Centaurium exaltatum*	PDGEN02060	G5	S1	SR
Western Low Hawksbeard	*Crepis modocensis ssp. rostrata*	PDAST2R0A3	G4G5T3T4	S1	SR
Western Stickseed	*Lappula occidentalis var. cupulata*	PDBOR0K061	G5T5	S1	SR
Whited's Halimolobos	*Halimolobos whitedii*	PDBRA1A050	G3?	S2	SR
Winged Combseed	*Pectocarya penicillata*	PDBOR0T030	G5	S1	S?
Wyeth's Lupine	*Lupinus wyethii*	PDFAB2B470	G5	S1	SR
Lichens					
Beard Lichen	*Usnea sphacelata*	NLLEC5P780	G4G5		S1
	Agrestia hispida	NLLEC04010	G3		S1
	Dactylina arctica	NLLEC48010	G4G5		S1
	Dactylina ramulosa	NLT0009730	G4G5		
	Dermatocarpon atrogranulosum		G1		
	Hypogymnia austerodes	NLTEST7550	G5		
	Massalongia microphylliza		G1?		
	Nephroma arcticum	NLT0019510	G5		
	Ophioparma ventosa		G2		
	Peltigera lepidophora	NLTEST5110	G4		S1
	Physcia dimidiata	NLTES11590	G5?	SNR	SNR
	Physcia tribacia	NLTES11750	G4?		
	Sclerophora amabilis		GNR		
	Stereocaulon nivale		G1		
	Umbilicaria hirsuta	NLT0030260	G2G4		
	Umbilicaria lambii	NLLEC5N110	G2G4		S1
	Umbilicaria nylanderiana	NLT0030300	G4		
	Vestergrenopsis isidiata	NLLEC5S010	G3G4		S1
	Vulpicida tilesii	NLLEC6K010	G4G5		S1
	Xanthoparmelia angustiphylla	NLTES10110	G5		
Scholander's navel lichen	*Umbilicaria scholanderi*	NLLEC5N230	G1	SNR	S1
Vitt tube Lichen	*Hypogymnia vittata*	NLLEC84160	G4G5		SNR

3.1.4 Terrestrial Animal Species

The team that developed the animal species target list and data for the assessment included

- Dick Cannings—Consulting Biologist, Cannings Holm Consulting
- Orville Dyer—Senior Wildlife Biologist, British Columbia Ministry of Environment
- Scott Fitkin—District Wildlife Biologist, Washington Department of Fish and Wildlife
- John Fleckenstein—Zoologist, Washington Natural Heritage Program
- Lisa Hallock—Herpetologist, Washington Natural Heritage Program
- Neal Hedges—Wildlife Biologist, USDI Bureau of Land Management
- Jeff Heinlen—Wildlife Biologist, Washington Department of Fish and Wildlife
- Pamela Krannitz—Research Scientist, Environment Canada, Canadian Wildlife Service
- Jeff Lewis—Wildlife Biologist, Washington Department of Fish and Wildlife, Subteam Lead
- Jim Priest—Wildlife Biologist, Colville Confederated Tribes
- John Rohrer—Supervisory Wildlife Biologist, Okanogan National Forest
- Geoff Scudder—Professor Emeritus, University of British Columbia
- Andy Stewart—Zoologist, British Columbia Conservation Data Centre
- Kent Woodruff—District Wildlife Biologist, Okanogan National Forest
- Steve Zender—District Wildlife Biologist, Washington Department of Fish and Wildlife

Selecting Animal Species Targets

Animal species were selected as fine-filter targets if they met one or more of the following selection criteria which were developed by the team based on the guidelines provided in Groves et al. (2000):

- globally imperiled species (G1–G3 ranked species)
- federally listed threatened or endangered species
- IUCN red list species
- species of special concern (declining, endemic, disjunct, vulnerable, keystone, indicator, or wide-ranging species)
- species aggregations

- biodiversity hotspots
- sub-nationally imperiled species (S1–S3 ranked species)
- bird species having a Partners In Flight (PIF) conservation status score of >23 (Mehlman and Hanners 1999)
- species with PIF conservation scores of 19–22 were also considered as targets if they had a PIF score of 5 for either the breeding area importance factor or the population decline factor.

While some criteria clearly indicated that a species should be selected as a target (e.g., federally listed as endangered), other criteria were more subjective (e.g., vulnerable or declining), so the team and other experts evaluated each species to determine whether to incorporate it or exclude it.

Using the above criteria, the team developed a draft target list which was sent to regional biologists and experts in British Columbia and Washington. Their comments were evaluated and incorporated by the team to create a final target list that included 103 target species—3 amphibians, 5 mollusks, 7 reptiles, 38 birds, 22 mammals, 16 butterflies, and 12 dragonflies (Table 3.4 lists the targets).

The occurrence data for a number of species were used to evaluate rather than define the portfolio. We refer to these species as retro species because we use data for these species to retrospectively review completed conservation portfolios. There were 11 retro species designated among the animal targets: grizzly bear, fisher, grey wolf, olive-sided flycatcher (*Contopus cooperi*), sandhill crane (*Grus canadensis*), barn owl (*Tyto alba*), American dipper (*Cinclus mexicanus*), ferruginous hawk (*Buteo regalis*), burrowing owl, western grebe (*Aechmophorus occidentalis*) and coastal tailed frog (*Ascaphus truei*). The grizzly bear and fisher were included as retro species because the amount of data used to represent them was so great that it overwhelmed the site selection process and reduced its sensitivity to other targets. The other targets were included as retro species because they are species of concern but their status is considered more secure than other targets. We could then evaluate how well the portfolio captured hexagons where retro species occur and determine if the goals of a retro species were met incidentally, as was done for non-retro targets.

Data Sources

Occurrence data for target species were collected from throughout the ecoregion. Primary sources were:

- British Columbia Conservation Data Centre
- Washington Department of Fish and Wildlife
- British Columbia Ministry of Environment
- Okanogan, Colville, and Wenatchee National Forests
- Royal British Columbia Museum
- Washington Natural Heritage Program
- Dr. Dennis Paulson, University of Puget Sound
- Bella Vista-Goose Lake Range Sensitive Ecosystem Inventory
- Artemis Wildlife Consultants
- Ophiuchus Consulting Ltd

Occurrence data were screened to eliminate data that were more than 20 years old, spatially inaccurate, and incomplete. Data for several species were screened to include only occurrences that documented observations of reproduction (e.g., great gray owl [*Strix nebulosa*] nests) or larger nest colonies (e.g., great blue heron [*Ardea herodias*] rookeries with more than ten nests).

Okanagan Animal Targets

Table 3.4. Okanagan Animal Targets

Common Name (where applicable)	**Scientific Name**	**GEL Code**	**Global Rank**	**S Rank (BC)**	**S Rank (WA)**
Amphibians					
Great Basin spadefoot toad	*Spea intermontana*	AAABF02030	G5	S3	S5
Tiger salamander	*Ambystoma tigrinum*	AAAAA01140	G5	S2	S3
Western toad	*Bufo boreas*	AAABB01030	G4		S3S4
Birds					
American avocet	*Recurvirostra americana*	ABNND02010	G5	S2B,SZN	S4B,SZN
American bittern	*Botaurus lentiginosis*	ABNGA01020	G4	S3B,SZN	S4B,S4N
Bald eagle	*Haliaeetus leucocephalus*	ABNKC10010	G4	S4	S3S4B,S4N
Black-backed woodpecker	*Picoides arcticus*	ABNYF07090	G5		S3
Blue grouse	*Dendragapus obscurus*	ABNLC09020	G5	S4	S5
Bobolink	*Dolichonyx oryzivorus*	ABPBXA9010	G5	S3B,SZN	S3B,SZN
Brewer's sparrow (breweri ssp)	*Spizella breweri breweri*	ABPBX94941	G5T4	S2B	S4B,SZN
Calliope hummingbird	*Stellula calliope*	ABNUC48010	G5	S4S5B,SZN	S4S5B,SZN
Canyon wren	*Catherpes mexicanus*	ABPBG04010	G5	S3	S4
Common Loon	*Gavia immer*	ABNBA01030	G5	S4S5B,SZN	S2B,S5N
Flammulated owl	*Otus flammeolus*	ABNSB01020	G4	S3S4B,SZN	S3B,SZN
Golden eagle	*Aquila chrysaetos*	ABNKC22010	G5	S4B,SZN	S3B,S3N
Grasshopper sparrow	*Ammodramus savannarum*	ABPBXA0020	G5	S2B	S3B,SZN
Great blue heron	*Ardia herodius*	ABNGA04010	G5	S3B,S4N	S4S5
Great gray owl	*Strix nebulosa*	ABNSB12040	G5	S4B,SZN	S2B,SZN
Lark sparrow	*Chondestes grammacus*	ABPBX96010	G5	S2B,SZN	S4B,SZN
Lewis' woodpecker	*Melanerpes lewis*	ABNYF04010	G4	S3B,SZN	S3B,SZN
Long-billed curlew	*Numenius americanus*	ABNNF07070	G5	S3B,SZN	S2B,S2N
Northern goshawk	*Accipiter gentilis*	ABNKC12061	G5	S4B,S4N	S3B,S3N
Northern spotted owl	*Strix occidentalis caurina*	ABNSB12011	G3	S1	S3
Peregrine falcon	*Falco peregrinus anatum*	ABNKD06071	G4T3	S2B,SZN	S2B,S3N

Common Name (where applicable)	**Scientific Name**	**GEL Code**	**Global Rank**	**S Rank (BC)**	**S Rank (WA)**
Prairie falcon	*Falco mexicanus*	ABNKD06090	G5	S2B,SZN	S3B,S3N
Rufus hummingbird	*Selasphorus rufus*	ABNUC51020	G5	S4S5B,SZN	S5B,SZN
Sage thrasher	*Oreoscoptes montanus*	ABPBK04010	G5	S1B	S3B,SZN
Sharp-tailed grouse (columbianus ssp)	*Tymphanuchus phasianellus columbianus*	ABNLC13030	G4T3	S2S3	S2
Short-eared owl	*Asio flammeus*	ABNSB13040	G5	S3B,S2N	S4B,S4N
Swainson's hawk	*Buteo swainsoni*	ABNKC19070	G5	S2B,SZN	S3B,SZN
Trumpeter swan (S. Thompson R.)	*Cygnus buccinator*	ABNJB02030	G4	S4B,S4N	S3N
Vaux's swift	*Chaetura vauxi*	ABNUA03020	G5	S4B,SZN	S3S4B,SZN
Western screech owl	*Otus kennicotii macfarlanei*	ABNSB01041	G5T4	S1	S5
Western yellow-breasted chat	*Icteria virens auricollis*	ABPBX24010	G5	S1B	S4B,SZN
White-headed woodpecker	*Picoides albolarvatus*	ABNYF07070	G4	S1	S3
Williamson's sapsucker	*Sphyrapicus thyroideus thyroideus*	ABNYF05032	G5	S3B,SZN	S4B,SZN
Wilson's phalarope	*Phalaropus tricolor*	ABNNF20010	G5	S4S5B,SZN	S4B,SZN
Dragonflies					
Black-tipped darner	*Aeshna tuberculifera*	IIODO14180	G4	S3	S4
Boreal whiteface	*Leucorrhinia borealis*	IIODO44010	G5	S5	S1
Lance-tailed darner	*Aechna constricta*	IIODO14040	G5	S2S3	S4
Nez Perce dancer	*Argia emma*	IIODO68160	G5	S3S4	S5
Olive clubtail	*Stylurus olivaceus*	IIODO80060	G4	S2	S4
Pronghorn clubtail	*Gomphus graslinellus*	IIODO08310	G5	S2S3	S3
River jewelwing	*Calopteryx aequabilis*	IIODO65010	G5	S1	S4
Subarctic (muskeg) darner	*Aeshna subarctica*	IIODO14170	G5	S5	S2
Subarctic bluet	*Coenagrion interrogatum*	IIODO70020	G5	S4	S2
Twelve-spotted skimmer	*Libellula pulchella*	IIODO45140	G5	S3	S5
Western pondhawk	*Erythemis collocata*	IIODO39020	G5	S3	S5
Western river cruiser	*Macromia magnifica*	IIODO26060	G4	S3	S3
Lepidopterans					
Astarte fritillary	*Boloria astarte*	IILEPJ7120	G5	S5	S3
Behr's (Columbia) hairstreak	*Satyrium behrii columbia*	IILEPD4010	G5	S2	S5
California hairstreak	*Satyrium californicum*	IILEPD4040	G5	S3	S5

Common Name (where applicable)	**Scientific Name**	**GEL Code**	**Global Rank**	**S Rank (BC)**	**S Rank (WA)**
Eastern tailed blue	*Everes comyntas*	IILEPF9010	G5	S3	S2
Freija fritillary	*Boloria freija*	IILEPJ7100	G5	S5	S2
Juniper hairstreak	*Callophrys gryneus*	IILEPE2130	G5	S4	S3
Meadow fritillary	*Boloria bellona toddi*	IILEPJ7040	G5	S3	S2?
Melissa arctic	*Oeneis melissa*	IILEPP1100	G5	S5	S2
Mormon metalmark	*Apodemia mormo*	IILEPH7010	G5	S1	S4
Silver-bordered fritillary	*Boloria selene*	IILEPJ7030	G5	S5	S3
Sonora skipper	*Polites sonora*	IILEP66090	G4	S1	S4
Sooty hairstreak	*Satyrium fuliginosum*	IILEPD4020	G4	S1	S4
Mammals					
Badger	*Taxidea taxus jeffersoni*	AMAJF04010	G5	S1	S5
Bighorn sheep	*Ovis canadensis*	AMALE04010	G4	S2S3	S3S4
Bighorn sheep-WA	*Ovis canadensis*	AMALE04010	G4	S2S3	S3S4
Fringed myotis	*Myotis thysanodes*	AMACC01090	G4G5	S2S3	S3?
Great Basin pocket mouse	*Perognathus parvus*	AMAFD01070	G5	S2S3	S5
Long-legged myotis	*Myotis volans*	AMACC01110	G5	S4S5	S3
Lynx	*Lynx canadensis*	AMAJH03010	G5	S4	S1S2
Mountain beaver	*Aplodontia rufa rainieri*	AMAFA01014	G5T4	S3	S5
Mountain goat	*Oreamos americanus*	AMALE02010	G5	S4	S4S5
Mountain goat-WA	*Oreamos americanus*	AMALE02010	G5	S4	S4S5
Nuttall's cottontail	*Sylvilagus nutalli*	AMAEB01060	G5	S3	S5
Pallid bat	*Antrozous pallidus*	AMACC10010	G5	S1	S3
Preble's shrew	*Sorex preblei*	AMABA01030	G4	S1S2	SR
Spotted bat	*Euderma maculatum*	AMACC07010	G4	S3S4	S3
Townsend's big-eared bat	*Coryhorhinus townsendii*	AMACC08010	G4	S2S3	S2
Western gray squirrel	*Sciurus griseus*	AMAFB07020	G5		S2
Western harvest mouse	*Rheithrodontomys megalotis*	AMAFF02030	G5	S2S3	S5
Western red bat	*Lasiurus blossevillii*	AMACC05060	G5	S1	
Western small-footed myotis	*Myotis ciliolabrum*	AMACC01140	G5	S2S3	S4
Wolverine	*Gulo gulo*	AMAJF03012	G4	S3	S1

3.2 Freshwater Ecological Systems and Species

Freshwater ecological systems support an exceptional concentration of biodiversity and almost all terrestrial animal species since they depend on freshwater systems for water, food, and various aspects of their life cycles. As with the terrestrial analysis, the freshwater component of this project used two types of conservation targets. Ecological systems were used as coarse-filter targets; animal species were selected as fine-filter targets. Plant species were not used because there were insufficient standardized data available for freshwater plants.

The freshwater assessment was based on ecological drainage unit boundaries instead of the ecoregion boundary. Map 5 shows EDUs in and intersecting with the Okanagan Ecoregion.

Four ecological drainage units were used in this assessment:

- Middle Fraser EDU
- Upper Fraser EDU
- Thompson EDU
- Okanagan EDU

In the interests of preserving the ecological integrity of freshwater systems, the Upper Fraser EDU, which does not intersect the ecoregion, was included in the analysis because of its connectivity to the Middle Fraser EDU, which does intersect the ecoregion.

3.2.1 Freshwater Ecological Systems

The team that developed the freshwater ecological systems target list and data for the assessment included

- Bart Butterfield—Spatial Analyst/GIS Expert
- Kristy Ciruna—Director of Conservation Programs, Nature Conservancy of Canada, Subteam Lead
- Ted Down—Manager of Aquatic Ecosystem Science, BC Ministry of Environment
- Tracy Horsman—Spatial Analyst, The Nature Conservancy
- Craig Mount—Aquatic Geomorphologist, BC Ministry of Environment
- Peter Skidmore—Aquatic Ecologist, The Nature Conservancy
- Art Tautz—Science Advisor, BC Ministry of the Environment
- Dave Tredger—Manager of Ecosystem Information, BC Ministry of Environment

Definition

For classification purposes, freshwater ecological systems are defined as networks of streams, lakes, and wetlands that are distinct in geomorphological patterns, connected by similar environmental processes and gradients, occur in the same part of the drainage network, and form a distinguishable drainage unit on a hydrography map. Freshwater ecological systems are spatially nested within major river drainages and are defined at a spatial scale that is practical for regional planning.

Ecological systems provide a means of generalizing about large-scale patterns in networks of streams and lakes, and the ecological processes that link them together, whereas finer-scale freshwater systems capture a detailed picture of physical diversity at the stream reach level.

Selecting Freshwater Ecological System Targets

The team's first step was to create a freshwater ecosystem classification for EDUs that intersect the Okanagan Ecoregion or were used in the assessment. The classification of freshwater systems is a relatively new pursuit. Unlike terrestrial systems classification, it is virtually impossible to build a hierarchical freshwater classification founded on biological data because freshwater communities have not been identified in most places, and there is generally a lack of adequate survey data for freshwater species. Therefore, abiotic factors that have been shown to influence the distribution of species and communities are used to delineate freshwater ecological system types. Nine abiotic variables were used to develop the classification for the Okanagan EDUs: drainage area, underlying biogeoclimatic zone and geology, stream gradient, accumulative precipitation yield, lake and wetland influence, glacial connectivity, and Melton's R (watershed ruggedness). Different combinations of these variables will likely result in different freshwater communities.

The four EDUs analyzed in the assessment collectively consist of 4,307 watershed units. These were grouped into 44 freshwater ecological systems using the following statistical methods. The freshwater ecological systems are listed in Table 3.5 and Appendix 5. They are shown on Map 9.

Descriptive statistics (mean, standard deviation, skewness, and variance) were calculated for each variable. Variables that were highly skewed (skewness values ≥ 2) were log 10 transformed to help meet the assumptions of normality for parametric statistics. Variability in categorical variables such as gradient classes, biogeoclimatic zones, and geology classes was reduced into two continuous axes using nonmetric multidimensional scaling.

All variables were normalized for proportional comparisons between variables. Cluster analysis was performed on all normalized variables (agglomerative hierarchical clustering [Sorensen distance measure using a flexible beta value of -0.25]), and 44 freshwater system types were selected.

Data Sources

The following summarizes data sources used to develop the freshwater ecological systems:

- drainage area—BC Watershed Atlas; Interior Columbia Basin Ecosystem Management Project watersheds
- accumulative precipitation yield—ClimateSource
- percent of lake area to watershed polygon area—BC Watershed Atlas; USGS NHD data
- percent of wetland area to watershed polygon area—BC Watershed Atlas; USGS NHD data
- percent glacial influence—BC Watershed Atlas; USGS NHD data
- biogeoclimatic zones / ecozones—BC Ministry of Forests Biogeoclimatic Ecosystem Classification; BC Mnistry of Sustainable Resource Management Regional and Zonal Ecosystems of the Shining Mountains
- geology—BC Ministry of Energy and Mines; Washington Department of Natural Resources http://www.dnr.wa.gov/geology/dig100k.htm

- mainstem and tributary stream gradient—BC Watershed Atlas, BC TRIM/TRIMII 25 m DEM; USGS NHD data

Okanagan Freshwater Ecological System Targets

Table 3.5. Okanagan Freshwater Ecological System Targets

Freshwater Ecological Systems
intermediate, intrusives, alluvium, elevation 820, shallow
intermediate, intrusives, elevation 1032, shallow, glacial
intermediate, intrusives, elevation 722, shallow, lakes
intermediate, volcanics, alluvium, elevation 1080, shallow, lakes/wetlands
intermediate, volcanics, elevation 1001, shallow, lakes/wetlands
large volcanics, intrusives/alluvium, elevation 658, shallow
large, intrusives, alluvium, elevation 621, shallow
large, intrusives, elevation 546, shallow
small, alluvium, elevation 1098, shallow
small, alluvium, elevation 1098, shallow, wetlands
small, alluvium, elevations 1118, shallow
small, alluvium, intrusives, elevation 919, shallow
small, alluvium, volcanics, 765, shallow
small, intrusives, alluvium, elevation 1058, shallow
small, intrusives, elevation 1035, shallow, lakes
small, intrusives, elevation 1141, shallow
small, intrusives, elevation 1151, shallow
small, intrusives, elevation 1164, shallow
small, intrusives, elevation 1417, shallow
small, intrusives, elevation 1450, shallow
small, intrusives, elevation 1522, shallow
small, intrusives, elevation 1597, shallow
small, intrusives, elevation 1648, shallow
small, intrusives, elevation 1758, shallow, glacial
small, intrusives, elevation 1907, shallow, glacial
small, intrusives, sediments, 1965, shallow/steep, glacial
small, intrusives, sediments, elevation 1279, shallow
small, intrusives, volcanics, elevation 1019, shallow, lakes/wetlands
small, intrusives, volcanics, elevation 1032, shallow, lakes/wetlands
small, sediments, alluvium, elevation 972, shallow, lakes/wetlands
small, sediments, elevation 1683, shallow

Freshwater Ecological Systems
small, sediments, elevation 1799, steep
small, sediments, elevation 791, shallow
small, volcanics, alluvium, elevation 1038, shallow, wetlands
small, volcanics, alluvium, elevation 1137, shallow, lakes/wetlands
small, volcanics, alluvium, elevation 1156, shallow, wetlands
small, volcanics, alluvium, elevation 1442, shallow, lakes
small, volcanics, elevation 1002, shallow, lakes/wetlands
small, volcanics, elevation 1303, intermediate/steep
small, volcanics, elevation 950, shallow, wetlands
small, volcanics, intrusives, elevation 1418, shallow, lakes/glacial
small, volcanics, sediments, elevation 1017, shallow, lakes/wetlands
small, volcanics, sediments, elevation 1155, shallow
small, volcanics, sediments, elevation 907, shallow

3.2.2 Freshwater Species

The team listed above for the terrestrial animal species also developed an initial list of freshwater species. In addition to those team members, others reviewed and expanded the list:

- Kristy Ciruna—Director of Conservation Programs, Nature Conservancy of Canada
- Jeff Lewis—Wildlife Biologist, Washington Department of Fish and Wildlife
- Geoff Scudder—Professor Emeritus, University of British Columbia
- Peter Skidmore—Aquatic Ecologist, The Nature Conservancy
- Sairah M. Tyler—Conservation Planning Consultant, Nature Conservancy of Canada, Subteam Lead

Selecting Freshwater Species Targets

The target list developed by the terrestrial team included some semi-aquatic and riparian species that were also included in the freshwater species list. That list was expanded to include obligate aquatic species and to cover the expanded geographic area of the freshwater analysis. Map 10 represents freshwater fine-filter data.

A total of 48 freshwater fine-filter targets were identified, 35 of which had spatial data. An additional 28 secondary or retro, species were identified, 18 of which had spatial data. Species spanned the range of vascular plants, mollusks, insects, fish, amphibians, reptiles, birds, and mammals. All 6 species of salmon and 4 separate populations of white sturgeon were included in the target list. Only 2 plant species were included in the list due to a lack of available data. Table 3.6 lists freshwater species targets.

Data Sources

In addition to the data sources listed above for the terrestrial animal species, spatial data to map occurrences of additional freshwater species were collected from

- BC Fisheries / Canadian Department of Fisheries and Oceans; Fisheries Information Summary System
- American Fisheries Society, Fish Occurrence Data
- Pacific States Marine Fisheries Commission, StreamNet Project (Anadromous Fish)
- Washington Department of Fish and Wildlife, Salmonid Stock Inventory and Ecosystem Diagnosis and Treatment (EDT)

Records that were older than 20 years, locationally inaccurate, or incomplete were removed from the datasets.

Okanagan Freshwater Species Targets

Table 3.6. Okanagan Freshwater Species Targets

Common Name	Scientific Name	GEL Code	Global Rank	S Rank BC	S Rank WA
Amphibians					
Columbia Spotted Frog (EDU)	*Rana luteiventris*	AAABH01290	G4		S4
Great Basin Spadefoot (EDU)	*Spea intermontana*	AAABF02030	G5	S3	S5
Tiger Salamander (EDU)	*Ambystoma tigrinum*	AAAAA01140	G5	S2	S3
Western toad (EDU)	*Bufo boreas*	AAABB01030	G4		S3S4
Birds					
American avocet (EDU)	*Recurvirostra americana*	ABNND02010	G5	S2B,SZN	S4B,SZN
American bittern (EDU)	*Botaurus lentiginosus*	ABNGA01020	G4	S3B,SZN	S4B,S4N
American dipper (EDU)	*Cinclus mexicanus*	ABPBH01010	G5	S5B, S4N	S5
American White Pelican	*Pelecanus erythrorhynchos*	ABNFC01010	G3	S1B,SZN	
Common Loon (EDU)	*Gavia immer*	ABNBA01030	G5	S4S5B, SZN	S2B,S5N
Harlequin duck (EDU)	*Histrionicus histrionicus*	ABNJB15010			
Long-billed curlew (EDU)	*Numenius americanus*	ABNNF07070	G5	S3B,SZN	S2B,S2N
Sandhill Crane (EDU)	*Grus canadensis*	ABNMK01010	G5	S3S4B,SZN	
Trumpeter swan (S. Thompson R.) (EDU)	*Cygnus buccinator*	ABNJB02030	G4	S4B, S4N	S3N
Upland Sandpiper	*Bartramia longicauda*	ABNNF06010	G5	S1S2B,SZN	
Western grebe (EDU)	*Aechmophorus occidentalis*	ABNCA04010	G5	S1B,S3N	S3B,S5N

Common Name	Scientific Name	GEL Code	Global Rank	S Rank BC	S Rank WA
Wilson's phalarope (EDU)	*Phalaropus tricolor*	ABNNF20010	G5	S4S5B, SZN	S4B,SZN
Fishes					
Bull trout	*Salvelinus confluentus*	AFCHA05020	G3	S3	S3
Chinook Salmon	*Oncorhynchus tshawytscha*	AFCHA02050			
Chiselmouth	*Acrocheilus alutaceus*	AFCJB01010	G5	S3?	S4
Chum Salmon	*Oncorhynchus keta*	AFCHA02020			
Coho Salmon	*Oncorhynchus kisutch*	AFCHA02030		S3	
Columbia Mottled Sculpin, Hubbsi Subspecies	*Cottus bairdi hubbsi*	AFC4E02053	G5	S3	S3?
Lake chub	*Cousius plumbeus*	AFCJB06010	G5	S5	SU
Leopard dace	*Rhinichthys falcatus*	AFCJB37040	G4	S4	S2S3
Mountain sucker	*Catostomus platyrhynchus*	AFCJC02160	G5	S3?	S3
Mountain sucker - N. Thompson	*Catostomus platyrhynchus*	AFCJC02160	G5	S3?	S3
Pacific Lamprey	*Lampetra tridentata*	AFBAA02100	G5	S4	
Pink Salmon	*Oncorhynchus gorbuscha*	AFCHA02010			
Pygmy whitefish	*Prosopium coulteri*	AFCHA03020	G5	S4S5	S2
Pygmy whitefish - Okanagan Lake	*Prosopium coulteri*	AFCHA03020	G5	S4S5	S2
Shorthead sculpin	*Cottus confusus*	AFC4E02090	G5	S2S3	S3S4
Sockeye Salmon	*Oncorhynchus nerka*	AFCHA02040			
Speckled dace	*Rhinichthys osculus*	AFCJB37050	G5	S2	S4
Steelhead Salmon	*Oncorhynchus mykiss*	AFCHA02090			
Umatilla dace	*Rhinichthys umatilla*	AFCJB37120	G4	S1S2	SU
Westslope cutthroat trout	*Onchorynchus clarki lewisi*	AFCHA02088	G4T3	S3SE	SU
White Sturgeon (Columbia River Population)	*Acipenser transmontanus pop. 2*	AFCAA01052	G4T3T4Q	S1	
White Sturgeon (Lower Fraser River Population)	*Acipenser transmontanus pop. 4*	AFCAA01054	G4T2Q	S2	
White Sturgeon (Nechako River Population)	*Acipenser transmontanus pop. 3*	AFCAA01053	G4T1Q	S1	
White Sturgeon (Upper Fraser River Population)	*Acipenser transmontanus pop. 5*	AFCAA01055	G4T1Q	S1	

Common Name	Scientific Name	GEL Code	Global Rank	S Rank BC	S Rank WA
Insects					
Black-tipped darner (EDU)	*Aeshna tuberculifera*	IIODO14180	G4	S3	S4
Lance-tipped darner	*Aechna constricta*	IIODO14040	G5	S2S3	S4
nez Perce dancer (EDU)	*Argia emma*	IIODO68150	G5	S3S4	S5
Olive clubtail (EDU)	*Stylurus olivaceus*	IIODO80060	G4	S2	S4
Pronghorn clubtail (EDU)	*Gomphus graslinellus*	IIODO08310	G5	S2S3	S3
River jewelwing (EDU)	*Calopteryx aequabilis*	IIODO65010	G5	S1	S4
Twelve-spotted skimmer (EDU)	*Libellula pulchella*	IIODO45130	G5	S3	S5
Western pondhawk (EDU)	*Erythemis collocata*	IIODO39020	G5	S3	S5
Western river cruiser (EDU)	*Macromia magnifica*	IIODO26060	G4	S3	S3
Mammals					
Mountain Beaver, Rainieri Subspecies	*Aplodontia rufa rainieri*	AMAFA01014	G5T4	S3	SA
Mollusks (Ecoregion targets)					
California floater	*Anodonta californiensis*	IMBIV04020	G3		S1S2
Western pearlshell	*Margaritifera falcata*	IMBIV27020	G4		S3
Mollusks (EDU targets)					
California floater (EDU)	*Anodonta californiensis*	IMBIV04020	G3	na	S1S2
Western pearlshell (EDU)	*Margaritifera falcata*	IMBIV27020	G4	na	S3
Western ridgemussel (EDU)	*Gonidea angulata*	IMBIV19010	G3	na	S2
Reptiles					
Painted Turtle	*Chrysemys picta*	ARAAD01010	G5	S3S4	
Vascular Plants					
Leafy Pondweed	*Potamogeton foliosus*	PMPOT030B0	G5	S4	SNR
Nuttall's waterweed (EDU)	*Elodea nuttalli*	PMHYD03080	G5	S2S3	SNR

3.2.3 Ecosystem Diagnosis and Treatment

For those salmon species that had available data, an index that reflected both the quality and quantity of habitat was the fine-filter target input to MARXAN. We used an EDT model output to represent the habitat for these species. EDT is a system for rating the quality, quantity, and diversity of habitat along a stream, relative to the needs of a focal species such as chinook salmon (Mobrand et al. 1997; Lestelle 2004). EDT has been used by government agencies and tribes/First Nations to analyze salmon habitat value throughout the Pacific Northwest. EDT produces two metrics of relative habitat value: restoration potential and protection potential.

The EDT process begins by segmenting a stream network into reaches. EDT characterizes the condition of 46 habitat attributes for each reach to provide evaluations of current and historical conditions. EDT then uses habitat-dependent survival rules to simulate three population performance measures—intrinsic productivity, equilibrium abundance, and life-history diversity—for both current and historical habitat conditions. Based on the simulated population performance, EDT estimates the restoration and protection potentials for each reach. To calculate protection potential, EDT simulates the relative decrease in population performance that would be expected if habitat conditions for a given reach become fully degraded beyond current habitat conditions. The result is a set of reach-specific protection values expressed as percent change in population performance parameters from current conditions. We used the protection potential as explained below.

Calculating the habitat quality index for a given EDT reach was a four-step process. First, we combined EDT assessments for a given salmonid target from all basins within a given Evolutionary Significant Unit (ESU). A table was created that contained every EDT reach in a given ESU and values of the three performance measures for each reach. Second, a single protection potential estimate for each reach was calculated by summing percent change in productivity, abundance, and life history diversity for each reach. Third, all reaches were sorted by the new single protection potential estimate. Finally, the resulting reach-specific values were normalized such that the maximum value equaled 1000:

$$\text{Habitat Quality Index of reach } i = (pi / pmax) * 1000$$

where pi is the protection potential estimate for a given reach and pmax the protection potential estimate for the reach ranked as having the greatest protection potential in the ESU. We obtained the results of EDT analyses that had been done for salmon recovery efforts in the Columbia River Basin. In the Okanogan EDU, EDT analyses had been done for chinook and steelhead salmon.

Where EDT had not been completed but reaches had been identified, we obtained qualitative protection rankings (i.e., high, medium, low) that had been done in lieu of EDT modeling (Casey Baldwin, WDFW, pers. comm.). We translated these qualitative rankings into habitat quality scores as follows. We plotted the distribution of normalized habitat quality scores for all Okanogan EDU reaches where EDT output was available and then identified two break points that were used to stratify these reaches into high, medium, and low habitat quality. We then calculated the mean habitat quality score for these three strata and assigned these mean values to the corresponding qualitative rankings for reaches that lacked EDT (e.g., Wenatchee reaches).

Most assessment units (i.e., a class 1 watershed) encompassed more than one EDT reach. Hence, the conservation value of an assessment unit was the sum of habitat quality index values for all reaches in the assessment unit. This is the value that was used in MARXAN. This cumulative value was calculated separately for chinook and steelhead targets.

Chapter 4 – Suitability Indices

4.1 Introduction

MARXAN searches for the lowest cost set of assessment units that will meet representation levels for all conservation targets. This set of assessment units is defined as an efficient or "optimal" solution. "Cost" corresponds to economic, socio-political, and environmental factors operating on the landscape that either support or impede management regimes that emphasize biodiversity conservation (Comer 2003) and is represented in MARXAN by the suitability index. Used in this context, cost refers not only to financial considerations but also to likelihood of success, especially in terms of species viability or persistence. In other words, our conservation investment (whether financial or effort-based) has a higher return if it sustains biodiversity for the long term.

The actual cost of conservation encompasses many complicated factors including acquisition or easement costs, management costs, restoration costs and costs of failing to maintain a species at a given site. Determining monetary costs of conservation for all available targets for each assessment unit would be prohibitive; therefore, the suitability index serves as a surrogate measure for cost. Cost, as defined here, is an inverse function of suitability; the higher the cost, the less suitable an assessment unit is for conservation.

Land use suitability is a well established concept among planners (Hopkins 1977; Collins et al. 2001), and there are many different methods for constructing an index (Banai-Kashini 1989; Carver 1991; Miller et al. 1998; Stoms et al. 2002). Suitability indices have been used to locate the best places for a wide range of land uses from farms to nuclear waste sites. We applied a suitability index in an optimization algorithm in order to identify the best places for biodiversity conservation.

MARXAN requires that all suitability factors be represented by a single cost value. This single value must represent the combination of all factors, whether biological or non-biological, and their relative importance. The algorithm favours analysis units with lower cost values.

It is important to note that MARXAN will still select areas of high cost / low suitability if they are required to meet representation goals. For example, rare species or those with limited range will have fewer places for MARXAN to choose from and may force the selection of high cost areas. The suitability index simply ensures that if there is a high suitability / low cost alternative, it will be preferentially selected.

A summary of threats to biodiversity in the Okanagan Ecoregion can be found in Appendix 14. The team did not have the resources or time to include these factors in the suitability index..

4.2 Assumptions

We developed the suitability index based on three assumptions:

1) Existing public land is more suitable for conservation than private land.
2) Rural areas are more suitable for conservation than urban areas.
3) Areas with low habitat fragmentation are more suitable for conservation than areas with high fragmentation.

The first assumption is based on the work of the Gap Analysis Program (Cassidy et al. 1997; Kagan et al. 1999). The Oregon and Washington GAP projects rated nearly all public lands as better managed for biodiversity than most private lands. Furthermore, 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/First Nations 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 conservation is a major management goal.

The second assumption is based on the definition 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. However, it is worth noting that this definition of urban does not preclude a need for natural areas or habitat restoration within the urban environment.

The third assumption is based on the work of Diamond (1975) and Forman (1995), among others, and is a well-accepted principle of conservation biology.

The validity of the first two assumptions is 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 urban areas are a land use designation that is mostly incompatible with maintaining a full suite of existing biodiversity.

Although the simple index used in this assessment cannot account for the many complex local situations that influence successful conservation, we believe that some reasonable generalities are still quite useful for assessing conservation opportunities across an entire ecoregion. For a more detailed account of the suitability index, refer to Appendix 13.

4.3 Methods

The suitability index used in this project was based on the analytic hierarchy process (AHP) (Saaty 1980; Banai-Kashini 1989). AHP generates an equation that is a linear combination of factors thought to affect suitability. Each factor is represented by a separate term in the equation, and each term is multiplied by a weighting factor. AHP is unique because the weighting factors are obtained through a technique known as pair-wise comparisons (Saaty 1977) where expert opinion is solicited regarding the relative importance of each term in the equation. To simplify the elicitation process, we used the "abbreviated pair-wise comparisons" technique. That is, we assumed perfect internal consistency for each expert, which allowed us to reduce the number of comparisons. AHP has been used in other conservation assessments where expert judgments are needed in lieu of empirical data (Store and Kangas 2001; Clevenger et al. 2002; Bojorquez-Tapia 2003).

We asked several experts with knowledge of the ecoregion to give their opinion on the ranks and relative importance values for factors used in the suitability index. They were asked to do the same for sub-terms from management status, land use and fire condition. Weights for each factor were calculated using a pairwise comparisons matrix as described by Saaty (1977).

We built two similar cost suitability indices—one for terrestrial areas, and one for freshwater areas—by compiling spatial data relating to the human use footprint (e.g., road density, urban growth, conversion of natural landscapes), current management, divergence from the historic fire regime and presence of dams. We incorporated these data into the AHP equation and generated a single suitability value or cost for each assessment unit (see Appendix 8 for more details on assessment units).

The use of suitability indices for assessing the likelihood of successful conservation has some potential drawbacks. For example, our index is built upon expert opinions about which factors to include and the relative importance of each factor. Also, few if any of these GIS data are ever ground-truthed for accuracy, which would greatly improve the quality of those data (Groves 2003). To address these concerns, we performed a sensitivity analysis on the suitability index (Chapter 5.0).

4.3.1 Terrestrial Suitability Index

Terrestrial suitability is expressed quantitatively as

$$\text{Terrestrial Suitability} = A * \text{management\_status} + B * \text{land\_use} + C * \text{road\_density} + D * \text{future\_urban\_potential} + E * \text{fire\_condition}$$

A, B, C, D and E are weighting factors calculated from expert input and pairwise comparison, which collectively sum to 100%. The individual index factors are shown in Map 11. Map 12 shows the combined terrestrial suitability index factors.

Weights, summing to 100% of the category, were also applied to sub-factors within management status, land use and fire condition class. For example,

$$\text{Land\_use} = q * \%\ \text{urban} + r * \%\ \text{agriculture} + s * \%\ \text{mine}$$

Values for each factor (or sub-factor) are based on the percent area of that factor in the assessment unit. Values for each factor are normalized prior to applying the weights according to the following equation:

$$\text{Normalized score} = (\text{score for that AU} / \text{highest score for all AUs}) * 100$$

Weights were obtained from input provided by 18 people—9 members of the technical team and 9 outside experts. Ten of the respondents were from British Columbia; 8 were from Washington.

Appendix 13 provides details on how each of the factors were developed, including rationale for inclusion in the index, processing methods, factor weights and sub-weight values and data sources. The appendix also provides details on other factors that were considered for inclusion, including rationale for not including the factors in the index.

4.3.2 Freshwater Suitability Index

Freshwater suitability is expressed quantitatively as

$$\text{Freshwater Suitability} = A * \text{management\_status} + B * \text{land\_use} + C * \text{road\_density} + D * \text{dams}$$

A, B, C, and D are weighting factors calculated from expert input and pairwise comparison, which collectively sum to 100%. Map 13 shows the combined freshwater suitability index factors.

Weights, summing to 100% of the category, were also applied to sub-categories within management status and land use. For example,

$$\mathit{Land\_use} = q * \%\_\mathit{urban} + r * \%\ \mathit{agriculture} + s * \%\ \mathit{mine}$$

Values for each factor (or sub-factor) are based on the percent area of that factor in the assessment unit. Values for each factor are normalized prior to applying the weights according to the following equation:

$$\mathit{Normalized\ score} = (\mathit{score\ for\ that\ AU} / \mathit{highest\ score\ for\ all\ AUs}) * 100$$

Weights were obtained from input provided by13 people—6 members of the technical team and 7 outside experts. Six of the respondents were from British Columbia; 7 were from Washington.

Appendix 13 provides details on how each of the factors were developed, including rationale for inclusion in the index, processing methods, factor weights and sub-weight values and data sources. The appendix also provides details on other factors that were considered for inclusion, including rationale for not including the factors in the index. An overview Threats Assessment was compiled as a companion to the suitability index; it can be found in Appendix 14.

Chapter 5 – Prioritization of Assessment Units

5.1 Introduction

A conservation portfolio could serve as a conservation plan to be implemented over time by non-governmental organizations, government agencies and private landowners. In reality, however, an entire portfolio cannot be protected immediately, and some conservation areas in the portfolio may never be protected (Meir et al. 2004). Limited resources and other social or economic considerations may make protection of the entire portfolio impractical. This situation can be addressed two ways. First, we should narrow our immediate attention to the most important conservation areas within the portfolio. We prioritized conservation areas to facilitate this (Chapter 7.0, Maps 27 and 28). Second, we should provide organizations, agencies and landowners with the flexibility to pursue other options when portions of the portfolio are too difficult to protect. We assigned a relative priority to all AUs in the ecoregion, which will help planners explore options for conservation.

5.1.1 Sensitivity Analysis

A sensitivity analysis is necessary whenever there is considerable uncertainty regarding modeling assumptions or parameter values. A sensitivity analysis determines what happens to model outputs in response to a systematic change of model inputs (Jorgensen and Bendoricchio 2001). Sensitivity analysis serves two main purposes: (1) to measure how much influence each parameter has on the model output, and (2) to evaluate the potential effects of poor parameter estimates or weak assumptions (Caswell1989). Through a sensitivity analysis, we can ascertain the robustness of our results and judge how much confidence we should have in our conclusions.

The inputs to the reserve selection algorithm are explained in Appendices 9 and 10. The input with the greatest uncertainty is the suitability index. The suitability index was not a statistical model—variable selection and parameter estimates for the index were based on professional judgment. For this reason, the sensitivity analysis focused on the index. The methods for the sensitivity analysis are thoroughly explained in Appendix 18.

5.2 Methods

5.2.1 Irreplaceability

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

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

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

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

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

where I_{jk} are relative irreplaceability values as defined in equation (2), and m is the number of representation levels used in the site selection algorithm. G_j have values between 0 and 1. Each I_{jk} is relative irreplaceability at a particular representation level. We ran MARXAN at 10 representation levels for coarse- and fine-filter targets. At the highest representation level, nearly all AUs attained a positive irreplaceability.

5.2.2 Conservation Utility

We extended upon the concept of irreplaceability with conservation utility, a term coined by Rumsey et al. (2004). Conservation utility is defined by equation (2), but the optimization algorithm is run with the AU costs incorporating a suitability index. To generate irreplaceability, AU "cost" equals the AU area. To create a map of conservation utility values, AU "cost" reflects practical aspects of conservation—current land uses, current management practices, habitat condition, etc. (see Chapter 4.0). In effect, conservation utility is a function of both biodiversity value and the likelihood of successful conservation.

5.2.3 Representation Levels

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

Coarse-filter

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

Fine-filter

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

$$\textit{Species Persistence Probability} = \quad 1 - [1 - pr(P)]^n$$

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

Luckily, other relationships were available to us. The Natural Heritage Programs use many criteria to determine G and S ranks. These criteria indicate the degree of imperilment—i.e., the risk of extinction. One such criterion relates the number of occurrences to degree of imperilment (Table A16.2, Appendix 16; Master et al. 2003)[2]. This system expresses the idea that the first 5 occurrences make about the same contribution toward species rank as the next 21–80 occurrences. If we assume equal imperilment intervals and equate A, B, C (a nominal scale) with 1, 2, 3 (an ordinal scale), then the relationship in Table A16.2 can be modeled as a power function. We used the function to interpolate between 1, 2, and 3 to yield multiple regularly spaced steps for the fine-filter levels. We did this to give 10 representation levels—the same number as for the coarse-filter.

5.2.4 Sensitivity Analysis

We explored sensitivity to the suitability index by altering the index's parameter values, running the selection algorithm with the new index, and then quantifying the resulting changes in the conservation utility map. Recall that the suitability index equation is a weighted linear combination of factors:

$$\textit{Suitability} = A * \textit{management status} + B * \textit{\% converted land} + C * \textit{road density} + \\ D * \textit{\% urban growth area} + E * \textit{fire condition class}$$

where A + B + C + D + E = 1, and management status, % converted land, road density, % urban growth area, and fire condition class were each normalized to a maximum value of 1. Also, recall that MARXAN tries to minimize the "cost" of AUs. Therefore, the suitability index is actually formulated as an "unsuitability" index.

The values for parameters A, B, C, D and E were determined by averaging expert opinion using the Analytic Hierarchy Process (Saaty 1980). Each parameter was changed by +0.2, an amount that we thought might reflect moderately different opinions regarding the importance of each factor in the suitability index. After changing a parameter value, the other parameters were adjusted so that they all still summed to 1. Only the suitability index parameters were changed; none of the other inputs to the selection algorithm used to produce the original utility map were changed. We changed only one parameter at a time, and hence, did not investigate interactions between or among index parameters.

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[2] Table A16.2 is a modification of the older system (Master 1991) for species ranking, where G1/S1 equaled 1–5 occurrences, G2/S2 equaled 16–20 occurrences, and G3/S3 equaled 21–100 occurrences.

Resulting changes in the algorithm's output were quantified several ways. First, three similarity measures were calculated to compare the conservation utility maps generated: mean absolute difference in utility, Bray-Curtis similarity measure, and Spearman rank correlation (Krebs 1999). The Bray-Curtis similarity measure normalizes the sum absolute difference to a scale from 0 to 1. Hence, mean absolute difference and the Bray-Curtis similarity measure give the same result but on different scales. Because utility will be used for prioritizing AUs, the rank correlation is particularly informative. Rank correlation tells us how the relative AU priorities change in response to changes in the suitability index. Because we were interested in prioritizing AUs, we also calculated the mean absolute difference in rank.

5.3 Results

5.3.1 Terrestrial Analysis

The irreplaceability and utility maps for the terrestrial analysis are shown in Maps 14 and 15. The categories on these maps correspond to deciles. That is, the statistical distribution of utility and irreplaceability scores were each divided into 10% quantiles. The decile map depicts where the AUs with a selection frequency (or score) in the top 10 or 20% of all AUs are located. Scores at the 90th percentile were 77 for irreplaceability and 73 for utility. The percentage of AUs with a score greater than 90 was 3.8 % and 3.9 % for irreplaceability and utility, respectively (Figure A16.1).

AUs with scores equal to 100 are those selected in every replicate at every representation level— 2.5% had irreplaceability equal to 100, 2.6 % had utility equal to 100, and 2.3 % AUs had both scores equal to 100 (Table 5.1).

At the lowest representation level, the best solutions for irreplaceability and utility consisted of 6.0% and 6.6% of AUs, respectively. Scores greater than 90 were attained by 55% of AUs in both the irreplaceability best solution and the utility best solution, which demonstrates that some options existed for meeting the lowest representation level. That is, rare targets could only be captured at high scoring AUs, but there were many different AU combinations that could satisfy the minimum dynamic area requirement of ecological systems.

Table 5.1. Percentage of AUs with High Selection Frequencies for Both Terrestrial and Freshwater Analyses

Portfolio	Number of AUs	Selection Frequency	Irreplaceability (%)	Utility (%)	Both (%)
Terrestrial	19210	100 %	2.5	2.6	2.3
		≥ 95%	3.1	3.3	2.8
		≥ 90 %	4.0	4.4	3.4
Freshwater	4307	100 %	0.9	1.2	0.9
		≥ 95%	1.2	3.8	1.1
		≥ 90 %	2.6	6.6	1.9

5.3.2 Freshwater Analysis

The irreplaceability and utility maps for the freshwater only analysis are shown in Maps 16 and 17. The utility and irreplaceability scores are displayed two ways: (1) the distribution of values are divided into deciles (10% quantiles); and (2) the range of values are divided into 10 equal intervals. One decile contains 430 AUs. The number of AUs with a score greater than 90 was 119 (2.6%) and 301 (6.6%) for irreplaceability and utility, respectively (Figure A16.1 in Appendix 16). Forty-three AUs (0.9%) had an irreplaceability score of 100, 55 (1.2 %) had a utility score of 100, and 41 AUs (0.9%) had both scores equal to 100 (Table 5.1).

At the lowest representation level (10% of the current amount of coarse-and fine-filter targets), the best solutions for irreplaceability and utility consisted of 297 and 344 AUs, respectively. Perfect scores were attained by 31% of the irreplaceability best solution and 13% of the utility best solution, which demonstrates considerable flexibility at the lowest representation level. That is, the solution was not greatly affected by the location of rare targets.

5.3.3 Sensitivity Analysis

Changes to parameters A, C, and E, which reflect the influence of management status, road density, and fire condition class, respectively, had approximately the same effect on conservation utility values. Changes to these three parameters had a greater effect than parameters B and D. Changes to A, C, and E resulted in approximately the same values for mean absolute difference, the Bray-Curtis similarity measure, and Spearman rank correlation. (Figures A16.2 and A16.3). Changes to parameters B and D also had approximately the same effect on similarity measures. For changes to all parameters, the null hypothesis was accepted for all similarity measures. That is, none of the changes to index parameters resulted in significant changes to the overall utility map.

According to the similarity measures, there was little overall difference between the original and altered utility maps. However, many individual AUs did change and some showed statistically significant changes in utility (Figure A16.4). When A, C, or E were changed by 0.2, about 86– 87% of AUs changed utility score, but only about 17–21% had a statistically significant change. Utility scores were much less sensitive to changes in parameters B or D.

5.4 Discussion

How should our irreplaceability and conservation utility indices be interpreted? These indices were constructed by running MARXAN at 10 representation levels. The first level captured a very small amount of each target, and the last level captured everything—i.e., all known occurrences of all targets. Consider the first representation level as the amount of biodiversity to be captured in an initial set of reserves, the second level as an additional amount to be captured by an enlarged set of reserves, the third level as an even greater additional amount, and so on. At each level, MARXAN's output indicates the relative necessity of each AU for efficiently capturing that particular amount of biodiversity. When the outputs from each level are summed, the result specifies the most efficient sequence of AU protection that will eventually represent all biodiversity. The sequence in which AUs should be protected is one way to gauge their relative importance. AUs that have the highest irreplaceability or utility scores should be protected first, and therefore, are the most important AUs for biodiversity conservation.

The MARXAN algorithm generates a set of AUs corresponding to a local minimum of the objective function (Appendix 8). AUs are included in a solution because they serve to minimize the objective function. Therefore, AUs with high irreplaceability or high utility scores are those that (1) contain one or more rare targets and/or (2) contain a large number of target occurrences. High utility scores are also attained by AUs with low relative cost. AUs with scores of 100 are those that were selected in every replicate at every representation level. To be chosen in every replicate, the AU must be unique. That is, the

AU contained target occurrences that were found in no other AU, contained a substantially larger number of occurrences than other AUs, or contained targets and had a substantially lower cost than other AUs.

Irreplaceability and utility scores in the Okanagan Ecoregion exhibit abrupt changes at the international border—a much higher proportion of AUs in the British Columbian portion scored greater than 95 relative to Washington. There are two reasons for this, one proximal and one ultimate. First, the proximal reason is data density bias. Government and non-governmental organizations have conducted more plant and wildlife surveys on the Canadian side of the border. Hence, data density in British Columbia is much higher than in Washington; consequently, imperiled species appear to be more abundant on the Canadian side. Second, the ultimate reason is the national significance of the Okanagan valley. In Canada, the Okanagan valley is widely acknowledged as a biodiversity hotspot, and relative to the rest of Canada, it is. In the United States, the Okanogan valley is not considered to be nationally significant; consequently, government and non-governmental organizations have not directed resources for field inventory in this area. An investment in plant and animal surveys on the Washington side of the ecoregion might reveal species richness and rarity equal to that in British Columbia.

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

Utility and irreplaceability scores were significantly different for many individual AUs at the middle and low end of the utility score range (see Appendix 16, Figure A16.2). This is useful information for prioritization. AUs at the low end of utility (or irreplaceability) typically are unremarkable in terms of biodiversity value. They contribute habitat or target occurrences, but they are interchangeable with other AUs. For these AUs, prioritizing on the basis of suitability rather than biodiversity value makes most sense. If an AU can be distinguished from other AUs because conservation there will be cheaper or more successful, then that AU should be a higher priority for action. For these AUs, the utility score should be used for prioritization.

The primary conclusion of the sensitivity analysis is that AU utility and rank vary in response to changes in the suitability index. Similarity measures that compare “before” and “after” utility maps of the entire ecoregion indicate that the overall map is relatively insensitive to changes in suitability index parameters. That is, the average change over all AUs is small. However, the utility and rank of many AUs do change, and some exhibit significant changes. The number of AUs that change significantly depends of which index parameter is changed and the amount of change to that parameter.

We investigated the sensitivity of the utility map to changes in the suitability index because of our uncertainty about the index. The variable selection and parameter estimates for the index were based on professional judgment. The results of the sensitivity analysis have two implications for conservation planning. First, highest priority AUs (approximately ranks 1 through 10; the top 3% AUs) are rather robust to changes in the suitability index. Therefore, regardless of the uncertainties in the suitability index, we can be confident about the most highly ranked AUs. These AUs were selected mainly for their relative biological value, not relative suitability. For similar reasons, the lowest ranked AUs (rank less than about 100), tend to be robust to changes in the suitability index—they maintain a low rank because they have relatively little biological value. Second, the utility of moderately ranked AUs (rank less than 10 and greater than 100; about 12% of AUs), is sensitive to changes in the suitability index. When choosing among AUs of moderate rank, we must explore how our assumptions about suitability affect rank. This is detailed in Appendix 18.

Chapter 6 – Portfolio of Conservation Areas

This chapter presents the development of the conservation portfolio and the results of the assessment. A conservation portfolio is a set of places where resources should be directed for the conservation of biodiversity. The conservation areas that make up the portfolio are summarized and the degree to which the portfolio represents fine- and coarse-filter targets is discussed. Alternative conservation portfolios reflecting different conservation goals for targets are reviewed.

6.1 Portfolio Development Process

Successful conservation will entail choices about where we should and should not expend limited resources (Ando et al. 1998; Pressey and Cowling 2001). Portfolio creation is a major step toward making informed choices about where conservation areas or reserves should be located. Selecting a set of sites that efficiently capture multiple occurrences of hundreds of targets from thousands of potential sites is a task that cannot be accomplished by expert judgment alone. For this reason, we used the optimal reserve selection algorithm, MARXAN (see Appendix 9 for in-depth description).

The portfolio creation process for the Okanagan Ecoregion occurred on two parallel tracks specific to two environmental realms—terrestrial and freshwater—that resulted in two portfolios (Maps 18 and 20). Portfolio creation was an iterative process that balanced the use of the optimal reserve selection algorithm with expert knowledge about important places for biodiversity conservation.

6.1.1 Terrestrial Process

The terrestrial portfolio identified a set of assessment units (AUs) that met conservation goals for terrestrial conservation targets in a way that maximized portfolio suitability (Map 18). Terrestrial conservation targets included coarse-filter targets such as terrestrial ecological systems and fine-filter targets such as rare plants, rare animals and rare communities (Chapter 3.0).

MARXAN analysis was completed and the resultant selected areas were used to create groups of AUs that would become terrestrial priority conservation areas.

6.1.2 Freshwater Process

The assessment of freshwater biodiversity used a different set of geographies than the ecoregion. It used ecological drainage units (EDUs) to define the analysis area, and these EDUs overlap or connect with ecoregion boundaries (Map 4 and Section 1.3.2). The freshwater portfolio was also developed using MARXAN. The freshwater portfolio identified a set of AUs that met conservation goals for freshwater conservation targets in a way that maximized portfolio suitability (Map 20). Freshwater conservation targets included coarse-filter targets such as freshwater ecological systems and fine-filter targets such as rare plants, rare animals and rare fishes.

6.2 Conservation Goals

Both the terrestrial and freshwater portfolios were created using conservation goals that specified a given number and distribution of populations (for species) and areas (for habitats) needed to sustain biodiversity in the ecoregion (for terrestrial) or ecological drainage unit (for freshwater) over the long term. Targets and goals summaries are listed in Appendix 5; setting goals is discussed in Appendix 6.

6.3 Summary of Portfolios

6.3.1 Portfolio Size and Distribution

The terrestrial portfolio, shown in Map 22, covers 3,093,000 ha (7,642,969 ac) or 32 % of the Okanagan Ecoregion. It includes a total of 137 priority conservation areas: 83 are entirely within British Columbia, 47 are entirely in Washington. Seven PCAs are shared between British Columbia and Washington. They range in size from 500 ha (i.e., 1 hexagon) to landscapes of 211,500 ha (522,600 ac).

Due to higher suitability/lower conservation costs, most conservation areas selected in the portfolio tend to build on to existing parks and protected areas. For example, the Cathedral (#75) and Cascades (# 81 and 72) PCAs encompass the majority of Cathedral and Manning provincial parks, and the Stein-Mehatl-Nahatlatch ((#43) and Spruce-Tyaughton (#8) PCAs encompass parts of Stein Valley, Mehatl Creek, Nahatlach, and Big Creek provincial parks. In Washington, the Pasayten-Upper Chelan (#93) and Colville (#94) PCAs encompass large portions of federal Forest Service lands. Despite low suitability/high cost, some PCAs were chosen in the area around Spokane (PCA # 132—Spokane, #136—Riverside, and #125—Little Blue Grouse). A quick overlay of the underlying data shows that it is reasonable to assume that these areas were partially chosen for the fine-filter target occurrences that occur there and could not be found elsewhere in the ecoregion. Interestingly, large areas of private land are also captured in British Columbia despite the high cost to the MARXAN model of including them in the portfolio. This is partly explained by the fact that much of the grassland ecosystems occur on private lands. This does not appear to be the case in Washington where most private land was avoided by MARXAN. Most of the South Okanagan in British Columbia and its extension into Washington is captured in the portfolio. As previously mentioned, this area is a national biological hotspot in Canada. Despite some higher suitability index scores along the river corridors running north-south, the biological importance of this area forces the MARXAN algorithm to select areas in the South Okanagan and into north-central Washington. Although the north-western portion of the ecoregion, the area west of Lillooet and Lytton, is generally high suitability/low cost, surprisingly not very much of the area is selected as PCAs. This may in part be due to the paucity of fine-filter data for this area relative to other parts of the ecoregion such as the South Okanagan. There are several transboundary PCAs that connect areas in British Columbia and Washington.

The freshwater portfolio includes 785 watersheds, totalling 9,173,851 ha (22,669,080 ac) and equalling 33% of the area contained in the four EDUs analyzed. The freshwater portfolio was aggregated and delineated as 135 PCAs for watersheds that intersected or were adjacent to the ecoregion (Map 23). The freshwater portfolio was reviewed by freshwater experts who added and deleted assessment units. A number of watersheds were added to the portfolio based on drainage network connectivity.

There are 113 delineated freshwater PCAs fully or partially in the Okanagan Ecoregion and covering 3,301,359 ha (8,157,835 ac) or 34% of the ecoregion. Of these, 73 are entirely within British Columbia, 38 are entirely in Washington. Two PCAs are shared between British Columbia and Washington. They range in size from partial watersheds of 82 ha (202 ac) to freshwater systems of 195,266 ha (482,513 ac).

The freshwater portfolio follows a similar pattern as the terrestrial portfolio in that most of the existing parks and protected areas are captured. The freshwater portfolio connects systems from Salmon Arm, British Columbia down through Okanagan, Skaha, and Osoyoos Lakes and the Okanagan River down to Tonasket, Washington. These watersheds are all rated as having high conservation value and high vulnerability. Other high value/high vulnerability watersheds are captured in the Omak Lake and Okanagan River drainages in Washington (PCA #114 and #109) and Methow River watersheds (PCA #104—Methow River and #122— Indian Dan). Most of the Kettle River system is also captured in the portfolio. Although there is a high cost/low suitability to capturing any freshwater systems in the Spokane area, the MARXAN model still captures watersheds in the Spokane River drainage (PCA #119—Eloika Lake, #120—Little Spokane, and #124—Spokane River-Deadman). Interestingly, these watersheds are rated from low conservation value/low vulnerability (PCA #119) to medium low conservation value/medium high vulnerability.

6.3.2 Land Ownership and Protected Status

The patterns of land ownership and management within the terrestrial portfolio of conservation areas are shown in Table 6.1. Public lands, both federal and state/provincial, make up the majority of the terrestrial portfolio: 61% of the portfolio is provincial public land, while 15% is U.S. federal land and 3% is state land. Private lands encompass approximately 13% of the PCAs, and tribal/First Nations lands represent 7% of the portfolio.

Approximately 23% of the terrestrial portfolio (12% of the ecoregion) is currently in designated protected areas (Table 6.2). Map 23 shows the area of overlap between the terrestrial portfolio and GAP 1 or GAP 2 areas. GAP definitions can be found in Appendix 1.

The patterns of land ownership and management within the freshwater portfolio of conservation areas are shown in Table 6.3. Public lands, both federal and state/provincial, make up the majority of the freshwater portfolio: 65% of the portfolio is provincial public land, while 9% is U.S. federal land and 2% is state land. Private lands encompass approximately 18% of the freshwater portfolio and tribal/First Nations lands encompass 6% of the portfolio.

Approximately 14% of the freshwater portfolio (to the extent of the EDUs in the ecoregion) is currently in designated protected areas (Table 6.4) Map 25 shows the area of overlap between the freshwater portfolio and GAP 1 or GAP 2 areas. GAP definitions can be found in Appendix 1.

Table 6.1. Land Ownership within the Terrestrial Portfolio

Jurisdiction	% in Portfolio	Hectares (Acres) in Portfolio	% in Ecoregion	Hectares (Acres) in Ecoregion
British Columbia				
Provincial Crown Land	38.3%	1,185,421 (2,929,239)	49.9%	4,793,157 (11,844,150)
Private Land	6.6%	203,168 (502,040)	7.1%	683,115 (1,688,013)
Provincial Park / Protected Area	14.1%	436,797 (1,079,350)	6.5%	622,977 (1,539,410)
Tree Farm License (Crown Land)	8.6%	267,343 (660,620)	3.4%	330,223 (816,000)
Indian Reserve	2.1%	63,904 (157,910)	1.7%	163,639 (404,361)
Conservation Trust Land	0.1%	3,529 (8,720)	0.1%	6,333 (15,649)
Federal Land	0.1%	1,755 (4,337)	0.0%	1,755 (4,337)

Jurisdiction	% in Portfolio	Hectares (Acres) in Portfolio	% in Ecoregion	Hectares (Acres) in Ecoregion
Washington—Federal Lands				
Forest Service: National Forest	9.6%	296,424 (732,480)	7.3%	700,471 (1,730,901)
Forest Service: Wilderness	3.6%	110,968 (274,208)	2.6%	246,004 (607,890)
National Park Service	0.7%	21,398 (52,877)	0.5%	46,119 (113,962)
Other Federal	0.3%	8,151 (20,142)	0.4%	41,244 (101,916)
Bureau of Land Management	0.5%	14,455 (35,720)	0.4%	40,920 (101,115)
Fish and Wildlife Service	0.4%	12,259 (30,294)	0.2%	17,117 (42,297)
Washington—State Lands				
Department of Natural Resources: trust lands	2.2%	67,553 (166,928)	1.9%	186,083 (459,821)
Department of Fish and Wildlife	0.6%	19,166 (47,359)	0.3%	28,237 (69,775)
Department of Natural Resources: NRCA and NAP	0.1%	5,224 (12,908)	0.1%	12,079 (29,847)
Parks and Recreation	0.1%	2,816 (6,958)	0.1%	5,303 (13,103)
Other State	0.0%		0.0%	706 (1,744)
Washington—Other Lands				
Private Land	6.8%	211,639 (522,971)	11.2%	1,073,561 (2,652,827)
Tribal Land	5.2%	159,839 (394,970)	5.9%	568,321 (1,404,352)
County or Municipal	0.0%	229 (567)	0.0%	4,077 (10,074)
Conservation Land (TNC/Other)	0.0%	960 (2,373)	0.0%	1,827 (4,514)

Table 6.2. Area of GAP* 1 to 4 Status Lands within the Terrestrial Portfolio.

	GAP 1	GAP 2	GAP 3	GAP 4	Total
Ecoregion Total (ha [ac])	846,459 (2,091,646)	294,306 (727,246)	5,995,740 (14,815,796)	2,468,495 (6,099,784)	9,605,000 (23,734,472)
% of Ecoregion	9%	3%	62%	26%	100%
Terrestrial Portfolio (ha [ac])	546,475 (1,350,370)	161,198 (398,330)	1,786,690 (4,415,007)	598,636 (1,479,262)	3,093,000 (7,642,969)
% of Portfolio	18%	5%	58%	19%	100%
BC Portion of Terrestrial Portfolio (ha [ac])	418,333 (1,033,723)	35,567 (87,889)	1,434,589 (3,544,946)	273,316 (675,380)	2,161,805 (5,341,937)
% of BC Portion	19%	2%	66%	13%	100%

	GAP 1	GAP 2	GAP 3	GAP 4	Total
WA Portion of Terrestrial Portfolio (ha [ac])	128,143 (316,647)	125,631 (310,441)	352,101 (870,061)	325,320 (803,882)	931,194 (2,301,031)
% of WA Portion	14%	13%	38%	35%	100%

* GAP status definitions are provided in Appendix 1

Table 6.3. Land Ownership within the Freshwater Portfolio

Jurisdiction	% in Portfolio	Hectares (Acres) in Portfolio	% in Ecoregion	Hectares (Acres) in Ecoregion *
British Columbia				
Provincial Crown Land	50.5%	1,667,711 (4,121,005)	49.0%	4,295,705 (10,614,919)
Private Land	9.2%	303,808 (750,727)	7.9%	696,110 (1,720,126)
Provincial Park or Protected Area	9.6%	316,775 (782,767)	5.8%	510,835 (1,262,300)
Tree Farm License (Crown Land)	4.7%	154,252 (381,166)	3.6%	311,822 (770,529)
Indian Reserve	2.4%	79,233 (195,790)	1.8%	156,824 (387,520)
Conservation Trust Land	0.2%	5,380 (13,294)	0.1%	6,333 (15,649)
Federal Land	0.1%	1,755 (4,337)	0.0%	1,755 (4,337)
Washington—Federal Lands				
Forest Service: National Forest	6.7%	221,307 (546,860)	7.6%	670,489 (1,656,813)
Forest Service: Wilderness	1.8%	59,319 (146,581)	2.5%	219,810 (543,163)
Other Federal	0.2%	7,874 (19,457)	0.5%	41,212 (101,838)
Bureau of Land Management	0.5%	15,583 (38,508)	0.5%	40,869 (100,990)
National Park Service	0.0%	0 (0)	0.4%	31,040 (76,703)
Fish and Wildlife Service	0.0%	0 (0)	0.2%	17,117 (42,297)
Washington—State Lands				
Department of Natural Resources: trust lands	1.5%	50,173 (123,981)	2.1%	184,311 (455,442)
Department of Fish and Wildlife	0.2%	7,767 (19,193)	0.3%	28,237 (69,775)
Department of Natural Resources: NRCA and NAP	0.1%	1,878 (4,639)	0.1%	11,748 (29.030)
Parks and Recreation	0.1%	3,761 (9,295)	0.1%	4,941 (12,210)
Other State	0.0%	0 (0)	0.0%	0 (0)

Jurisdiction	% in Portfolio	Hectares (Acres) in Portfolio	% in Ecoregion	Hectares (Acres) in Ecoregion *
Washington—Other Lands				
Private Land	8.7%	286,200 (707,215)	11.1%	969,754 (2,396,315)
Tribal Land	3.5%	116,620 (288,174)	6.5%	568,321 (1,404,352)
Conservation Land (TNC/Other)	0.0%	313 (774)	0.0%	1,827 (4,514)
County or Municipal	0.0%	1,620 (4,004)	0.0%	1,805 (4,461)

* Portion of ecoregion covered by a freshwater analysis units

Table 6.4. Area of GAP* 1 to 4 Status Lands within the Freshwater Portfolio.

	GAP 1	GAP 2	GAP 3	GAP 4	TOTAL
EDU's in Ecoregion (ha [ac])	707,861 (1,749,164)	279,527 (690,726)	5,444,474 (13,453,588)	2,339,121 (5,780,094)	8,770,983 (21,673,572)
% of EDUS in Ecoregion	8%	3%	62%	27%	100%
Freshwater Portfolio in Ecoregion (ha [ac])	357,583 (883,608)	107,457 (265,532)	2,069,943 (5,114,940)	766,375 (1,893,755)	3,301,359 (8,157,835)
% of Freshwater Portfolio in Ecoregion	11%	3%	63%	23%	100%
BC portion of Freshwater Portfolio in Ecoregion (ha [ac])	296,331 (732,250)	35,847 (88,580)	1,813,764 (4,481,907)	383,001 (946,416)	2,528,943 (6,249,154)
% of BC portion of Freshwater Portfolio in Ecoregion	12%	1%	72%	15%	100%
WA portion of Freshwater Portfolio in Ecoregion (ha [ac])	61,252 (151,358)	71,610 (176,952)	256,179 (633,032)	383,374 (947,338)	772,416 (1,908,681)
% of WA portion of Freshwater Portfolio in Ecoregion	8%	9%	33%	50%	100%

* GAP status definitions are provided in Appendix 1

6.3 Target Representation and Conservation Goals

Major ecological gradients and variability are well represented across the portfolio of conservation areas as evidenced by the high degree of representation of ecological systems and the ecological variables used to characterize them (vegetation, elevation, landform, geologic substrate, etc.).

The stated conservation goals were met for 91% of the terrestrial ecological systems and 6% of the terrestrial fine filter species. For targets in the terrestrial species groups, the conservation goals were met for 100% of the amphibians and reptiles, 47% of the birds, 8%

of the dragonflies, 70% of mammals, 8% of the vascular plants and none of the lepidopterans, mollusks and nonvascular plants (see Tables 6.5 and 6.6). Goals were not achieved for 175 fine-filter terrestrial targets and spatial data was not available for 48 of these.

The stated conservation goals were met for 77% of the freshwater ecological systems, and 60% of the species in the Middle Fraser EDU. The stated conservation goals were met for 55% of the freshwater ecological systems, and 58% of the species in the Okanagan EDU. The stated conservation goals were met for 68% of the freshwater ecological systems, and 52% of the species in the Thompson EDU. The stated conservation goals were met for 87% of the freshwater ecological systems, and 100% of the species in the Upper Fraser EDU. Targets were met for all salmon in all EDUs, but not met for insects-other, molluscs, reptiles or vascular plants in any EDU. Spatial data was not available for 23 freshwater fine filter targets in any EDU. Tables 6.7 and 6.8 provide a breakdown of targets met for each EDU. Table 6.9 provides information about the area and number of watershed in the freshwater portfolio by EDU.

A number of plants and rare plant communities have less than seven occurrences; therefore, the conservation goals for those species and communities could not be met until further inventories identify more occurrences. There were no documented occurrences or occurrence data were unsuitable for our terrestrial analyses for 15 animal, 32 vascular plant, 1 non-vascular plant and 54 plant association targets. Future work should focus on systematic inventory of conservation targets that lacked occurrence data (and representation in the portfolio) and targets with too few data to have their conservation goals met. With additional knowledge of target distributions and quality, we will further refine conservation goals for conservation targets.

The following tables summarize goal achievement by target type:

Table 6.5. Summary of Targets and Goal Performance for Okanagan Terrestrial Biological Groups

Biological Group	Number of Targets	Targets with Spatial Data	Targets Meeting Goals for Ecoregion	Percent Targets with Data Meeting Goals for Ecoregion	Targets Meeting Ecoregion Goals Meeting Distribution Goals	Percent Targets with Data Meeting Distribution Goals*
Amphibians	3	3	3	100%	3	100%
Birds	38	34	16	47%	9	56%
Dragonflies	12	12	1	8%	0	0%
Lepidopterans	16	12	0	0%	0	
Mammals **	22	20	14	70%	10	71%
Mollusks	5	2	0	0%	0	
Reptiles	7	5	5	100%	3	60%
Nonvascular Plants	11	10	0	0%	0	
Vascular Plants	106	74	6	8%	4	67%

* Distribution goals = meeting goals for all ecosections where target occurred

** Mountain goat and bighorn sheep in BC and WA counted as separate targets

Table 6.6. Summary of Targets and Goal Performance for Okanagan Terrestrial Ecological Systems

	Number of Systems Targets*	Targets Meeting Goals	Percent Targets with Data Meeting Goals for Ecoregion	Targets Meeting Ecoregion Goals Meeting Distribution Goals	Percent Targets Stratified by ELU Meeting Distribution Goals
Interior Transition Ranges	22	22	100%	22	100%
Thompson Okanagan Plateau	17	15	88%	15	100%
Northwestern Okanagan	17	15	88%	15	100%
Northern Cascade Ranges	22	20	91%	20	100%
Okanagan Highlands	16	14	88%	14	100%
	94	**86**	**91%**	**86**	

* Includes unique system/section combinations; does not include stratification by Ecological Land Unit (ELU). ELU stratification is distribution goals

Table 6.7. Summary of Targets and Goal Performance for Okanagan Freshwater Biological Groups

Biological Group by EDU	Number of Targets	Number of Targets with Spatial Data (with Goals) *	Number of Targets Meeting Conservation Goals	Percent of Targets Meeting Conservation Goals
Amphibians	9	4		
Middle Fraser		---**	---	---
Upper Fraser		---	---	---
Okanagan		4	4	100%
Thompson		2	0	0%
Birds	15	11		
Middle Fraser		6	1	17%
Upper Fraser		---	---	---
Okanagan		9	3	33%
Thompson		5	0	0%
Fish – Nonsalmonoid	18	16		
Middle Fraser		8	7	88%
Upper Fraser		5	5	100%
Okanagan		17	14	82%
Thompson		8	7	88%
Fish - Salmon	6	6		
Middle Fraser		4	4	100%
Upper Fraser		2	2	100%
Okanagan		2	2	100%
Thompson		4	4	100%

Biological Group by EDU	Number of Targets	Number of Targets with Spatial Data (with Goals) *	Number of Targets Meeting Conservation Goals	Percent of Targets Meeting Conservation Goals
Okanogan River Sockeye ESU		1	1	100%
Lake Wenatchee Sockeye ESU		1	1	100%
Columbia River OEU		2	2	100%
Fraser River OEU		2	2	100%
Puget Sound-Georgia Basin OEU		2	2	100%
EDT		3	3	100%
Insects - Dragonflies	13	9		
Middle Fraser		1	0	0%
Upper Fraser		---	---	---
Okanagan		9	4	44%
Thompson		---	---	---
Insects - Other	4	0		
Mammals	3	1		
Middle Fraser		---	---	---
Upper Fraser		---	---	---
Okanagan		1	1	100%
Thompson		1	0	0%
Mollusks	5	3		
Middle Fraser		---	---	---
Upper Fraser		---	---	---
Okanagan		3	0	0%
Thompson		---	---	---
Reptiles	1	1		
Middle Fraser		1	0	0%
Upper Fraser		---	---	---
Okanagan		1	0	0%
Thompson		1	0	0%

Biological Group by EDU	Number of Targets	Number of Targets with Spatial Data (with Goals) *	Number of Targets Meeting Conservation Goals	Percent of Targets Meeting Conservation Goals
Vascular Plants	2	2		
Middle Fraser		---	---	---
Upper Fraser		---	---	---
Okanagan		2	0	0%
Thompson		---	---	---

* Number of targets in the ecoregion only (does not include ecosection targets)
** Signifies no target species for that biological group in that EDU

Table 6.8. Summary of Targets and Goal Performance for Okanagan Freshwater Ecological Systems

Freshwater Systems by EDU	Number of Targets	Number of Targets with Spatial Data (i.e., with Goals)	Number of Targets Meeting Conservation Goals	Percent of Targets Meeting Conservation Goals
All systems	44			
Middle Fraser		43	33	77%
Upper Fraser		31	27	87%
Okanagan		33	18	55%
Thompson		41	28	68%

* Number of targets in the ecoregion only (does not include ecosection targets)

Table 6.9. Area and Number of Watersheds in the Freshwater Portfolio, by EDU, for Okanagan Freshwater Ecological Systems.

	Okanagan EDU	Thompson EDU	Middle Fraser EDU	Upper Fraser EDU
Total Area (ha [ac])	6,349,551 (15,690,082)	5,582,784 (13,795,360)	12,850,388 (31,754,000)	2,769,423 (6,843,393)
Area in Freshwater Portfolio (ha [ac])	2,005,405 (4,955,464)	1,939,415 (4,792,399)	4,187,240 (10,346,895)	1,041,791 (2,574,322)
Percent Area in Freshwater Portfolio	32%	35%	33%	38%
Total Number Watersheds	951	919	1964	473
NumberWatersheds in Freshwater Portfolio	185	184	322	94
Percent Watersheds in Freshwater Portfolio	19%	20%	16%	20%

6.5 Portfolio Integration Efforts and Portfolio Overlays

There is an underlying assumption in ecoregional assessment methodology. We want efficiency in selecting sites to reduce the cost of conservation, and minimizing portfolio area is one aspect of efficiency. This assumption also applies to the integration of the terrestrial and the freshwater portfolios. Ideally, integration between the portfolios would address common ecological functions, processes and biological elements that operate between them. However, we make no claims, even implicitly, regarding the integration between portfolios of these ecological factors.

In this assessment, we attempted to create an integrated portfolio by combining terrestrial and freshwater targets into one MARXAN run as described in Appendix 17. However, this presented several challenges. While the initial portfolio of selected sites was efficient in size at approximately 37% of the ecoregion, the sacrifices made to achieve this efficiency were not satisfactory.

Specifically, the goal of integration is to select areas of the highest-quality for the two portfolios to achieve a smaller spatial footprint. In our case, we found the process of integration to be exchanging too many high-quality sites for areas of marginal quality for the sake of a smaller footprint. During integration, we also had difficulty combining freshwater priority watersheds meaningfully within selected terrestrial hexagons, since watersheds and stream reaches would at times be selected in fragments. However, even before attempting integration, we could ascertain that with just 14% of the ecoregion overlapping between terrestrial and freshwater portfolios, it was clear that our intended integration method would result in a portfolio that, while efficient in spatial extent, would shift the selection away from important freshwater sites and important terrestrial sites to areas of lower value. This attempted integration did not achieve its intent, as it required too much compromise (too little area chosen, too many goals met in areas of marginal quality and too much fragmentation of freshwater priorities) than was acceptable by the Core Team.

The team discussed several methods for overcoming the lack of integration. This included alternate input parameters for the MARXAN model, including increased minimum dynamic area for stream networks, and using a hybrid cost index that favoured planning units selected in the separate portfolios. We also discussed using alternative methods, but the team decided that the small amount of overlap between the terrestrial and freshwater sites and the difference in the freshwater and terrestrial assessment units, made alternative methods just as likely to produce a suboptimal integrated portfolio. See Chapter 8.0 for further discussion. Future iterations of this assessment could produce a fully integrated portfolio.

6.5.1 Overlay of Freshwater and Terrestrial Portfolios

The terrestrial and freshwater portfolios were overlaid to show the total ecoregional area covered by the independent analyses. The area of overlap between the terrestrial and freshwater portfolios is relatively small – comprising only 14% of the ecoregion (1,341,400 ha/3,313,300 ac). Map 24 shows the overlay of the terrestrial and freshwater portfolios and the area of overlap. This does not represent an integrated portfolio, but the team determined it may be useful for the following reasons:

1) transparent - easy to identify why an area is selected
2) maintains the footprint of the expert-reviewed portfolios
3) neither portfolio is compromised
4) depicts where biodiversity values from each portfolio coincide

The overlapping areas may be further prioritized through the prioritization analyses of the freshwater and terrestrial portfolios (Chapter 5.0). Due to the need to practice freshwater conservation at the watershed scale and to address terrestrial conservation in the context of whole sites to incorporate areas large enough for natural disturbances, those referencing the area of overlap are advised to also consult the underlying freshwater and terrestrial sites.

This suite of sites collectively represents the biodiversity of the ecoregion. In addition to showing areas most important for terrestrial or freshwater species and natural systems, Map 24 also depicts areas of overlap where terrestrial and freshwater priorities can be found together.

The iterative nature of ecoregional assessments requires that we interpret results carefully. While the team compiled substantial new information, no amount of effort, within the timeframe of this project, could produce a "complete" dataset. We hope to clarify and fill information gaps over time, and to revisit/refine the portfolio as new information becomes available.

While these conservation areas were designed with knowledge of the area requirements of conservation targets, these areas do not specifically describe the lands and waters needed to maintain each target at that location. Site conservation planning is needed to determine what lands and waters are actually necessary to ensure conservation of the targets at any particular area. Also, because of the way in which portfolio conservation areas were assembled, it may be appropriate to join conservation areas at a later time. Similarly, it may be necessary to segregate individual conservation areas from larger ones. This refinement will be completed during later analyses that consider site-specific targets, threats, and goals. Thus the current boundaries are starting points for further analyses.

6.6 Alternative Portfolios

The size of the conservation portfolio is mainly determined by the goals—the larger the goals, the larger the portfolio. For this reason, goal setting is possibly the most critical step in creating a portfolio. We created three portfolios for this assessment for both the terrestrial (Map 19) and freshwater (Map 21) analyses.

The three alternative portfolios created for both the terrestrial and freshwater analyses represent different tolerances of risk to biodiversity loss, with the lower risk portfolio covering the largest geographic area and the higher risk the smallest. The three portfolios also are an acknowledgment of the uncertainty of how much is enough to conserve for the survival of biodiversity. Finally, the three portfolio levels illustrate that there are a range of policy options for biodiversity conservation. Due to our uncertainty, any portfolio's absolute risk to the loss of biodiversity is unknown and the actual risk might be higher or lower than stated here.

6.6.1 Methods

The methods for developing alternate portfolio scenarios were essentially the same as those used in developing the terrestrial and freshwater portfolios.

Risk is related to the amount of habitat or the number of occurrences that are protected in the portfolio. Capturing more habitat and occurrences yields less risk. The goals for the lower risk and higher risk portfolios were based on the goals of the mid-risk portfolio. For higher risk, the goals were reduced. We multiplied all mid-risk coarse-filter goals by 0.6 and fine-filter goals by 0.5, but the goals could not be less than 1 for targets with occurrence goals. For the lower risk, the goals were increased. We multiplied mid-risk coarse-filter goals by 1.6 and fine-filter goals by 1.5, but the goals could not exceed the maximum available.

We created higher and lower risk alternative portfolios that were derived from the mid-risk alternative. The alternative portfolios are nested. That is, all the AUs in the higher risk portfolio belong to the mid-risk portfolio and all AUs in the mid-risk portfolio belong to the lower risk portfolio. MARXAN has a feature for locking AUs into or out of the optimal solution. To create a nested higher risk portfolio, we locked out all AUs that were not in the mid-risk portfolio. This limited the algorithm's selection space to only the mid-risk portfolio. To create a nested lower risk portfolio, we locked in all AUs that were in the mid-risk portfolio. Hence, the low-risk portfolio started with these locked-in AUs so the algorithm added more AUs to the mid-risk portfolio.

The site selection algorithm for both the lower risk and higher risk portfolios was run with the same target list (terrestrial, freshwater) and with the same boundary modifier and target penalty factors as those used for the mid-risk portfolio.

6.6.2 Results

The alternative portfolios for terrestrial and freshwater biodiversity are depicted on Maps 19 and 21. The terrestrial mid-risk portfolio included 32.2% of the hexagonal assessment units (Table 6.10). In contrast, the freshwater mid-risk portfolio included 18.2% of the watershed assessment units analyzed. However, the assessment units in the freshwater portfolio tend to be among the largest watersheds; consequently, the freshwater portfolio captured about 33.3% of the land area.

The number of AUs in the terrestrial higher risk portfolio was roughly 0.59 times the mid-risk portfolio (Table 6.10), and the number of AUs in the terrestrial lower risk portfolio was about 1.66 times the mid-risk portfolio. These ratios were roughly the same ratios used to alter the mid-risk coarse-filter goals. The same ratios for the freshwater alternatives were 0.65 and 1.56. Again, these ratios were about the same as those used to alter the mid-risk coarse-filter goals.

Table 6.10. Percent of all AUs Captured by Each of the Alternative Portfolios

Portfolio	**Percent of AUs Selected**			**Total AUs Available**
	Higher risk	Mid-risk	Lower risk	
Terrestrial*	19.1	32.2	53.6	19,210
Freshwater**	10.4	18.2	32.8	4,307

* Based on ecoregion boundary
** Based on four EDUs analyzed in the assessment

Table 6.11. Percent of Land Captured by Each of the Alternative Portfolios

(Hexagons were used for terrestrial portfolio, so values are the same as Table 6.1).

Portfolio	**Percent of Area Captured**			**Total Area Available (ha)**
	Higher risk	Mid-risk	Lower risk	
Terrestrial*	19.1	32.2	53.6	9,605,000
Freshwater**	21.4	33.3	52.0	27,552,000

* Based on ecoregion boundary
** Based on four EDUs analyzed in the assessment

6.7 Retrospective Analysis

We identified a number of species that, while of interest, were considered to be of less conservation concern or did not have data covering their entire habitat. Referred to as secondary targets (retro targets), most were included in the MARXAN analysis where spatial data were available, but had assigned goals of zero. With a zero goal, the MARXAN analysis would not actively try to capture any of these secondary targets but would report out on how many were incidentally captured in the portfolio. We reviewed the results and determined if secondary targets were adequately represented. If inadequately represented, we had the option of elevating the targets to primary status, where a goal would be assigned and the analysis re-run.

Similarly, a number of potential targets were considered, but ultimately rejected for inclusion in the primary or secondary target lists. Referred to as non-targets, some spatial data were incidentally collected and included in the MARXAN analysis. These species were treated in the same manner as secondary targets in the MARXAN analysis. Results of the retrospective analysis for each of the target groups are presented below.

6.7.1 Terrestrial Plant Associations

Plant association data were available only for Washington State and were provided by the Washington Natural Heritage Program. Of the 66 plant associations identified as targets, spatial data were available for 12 targets (32 occurrences). Of these, there are 6 targets (8 occurrences) represented in the portfolio.

6.7.2 Terrestrial Fine-filter Plants

All lichens for which we had spatial data were included as primary targets in the MARXAN analysis. Of the 332 vascular plants on the target list, 170 species were identified as secondary targets and 56 species of interest were not classified as a primary or secondary target. Table 6.12 identifies the number of secondary and non-targets and their relationship to the portfolio.

Table 6.12. Terrestrial Fine-filter Plant Secondary Targets and Non-targets

	Number of Targets with Data (total # targets)	Conservation Goal Achieved in Ecoregion	Targets with 100% of Occurrences in Portfolio	Targets with 30%–99% of Occurrences in Portfolio	Targets with No Occurrences in Portfolio
Secondary Targets	134 (170)	7	49	51	23
Non-targets	24 (56)	n/a	5	3	13

6.7.3 Terrestrial Fine-filter Animals

Of the 117 animal species on the fine-filter target list, 17 were identified as secondary targets. Table 6.13 identifies the number of secondary targets and their relationship to the portfolio.

Table 6.13. Terrestrial Fine-filter Animal Secondary Targets

	Number of Targets with Data (total # targets)	Conservation Goal Achieved in Ecoregion	Targets with 100% of Occurrences in Portfolio	Targets with 30%–99% of Occurrences in Portfolio	Targets with No Occurrences in Portfolio
Secondary Targets	11 (17)	3	5	5	0

6.7.4 *Freshwater Fine-filter Targets*

Of the 87 freshwater species on the target list, 28 species were identified as secondary targets and 11 species of interest were not classified as a primary or secondary target. Table 6.14 identifies the number of secondary and non-targets and their relationship to the portfolio.

Table 6.14. Freshwater Fine-filter Secondary Targets and Non-targets

	Number of Targets with Data (total # targets)	Conservation Goal Achieved in Ecoregion	Targets with 100% of Occurrences in Portfolio	Targets with 30%–99% of Occurrences in Portfolio	Targets with No Occurrences in Portfolio
Secondary Targets	18 (28)				
Middle Fraser EDU	3	1	0	2	0
Okanagan EDU	19	10	4	12	2
Thompson EDU	6	1	2	2	2
Non-targets	1 (11)	1	0	1	0

6.7.5 *Grizzly Bear*

Grizzly bear data were obtained from two sources. Much of the Northern Cascades Ranges Ecosection was covered by the North Cascades Grizzly Bear Recovery Zone from the Grizzly Bear Recovery Plan developed by the Interagency Grizzly Bear Committee[3]. The area covered by this data has been reduced through habitat modeling to include only core habitats, by buffering and removing roads, trails and developed areas. For the remainder of the ecoregion in British Columbia we used grizzly population units that are designated as Threatened by the BC Ministry of Environment.

Grizzly bear data were included in the MARXAN analysis as a fine-filter animal target whose goals were to be attained retrospectively rather than as a primary target. The amount of data used to represent grizzly bears was so great and the goals were so large (>40% of the area) that when grizzlies were used as a primary target their data skewed the entire portfolio toward grizzly bear recovery zones and population units (see Map 27) in an attempt to meet grizzly conservation goals. Consequently, making grizzly bears a secondary target allowed the site selection algorithm to select important sites for other conservation targets while also nearly meeting grizzly conservation goals in the process.

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[3] U.S. Fish and Wildlife Service. 1993. Grizzly bear recovery plan; five-year revision draft. USDI Fish and Wildlife Service, Washington, DC.

A comparative analysis was made between the terrestrial portfolio and extent of grizzly recovery zone/population unit, which can be seen on Map 27. In total, grizzly habitat covers 2,626,305 ha (6,489,741 ac) of the ecoregion. This analysis shows that 33%, or 876,366 ha (3,183,718 ac), of the grizzly habitat falls within the terrestrial portfolio. The breakdown by ecosection is shown in Table 6.15.

Table 6.15. Grizzly Bear Habitat within the Terrestrial Portfolio

	Total Available (ha)	Total Captured (ha)	Target	% Captured
Okanagan Ecoregion	2,626,305	876,366	40% total	33%
Interior Transition Ranges Ecosection	1,288,405	355,257	40% total	28%
Thompson Okanagan Plateau Ecosection	26,015	2,251	40% total	9%
Central Okanagan Ecosection	317,625	85,501	40% total	27%
Northern Cascade Ranges Ecosection	967,278	425,166	67% total	44%
Okanagan Highlands Ecosection	25,982	8,191	40% total	32%

While the goal for grizzlies was to capture 40% of the area in threatened population units (for BC) or recovery zones (in WA), the terrestrial portfolio captured 33%. Although the 40% goal was not met for the ecoregion overall, it was exceeded (44%) in the North Cascade Ranges Ecosection, which contains the entire Washington recovery zone that lies within the ecoregion. Exceeding the 40% ecoregion goal for this ecosection is beneficial to grizzly bear conservation as it protects areas critical for bear recovery as well as areas that provide habitat connectivity throughout the North Cascades of Washington and British Columbia. While only 28% of the population unit within the Interior Transition Ranges was captured in the portfolio it identified a large amount (>355,000 ha, >876,850 ac) of bear habitat within the ecoregion and provides important habitat within a population unit and important connectivity within the North Cascades of British Columbia.

6.7.6 Native Grasslands in British Columbia

The Grasslands Conservation Council of British Columbia (GCC) mapped native grasslands for the entire province. This dataset was not included in the MARXAN analysis because it existed only for British Columbia and would have skewed the portfolio to British Columbia.

A comparative analysis was made between the terrestrial portfolio and extent of native grasslands in British Columbia. Native grasslands cover just over 400,000 ha (215,600 ac) of the British Columbia portion of the ecoregion. This analysis shows that 53% of the native grasslands mapped by the GCC fall within the terrestrial portfolio. Map 30 shows the native grasslands in British Columbia in comparison with the portfolio.

The GCC has categorized native grasslands according to four different types as shown in Table 6.16.

Table 6.16. Native Grasslands within the Terrestrial Portfolio

Grassland Type	Total Area in Ecoregion (ha)	Area Captured in Terrestrial Portfolio (ha)	Percent Area Captured in Terrestrial Portfolio
Open grasslands	373,003	199,085	53%
Open dry forest adjacent to open grasslands	14,473	7929	55%
Open dry forest in NDT4*	10,930	3436	31%
Burned forest in PP or BG BGC zone**	5047	3459	69%
Totals	**403,453**	**213,908**	**53%**

* Natural Disturbance Type 4

** Ponderosa Pine or Bunchgrass Biogeoclimatic zone

Chaper 7 – Prioritization of Portfolios

7.1 Introduction

Ecoregional assessments typically identify a large number of potential conservation areas.(Rumsey et al. 2003; Floberg et al. 2004). By virtue of its selection, each conservation area is worthy of action. However not all, areas are of equal conservation value or have the same degree of urgency in the need for action. The challenge of conserving all of the identified areas in an ecoregional assessment is overwhelming if not impossible for any single organization, but through establishing near-term priorities, resources can be focused upon an ambitious yet practical set of conservation areas, whose conservation may be within the collective reach of the conservation community as a whole or agency. Through a practical approach to priority setting, this challenge can be focused on an ambitious set of objectives, which if undertaken by the conservation community as a whole, is within our collective reach (Groves 2003).

These conservation portfolios are intended to serve as the conservation blueprint for protection of the ecoregion's native biodiversity. The prioritization of potential conservation areas is an essential element of conservation planning (Margules and Pressey 2000). The importance of prioritization is made evident by the extensive research conducted to develop better prioritization techniques (e.g., Margules and Usher 1981; Anselin et al. 1989; Kershaw et al. 1995; Pressey et al. 1996; Freitag and Van Jaarsveld 1997; Benayas et al. 2003). We chose MARXAN as our primary prioritization tool. The relative priorities were expressed as two indices – a measure of irreplaceability we refer to as conservation value and a measure of threats or vulnerability of an area. Assigning a relative priority to all conservation sites in the portfolio informs decision makers about their options for conservation.

7.2 Method

The portfolio delineation phase of the Okanagan Ecoregional Assessment identified a very large proportion of the ecoregion as Priority Conservation Areas (PCAs). With 32% of the ecoregion included in the terrestrial results and 34% in the freshwater, the team applied prioritization schemes to help distinguish which of these areas need conservation action more immediately than others. We also determined which areas within those PCAs require the most focus for implementing conservation strategies. The two most commonly used criteria in setting conservation priorities are conservation (or biodiversity) value and vulnerability (threat).

The method described below can provide conservation strategists working in the Okanagan Ecoregion with the means for evaluating priorities based on quantitative measures that emerged from the Okanagan Ecoregional Assessment. This work was based on criteria established in Groves et al. (2000) and on methods applied by Noss et al. (2002) in the Utah-Wyoming Rocky Mountains ecoregional plan. A more thorough evaluation of priorities is required and one that will need to build on the quantitative summary presented here with more qualitative measures related to conservation feasibility, opportunity and leverage.

7.3 Irreplaceability versus Vulnerability Scatterplot

The irreplaceability versus vulnerability scatterplot was first used by Pressey et al. (1996, as described by Margules and Pressey 2000) and was also recently used by Noss et al. (2002) and Lawler et al. (2003). These studies plotted irreplaceability versus vulnerability for a large number of potential conservation areas. We plotted irreplaceability versus vulnerability for the sites in both the terrestrial and freshwater conservation portfolios. Irreplaceability has been defined a number of different ways (Pressey et al. 1994; Ferrier et al. 2000; Noss et al. 2002; Leslie et al. 2003; Stewart et al. 2003). Our definition of irreplaceability (Section 5.2.1) is similar to those of Andelman and Willig (2002) and Leslie et al. (2003), where we selected two measures of irreplaceability to represent conservation value for each conservation area.

Margules and Pressey (2000) defined vulnerability as the risk of an area being transformed by any process which degrades its biodiversity value. The broader definition encompasses adverse impacts from additional factors such as invasive species and fire suppression. Vulnerability could also be defined from the perspective of target species—the relative likelihood that target species will be lost from an area. Since target persistence depends on habitat, a vulnerability index would be a function of current and likely future habitat conditions. Future habitat conditions are generally determined by the management practices and policies associated with an area. Our suitability index incorporated factors that reflected both current habitat conditions and management (Chapter 4.0). Therefore, for the purposes of prioritization, we assumed that our suitability index could also be used as a vulnerability index. We used two different measures from the suitability index to define vulnerability.

Margules and Pressey (2000) and Noss et al. (2002) divided their scatterplots into four quadrants which correspond to priority categories (Figure 7.1): high irreplaceability, high vulnerability (Q1); high irreplaceability, low vulnerability (Q2); low irreplaceability, high vulnerability (Q3) and low irreplaceability, low vulnerability (Q4). Potential conservation areas in Q1 could be considered the highest priority, although some might also prioritize areas in Q2 that are high value and less vulnerable because these areas tend to be in better condition (Pyke 2005). Some have argued that the highest priorities should be potential conservation areas in Q2 because such places have high biological value and a high likelihood of successful conservation.

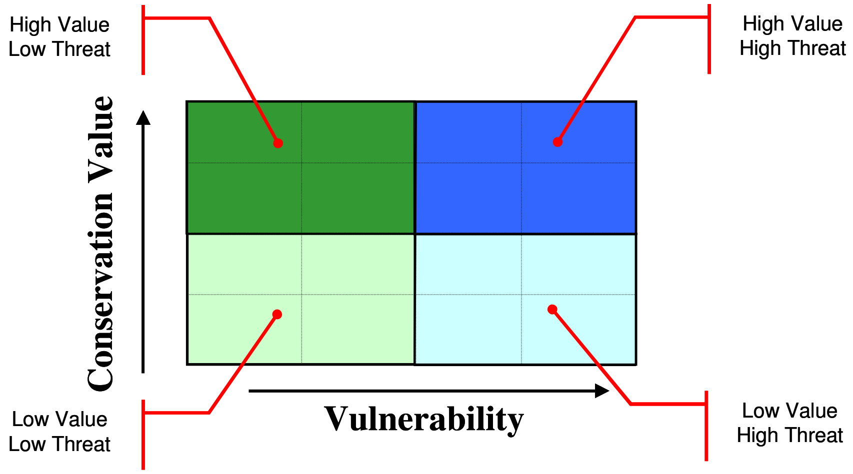

Figure 7.1. Graphing Relative Conservation Value and Vulnerability Scores

The purpose of dividing the scatterplot into quadrants is to assign sites in the freshwater and terrestrial portfolios into priority categories. But the scatterplot can be divided other ways as well. Utilizing a method used by Lawler et al. (2003), we divided the scatterplot into 16 sub-quadrants using the quartile values for irreplaceability and vulnerability. Each sub-quadrant corresponds to a priority category.

7.4 Prioritizing Terrestrial and Freshwater Portfolios in the Okanagan

Terrestrial and freshwater portfolios were prioritized separately using identical methodology. The first step was to define our measures of conservation value and vulnerability. For this analysis, our measures were a function of readily available GIS data compiled through the ecoregional assessment process. We based conservation value on irreplaceability measures, an output from running the MARXAN model; for vulnerability we used the suitability index that was an input to our model (Appendix 16). We populated these data into a custom Microsoft Excel spreadsheet allowing interactive weightings for each independent factor. Weightings included two different factors - certainty and importance. Certainty can be considered as a measure of how confident we are in the data, and how well the data reflect what we intend. Importance represents the assumptions about which factors best reflect conservation value, or alternatively which factors best reflect your organizational mandate. Weightings for certainty and importance are input as a range from zero to one (with 1 being greatest), then multiplied for a final cumulative weighting for each factor. The Core Team came to consensus on one set of weightings resulting in our preliminary site prioritization (Appendix 16).

7.5 Results

The following three products resulted from the prioritization:

1) scatterplots showing the relative position of portfolio sites for conservation value and vulnerability (Figure 7.2). Each of the factors comprising value and vulnerability were given weights reflecting the importance and confidence of each factor.

2) a table of portfolio sites organized by quartile position in the scatterplot (Volume 4, Map Book)

3) colour-coded maps combining the conservation value quartiles with the vulnerability quartiles results in 16 possible bins, represented by a 16 colour scatterplot grid (Maps 27, 27a, 28, 28a).

For planners at an ecoregional scale, this exercise allows potential conservation sites to be clearly sorted according to factors important for biodiversity value as well as those that pose threats. Relative positioning of sites on the scatterplot complements relative priority positioning of sites on the ecoregional map.

This prioritization method allows a way for alternative prioritization perspectives to be easily applied and compared. Such variations on prioritization, whether by use of a subset of factors used in this exercise or through an entirely new set of factors, are accommodated and examined by changing the values or value weights in an EXCEL spreadsheet. Future analysis could allow interested parties to experiment with different prioritization scenarios. The ability to quantify the relative relationship of conservation value and vulnerability provides a basis for strategic planning, and fosters debate on conservation needs.

The resulting scatterplots are shown below. The terrestrial priority conservation area results for individual sites accompany Map 27 and the scatterplot of terrestrial priority conservation areas is shown in Figure 7.2.

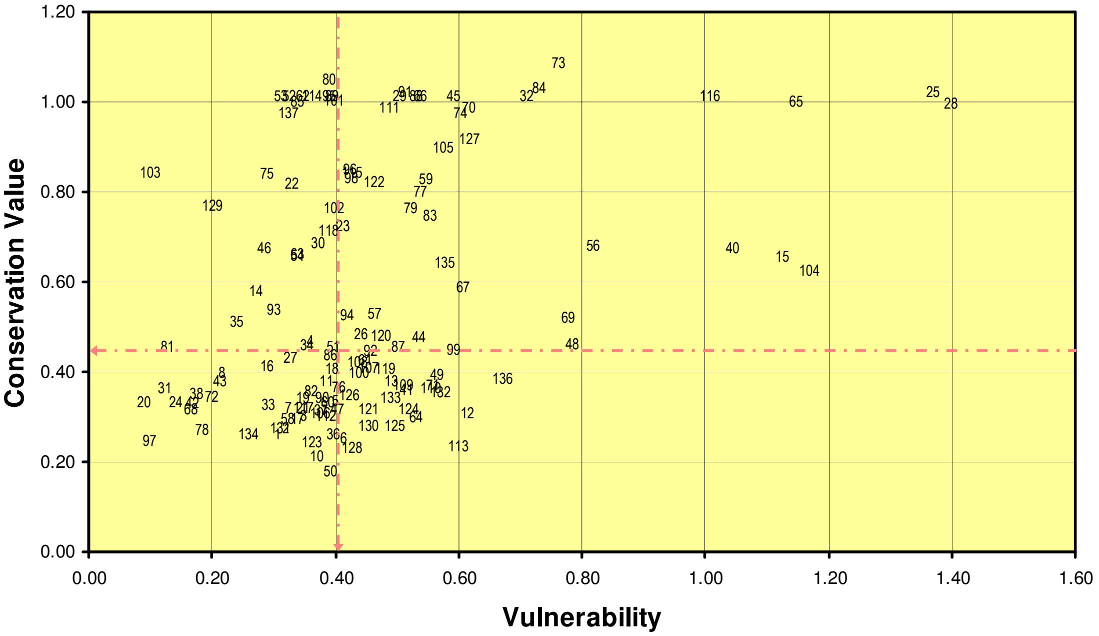

Figure 7.2. Terrestrial Prioritization Scatterplot

The scatterplot of weighted freshwater conservation areas is shown in Figure 7.3. Individual site results for freshwater priority conservation areas are shown accompanying Map 28.

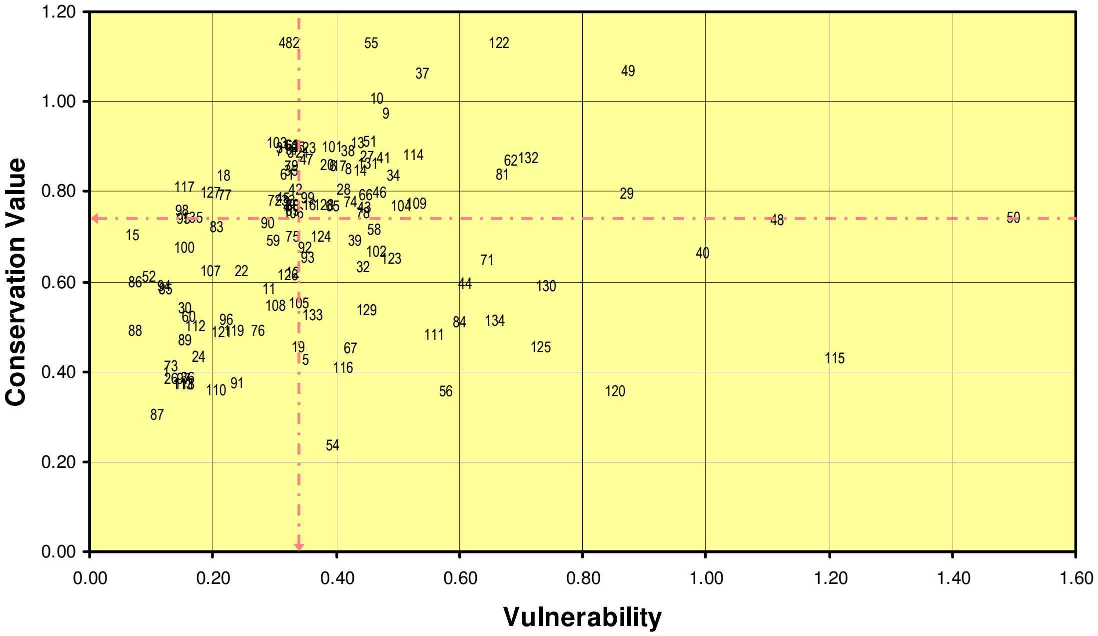

Figure 7.3. Freshwater Prioritization Scatterplot

Chapter 8 – Recommendations for Future Iterations

Ecoregional assessments are a work in progress. They represent the current state of knowledge for establishing region wide conservation priorities. It is expected that future iterations of assessments will be produced as needs change, methods are improved and new data are available. What follows is a list of suggestions to address in future iterations. Topics are arranged in approximate order of importance.

8.1 Data

There were a number of species, communities and natural systems for which the desired occurrence data did not exist, including many invertebrate species, non-vascular plants and imperiled and rare flora species and plant communities. As a broad strategy for filling this data gap, new survey efforts should focus on finding additional occurrences of these targets and documenting the condition of known occurrences. Up-to-date survey data would add considerably to the overall quality of the analysis.

In Washington, the density of species occurrence data is much lower than in British Columbia due in part to lack of survey effort. This data density bias between the political jurisdictions in the ecoregion can lead to problems in prioritizing areas—i.e., places may be identified as high priority because they were intensively surveyed, not because they are inherently more valuable for conservation.

A low cost method for overcoming the lack of occurrence data is to use species-habitat models to predict species occurrences (Scott et al. 2002). However, there were a number of reasons we did not use predictive models. First, we did not have any reasonably accurate species-specific habitat models. The ones available to us, (e.g., Cassidy et al. 1997), have low spatial precision and untested accuracy. Second, we did not have the resources needed to develop our own models for a large number of vertebrate species. Third, species-specific habitat models have both false negatives and false positives (areas where species exist or do not exist that are incorrectly represented in model results). Scientific literature suggests that false negatives inherent to survey data are likely to be less damaging than the false positives of habitat models. Freitag and Van Jaarsveld (1996) and Araujo and Williams (2000) recommend using only occurrence data because of the potential for false positives in habitat models. Loiselle et al. (2003) recommends that species-specific habitat models be used cautiously. Given the lack of readily available models of proven accuracy and without the resources to develop our own models, we believed the most prudent approach was to primarily use occurrence data (with the exception of five large mammals where we used existing models: grizzly bear, lynx, fisher, bighorn sheep and mountain goat).

Finally, gathering freshwater data was more challenging than gathering terrestrial data. The evaluations or assessments of drainage units are a useful beginning for freshwater conservation planning, the analyses varied considerably among ecological drainage units in terms of data availability and depth of expert input on such matters as watershed condition and importance. There is a pressing need for a comprehensive and coordinated approach to incorporating more species occurrence data into the freshwater analysis.

8.2 Conservation Goals

Establishing conservation goals is among the most difficult scientific endeavors in biodiversity conservation. There is much uncertainty, regarding the number of occurrences or the area of an ecological system necessary to maintain all species within an ecoregion (Soule and Sanjayan 1998).

Conservation goals are useful tools for assembling a portfolio of conservation areas that includes 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.

Improving information about estimating with confidence the number and distribution of occurrences that will be sufficient to ensure survival will enhance future assessments.

8.3 Expert Opinion

All judgments are made with imperfect knowledge, and expert opinion may be affected by motivational biases (e.g., judgments influenced by political philosophy) and cognitive biases (e.g., poor problem solving abilities) (Tversky and Kahneman 1974). A group of experts working together may be adversely affected by "groupthink", personality conflicts, and power imbalances (Coughlan and Armour 1992). Nevertheless, the reliance upon expert opinion is decidedly a greater advantage than a disadvantage in the assessment process, as experts were essential in filling data gaps and addressing shortcomings in the methodology. Future assessments should use more elicitation techniques that reduce subjectivity and error in expert opinion solicitation (e.g., Saaty 1980).

8.4 Integration of Terrestrial and Freshwater Portfolios

Integration of the terrestrial and freshwater portfolio posed many challenges. Perhaps most importantly, the terrestrial and freshwater analyses were based on different types of planning units. The terrestrial analysis used hexagons and the freshwater used watersheds and stream reaches. While each type of assessment unit may be appropriate to its respective portfolio, combining terrestrial and freshwater into one planning unit (required by MARXAN), created too great a compromise. In attempting to attribute freshwater data to terrestrial hexagons, we unacceptably fragmented freshwater stream reaches and created slivers of watersheds that were less useful to planners than the stand alone freshwater and terrestrial portfolios.

The terrestrial model is designed to select portfolio sites far from development with little fragmentation of landcover, while the freshwater portfolio must include main stem reaches, which are the areas where most of the human development occurs. Since many of the lower reaches in the freshwater portfolio are urbanized, they do not contribute to terrestrial goals. The result of the team's attempted integration was a less efficient portfolio—i.e., there was only 14% overlap between the terrestrial and freshwater portfolios and the size of the total portfolio increased.

Although we attempted integration, in the final analysis we lacked a satisfactory analytical method for integration. Our experience suggests that developing a system in which terrestrial, marine and freshwater information can be assigned to one cohesive planning unit would greatly enhance our efforts. Additionally, integration might be improved by incorporating the ecological processes or targets that explicitly link terrestrial and freshwater realms. Future assessments should also consider using watersheds for both terrestrial and freshwater realms so that an analytical computer-driven process could be used to more effectively minimize these compromises.

8.5 Threats Assessments

Previous ecoregional assessments consulted regional experts to describe the greatest threats in the ecoregion to biodiversity, including rating the severity and urgency of threats for each area of the ecoregion or individual portfolio site. However, in an effort to be more objective, we decided to only use available GIS data layers to depict threats. For ecoregion-wide analysis, we were therefore limited primarily to the suitability index factors, which show where human impacts are greatest. The advantages of using the suitability index are that it is a quantitative measure based on available GIS data and it is transparent and repeatable. The disadvantage is that it may not capture all the relevant threat categories and does not adequately address future threats. Future assessments might again use expert input to identify the suite of threats not addressed by available GIS data, so a plan to gather important missing data could be developed.

8.6 Connectivity and MARXAN

The draft terrestrial portfolio used the solution provided by MARXAN that offered the set of assessment units meeting conservation goals with the maximum suitability (least human impacts). However, because MARXAN selects places of known populations, instead of areas where populations of animals might occasionally migrate through, it does not adequately address connectivity. Expert review was conducted to address this deficiency in the model by explicitly adding in corridors to maintain biological connectivity, but important corridors may still have been missed. In the future, an additional modeling algorithm could be run on the ecoregion after running MARXAN, in order to specifically address habitat corridors.

8.7 Vegetation Mapping

We constructed a vegetation map by piecing together landcover data from a number of sources. The accuracy of the source data was variable or in some cases unknown, and the accuracy of the resulting vegetation map was not fully tested across the ecoregion. However, there were a number of positive responses from reviewers of the vegetation map that provided confidence that it accurately reflected the existing vegetation at a scale that was suitable for the assessment. In addition, because the analysis was stratified by ecological sections and the vegetation data were generally uniform across a section, the effects of the data gaps were minimized.

Weaknesses in the vegetation map developed for this assessment could be improved upon by quantitative evaluation of map accuracy for all system types and seral stages, especially where the map was developed with restricted plot data and remapping of those types that are found to be least accurate.

8.8 Update of Assessments

Updates or new iterations of ecoregional assessments are driven by the needs of specific conservation projects within an ecoregion or the availability of new methods and data. Since ecoregional assessments are large, complex and costly undertakings that typically take several years to complete, the decision to undertake a new iteration is not trivial. At the same time, conservation biologists have become increasingly aware that in order to respond to rapid changes, more frequent and consistent updates are critical. This is because habitat, ownership, and land use patterns across the ecoregion will change, the abundance and spatial distribution of some species will change, our understanding of ecosystems will increase, analytical methods will improve, and occurrence data will become more comprehensive. Additionally, as further research on climate change is conducted, future iterations will have the opportunity to address the effect on portfolio boundaries as species' ranges shift.

Conservation biologists have recently realized that we need information that will enable us to respond effectively to a dynamic landscape. Depending on the magnitude of change, we may need to frequently re-prioritize actions using up-to-date information about the status of the landscape and likely alterations of the landscape in the near future. Developing a formal process for updating ecoregional assessments will ensure that planners and decision makers have recent, applicable information on which to base their decisions.

8.9 Involvement of Decision Makers

Our assessment process was largely a scientific endeavor, without the involvement of the general public or policy makers. While certain aspects of the assessment must remain purely scientific, the usefulness, and hence effectiveness, of the assessment may be enhanced by working with the public and decision makers. For example, Rumsey et al. (2004) worked with stakeholders and decision makers on an ecoregional assessment in British Columbia that resulted in a decision by the provincial government to designate a network of parks and protected areas.

To assist public decision makers in this process, MARXAN and other such algorithms used for this analysis are expected to become fully interactive in the next several years. This will allow real-time scenario building. In Australia, an interactive computer program was used by stakeholder negotiators to prioritize potential reserves and make land use designations (Finkel 1998). By using the computer interactively, negotiations took place in an objective and transparent environment.

One of the original motivations for using site selection algorithms was the recognition that funds for conservation are limited (Pressey et al. 1993; Justus and Sarkar 2002). Therefore, cost-efficient reserve networks are essential for maximizing biodiversity conservation. Our cost index dealt with the economic cost of conservation in a superficial way. To fully inform decision makers, the economic costs must be examined more closely (Shogren et al. 1999; Hughey et al. 2003). The next iteration of this assessment would be improved by considering socio-economic factors as targets so that they may be included along with biodiversity targets. These could include high value farm or forest land or lands for recreation and urban development, enabling the assessment to be more inclusive in terms of supporting people in the environment.

8.10 Climate Change

Much more attention needs to be given to the effects of climate change on the ecoregion. In the ecoregional assessment process, climate change was taken into account only superficially by selecting examples of targets along a variety of physical gradients. However, global circulation models for the next 100 years now exist that can be used to predict temperature and precipitation changes for large areas in the ecoregion. The spatial information from these models can show areas that are expected to be most and least affected by changes in climate, and this information could be used in computer vegetation models that might predict the vulnerability of basic vegetation types to change. As additional research concerning the impacts of climate change on ecological systems and biological diversity becomes available, it must be incorporated into future iterations of ecoregional assessments.

Chapter 9 – Assessment Products and Their Uses

The Okanagan Ecoregional Assessment was prepared to support effective long-term conservation of the ecoregion's biodiversity. It provides information for decisions and activities that occur at an ecoregional scale: establishing regional priorities for conservation action, coordinating programs for species or habitats that cross political boundaries, and judging the regional importance of any particular place.

9.1 Assessment Products

Three principal products emerged from this effort: (1) a comprehensive compilation of conservation data for the ecoregion, (2) conservation utility maps, and (3) a conservation portfolio map. A number of important ancillary products were also produced, such as the suitability index, that are of considerable interest to groups with specific questions regarding threats, freshwater conservation, policy alternatives, and conservation site priorities in the Okanagan Ecoregion.

Underlying Data

The data that have been compiled specifically for this assessment have proven to be one of the most sought after products. Agencies and groups regularly request these data, especially because they are in a GIS format. One of the uses of the data is to determine how much known biodiversity is located in existing protected areas. This assessment can be used for a GAP-style analysis to direct conservation actions to specific aspects of biodiversity that are most in need of conservation.

Irreplaceability and Utility Maps

Irreplaceability indices represent the relative conservation value of all assessment units (AUs) in the ecoregion. One form of irreplaceability index, conservation utility, is a prioritization of all AUs based on the biological contents and relative suitability of each AU. This map can be used to guide ecoregion-level conservation action and can inform smaller-scale conservation decisions as well. A sensitivity analysis of the terrestrial utility map showed that the ranking of highest ranked AUs was robust to changing assumptions about AU suitability.

Conservation Portfolios and Alternative Portfolios

The conservation portfolio maps depict sets of conservation areas that most efficiently meet a specific set of conservation goals. The conservation areas identified in each portfolio are important for a number of reasons. First, some are the only places where one or more species or plant community targets are known to occur. This is particularly true for species and plant communities associated with shrub-steppe and grassland habitat types. Second, some of these areas are the last large, relatively intact landscapes in the ecoregion. Many of these places are parks or wilderness areas. Large areas are especially important to wide-ranging extant species such as the grizzly bear, grey wolf, lynx, and northern goshawk (*Accipiter gentiles*). These areas make irreplaceable contributions to ecoregional biodiversity and possess significant potential for the maintenance of landscape-scale ecological processes.

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

Suitability Index

Wherever possible, the assessment selected areas that are most promising for successful conservation. This assessment used a suitability index to map the relative likelihood of successful conservation across the ecoregion. The suitability index also relied on two assumptions: first, that existing public land is more suitable for conservation than private land; and second, rural areas are more suitable for conservation than urban areas. Application of these principles and assumptions generally guided site selection toward existing public lands and away from private land, and toward rural areas with low habitat fragmentation and away from urban areas. It is also important to realize that no areas in the ecoregion were excluded from the analysis. If the only place to get a needed population of a rare species to meet a goal was in the center of an urban area, then that area was most likely selected for conservation.

9.2 Caveats

This assessment has no regulatory authority. Rather, it is a guide to help inform conservation decision-making across the Okanagan 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 boundaries and management of any priority conservation area will be based on the policies, values, and decisions of the affected landowners, conservation organizations, governments, and other community members.

Many of the high priority conservation areas described in this assessment may accommodate multiple uses as determined by landowners, local communities and appropriate agencies. Rather than creating protected areas in the usual sense, we speak of the need for portfolio sites to be conserved. While effective conservation can necessitate restricted use, it does not necessarily exclude all human activities.

A reliable assessment of restoration priorities would require a different approach than the one we have presented. Assessment units and portfolio sites were selected for the habitats and species that exist there now, not for their restoration potential. However, many high priority areas will contain lower-quality habitats in need of restoration and this restoration could greatly enhance the viability of these areas and the conservation targets they contain.

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

Some factors in the suitability index require consideration of what are traditionally policy questions. For example, setting the index to favour 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 lands.

This assessment is one of many science-based tools that will assist conservation efforts by government agencies, non-governmental organizations, and individuals. It cannot replace, for example, recovery plans for endangered species, or the detailed planning required in designing a local conservation project. 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.

Chapter 10 – Summary and Conclusions

10.1 Ecoregional Goals

Goals established for the number and distribution of populations (for species) and area (for habitats) within the ecoregion were generally met in the terrestrial and freshwater portfolios. However, meeting goals does not mean that these populations or areas of habitat are all adequately conserved. In this case meeting goals means that adequate target occurrences exist within the ecoregion, and if these areas are conserved, the expectation is that biodiversity would be sustained, subject to many uncertainties associated with our knowledge of species, natural communities and future conditions. Of course, we have no way of knowing how well our goals will reflect the actual needs of biodiversity, and future iterations will no doubt improve on these estimates. In the meantime, organizations can use the stated goals as a starting place to address gaps in biodiversity protection and track progress.

10.2 Sensitivity Analysis

High irreplaceability values—i.e., greater than about 85 to 90—are mostly insensitive to the suitability index. AUs achieve high scores because of their biological contents not because of suitability. In contrast, moderate scores, about 50 to 80, tend to be much more sensitive to the suitability index. Since the suitability index relies on the subjective judgments of individuals, AUs with moderate irreplaceability scores should be examined more closely. Software like MARXAN is often referred to as a “decision support tool.” Such tools can best support decisions by enabling us to explore the effect of various assumptions and differing perspectives. Both Davis et al. (1996) and Stoms et al. (1998) did the equivalent of a sensitivity analysis for their suitability indices. However, they referred to their different indices as “model variations” or “alternatives”; an implicit recognition that different sets of assumptions may have equal validity. To address uncertainties in suitability indices, AU priorities, especially for moderately ranked AUs, should be derived from several different analyses using different indices. This will enhance the robustness of analytical results and lead to more confident decision making.

10.3 Alternative Portfolios

The alternative portfolios are intended as an illustration of how the conservation areas change based on different goals for species and ecosystem targets. Deciding which goals are most appropriate is ultimately a decision for the user and society to make based on the best available science, value-based policy decisions and the results of tracking the persistence of biodiversity over time. These particular alternatives were selected to bracket the scientific uncertainty in the relationship between changes in biodiversity associated with different amounts of landscape fragmentation and loss.

The higher risk portfolio appears to be pessimistically small. As “higher risk” implies, if this portfolio were implemented, then some species are more likely to vanish from the ecoregion. On the other hand, the lower risk portfolio appears impractically large. Undoubtedly under this alternative much habitat would be conserved in multiple-use landscapes where land uses, such as forestry, can be compatible with biodiversity conservation. Among the portfolios, the mid-risk portfolio strikes a balance between the risk of species loss and the impracticality of conserving extremely large areas. The mid-risk portfolio is also based on the stated conservation goals, regarding the number, area and distribution of species and habitats that might be required to maintain biodiversity.

For our example we referred to the alternative portfolios as “higher” and “lower” risk. The higher risk portfolio does indeed impose a higher degree of risk than the mid-risk portfolio and the lower risk portfolio a lower degree of risk, but we do not know how much higher and lower. In fact, the “mid-risk” portfolio could actually be high risk. That is, it might result in a high probability of ecoregional extinction or extirpation for some species. For a small number of species we may have the scientific capacity to determine the level of risk imposed by each portfolio, but given the enormous human changes to the ecoregion that have occurred and are expected to occur, we of course cannot *guarantee* certainty of the persistence of biodiversity by meeting ecoregional goals. As much as possible, future ecoregional assessments should attempt to overcome this shortcoming.

10.4 Use of Assessment

Biodiversity conservation in the ecoregion will attain its fullest potential if all conservation organizations, government agencies and private landowners coordinate their conservation strategies according to the priorities identified through this assessment. The Okanagan Ecoregional Assessment puts forth a baseline to be built upon and refined by site-scale planning efforts. It is intended to guide users to areas with high biodiversity value and suitability. The specifics of conservation site delineation, planning and management will rely on more localized expertise.

Priority Conservation Areas (portfolio sites) span lands that fall under various ownerships and within various jurisdictions and we recognize that some organizations and agencies will be better suited to work in specific areas than others may be. The ultimate vision of the ecoregional assessment process is to facilitate the thoughtful coordination of current and future conservation efforts by the growing number of federal, provincial, state, local, private and non-governmental organizations engaged in this field.

To that end, we encourage wide use of the data and products developed and welcome comments on how future iterations may be improved.