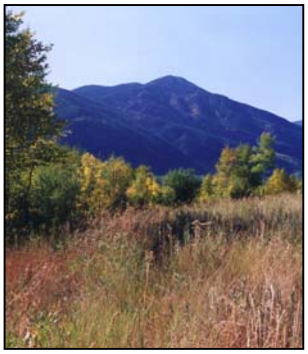
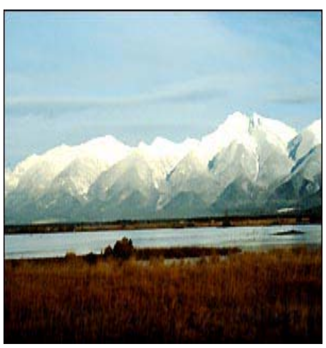



CANADIAN ROCKY MOUNTAINS ECOREGIONAL ASSESSMENT

Volume One: Report

Version 2.0

(May 2004)

British Columbia

Conservation Data Centre

TABLE OF CONTENTS

"At length the Rocky Mountains came in sight like shining white clouds in the horizon, and as we proceeded they rose in height, their immense masses of snow appeared above the clouds and formed an impassable barrier, even to the Eagle."
David Thompson, 1787 [1]

"It is inconceivable to me that an ethical relation to land can exist without love, respect, and admiration for land, and a high regard for its value. By value, I of course mean something far broader than mere economic value; I mean value in the philosophical sense."
Aldo Leopold, 1949, "A Sand County Almanac"

[1] Quoted in the Shining Mountains Mapping Project.

A. CANADIAN ROCKY MOUNTAINS ECOREGIONAL TEAM

The planning team for the Canadian Rocky Mountains ecoregion consisted of a core team with representatives from Montana, British Columbia, Idaho, Washington and The Nature Conservancy's Western Science Division and Ecoregional Planning Office. Leadership was shared between the Montana Field Office of The Nature Conservancy and the Nature Conservancy of Canada's British Columbia Office (NCC). Technical teams were assembled with participants from Idaho, Washington, Alberta, Montana and British Columbia. The entire planning team benefited from the participation of state, provincial and national TNC and NCC staff. The core team and their roles are listed below.

Canadian Rocky Mountains Ecoregional Assessment Core Team

Marilyn Wood, NW Program Manager, TNC, Montana
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Coordination Team

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Canadian Rocky Mountains Assessment Contact

For questions or to provide information for the next iteration of this assessment, please contact The Nature Conservancy of Canada, 207-26 Bastion Square, Victoria, BC, V8W1H9 at (250) 479-3191 and The Nature Conservancy Montana Field Office, P.O. Box 1139, Bigfork, Montana, 59911, at (406) 837-0909. See Appendix 11.0 for list of Conservancy contacts in the ecoregion.

B. ACKNOWLEDGEMENTS

This project could not have been completed without the generous and significant support of the Wilburforce Foundation, the Vancouver Foundation, the 444S Foundation, the Ian Cummings Foundation, the Nature Conservancy chapters of Idaho and Montana, The Nature Conservancy's Western Regional Office, and Washington Department of Fish and Wildlife.

A special thank you to the following people who not only participated in the expert review, but went the extra mile in our formative and summary review process: Paul Galbraith, Larry Halverson, Dave Gilbride, Bill Dolan, Garry Tipper, Ted Antifeau, Jim Thorsell, Bob Jamieson, Darrell Smith, and Paul Sihler.

A special thank you also goes to Andrew Harcombe, Marta Donovan, Steve Moslin, Carmen Cadrin, Sharon Hartwell, Andy Stewart, Leah Ramsay, George Douglas, Adolf Ceska, Samantha Flynn, and all of the staff at the British Columbia Conservation Data Centre for providing data and expertise. Thank you also to Ian Parfitt, Beth Woodbridge, Tom Braumandl, Dennis Demarchi, Mable Jankovsky-Jones, Maureen Ketcheson, Ted Lea, Del Meidinger, Scott Smith, Greg Utzig, Terry Wood, Robert Matt, Steve Binnall, Jeff McCreary, Bill Browne, Dr. John Woods, Murray Peterson, and Mitch Firman who provided data and/or expertise.

Agency support was provided by the Washington Department of Fish & Wildlife, Parks Canada – Western Region, the Montana Natural Heritage Program, British Columbia Ministry of Water, Land and Air Protection, the Alberta Natural Heritage Information Centre, the British Columbia Ministry of Sustainable Resource Management, the Idaho Conservation Center, and the Grasslands Conservation Council (Ryan Holmes and Bruno Delaselle).

Many thanks to the Science and Technology Association of The Rockies, Heather Mountain Lodge, Kicking Horse Coffee, Westroc Industries Inc., and Canmore Catering who provided either cash or in-kind support in hosting the expert workshops.

Thank you to the following people who committed at least one day of time to participate in the expert review process:
Ed Abbott, Paul Galbraith, Jan Simonsen, Ian Syme, Rob Niel, Bob Forbes, Rob Walker, Steve Donelon, Ray Andrews, Jim Skrenek, Perry Jacobsen, Lorna Allen, Peter Achuff, Garth Mowatt, Guy Woods, Ted Antifeau, John Krebs, Cameron Carlisle, Rob Watt, Cyndi Smith, Jon Jorgenson, Larry Ingham, Gerry Wilkie, Meredith Hamstead, Wayne Tucker, Trevor Kinley, Nancy Newhouse, Alan Dibb, Craig Dodds, Darcy Monchak, David Zehnder, David Phelps, Craig Smith, Kevin Weaver, Kathleen Shepherd, Kari Stuart Smith, Anne Skinner, Tom Volkers, Gail Berg, John Bisset, Bill Westover, Robert Matt, Marsha Gilbert, Steve Binnall, Jeff McCreary, Mary Terra-Burns, Bob Ralphs, Gerald Greene, David Leptich, Howard Ferguson, Kevin Robinette, Jeff Azerrad, David Volsen, Steve Zender, Dana Base and Al Palmanteer.

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Steve Carlson, Marc Porter, Linda Ulmer, Bruce Reimer, Dale Becker, Tony Cheong, Jack Stanford, Chris Frissell, Gordon Haas, Dave Tredger, Art Tautz, Dave Mayhood, Nathan Hitt, and Marcy Mahr.

Finally, thanks must also be given to several other regional planning efforts that generously allowed us to borrow from their texts for part of this report. In particular, we thank the Conservation Biology Institute and Jim Strittholt for use of text from the Institute's Pacific Northwest Conservation Assessment Report, (http://www.consbio.org/cbi/pacnw_assess/assess-main.htm).

Similarly, we thank the Southern Rocky Mountains Ecoregional planning team (Neely *et al*. 2001) and the Utah-Wyoming Rocky Mountains planning team (Noss *et al*. 2001), as both formatting and text from those two plans have been drawn from in the writing of this report.

C. EXECUTIVE SUMMARY

Description

The Canadian Rocky Mountains ecoregion (CRM) covers approximately 27.1 million hectares (66.9 million acres) extending across three states and two provinces. The ecoregion extends over a large portion of the Rocky Mountains from southeastern British Columbia and southwestern Alberta to northern Idaho, northwestern Montana and a small part of northeastern Washington. Elevation ranges from 915 m to 3,954 m (3,000 ft to 12,972 ft), with Mt. Robson (BC) being the highest peak in the ecoregion. Geologically, this ecoregion is very complex, containing bedrock of sedimentary, igneous, and metamorphic origin; and is largely characterized by steep glaciated over thrust mountains with sharp alpine ridges and cirques at higher elevations. Historic and current glaciation has sculpted the mountainous landscape filling many of the intermountain valleys with glaciofluvial deposits and moraines.

Land Ownership

Most of the ecoregion is public land and managed for various purposes by provincial, federal and state agencies. The largest land manager in the ecoregion is the Province of British Columbia, which controls 46.4% of the land base in the form of multiple use Crown Lands, Timber Supply Areas and Provincial Parks. The second largest land manager is the U.S. Forest Service, which manages 16.6% of the land within the ecoregion, followed by the Province of Alberta with 9.6% and Parks Canada with 8.4% of the ecoregion's land base under their jurisdiction. Most of the public and industrial land holdings are on the lowest productivity soils, either in the mountains or in arid valleys. Aside from a few mining claims in the mountains, private land occurs in the valley bottoms containing the best soils and access to water. Only 13.1% of the land within the ecoregion is privately held.

Protected Status

The CRM has one of the most extensive protected area systems of any conterminous North American ecoregion. Protected areas make up approximately 23.8% of the ecoregion. A combination of extensive rugged topography and public ownership favored these areas for protected status. Several large wilderness areas account for most of the total, but there is an extensive system of smaller public and private reserves throughout the ecoregion. A detailed study of protected status carried out for this ecoregional plan identified 358 protected areas and reveals that approximately 2.2% of the ecoregion is managed strictly for biodiversity values (equivalent to GAP Status I), and 21.0% is moderately protected (equivalent to GAP Status II).

Biodiversity Status

At least 67 plants, animals and plant communities are known to be endemic to the CRM. There are 56 known globally imperilled (G1-G2) species and 21 species federally listed as threatened or endangered (*U.S. Endangered Species Act* and the *Committee On the Status of Endangered Wildlife In Canada (COSEWIC)*). Another 9 are of special concern due to their vulnerable, declining, endemic, and/or disjunct status.

This ecoregion is best recognized for its full complement of large mammals. Elk, Rocky Mountain bighorn sheep, mountain goats, mule deer, white-tailed deer, moose, and woodland caribou are among the large ungulate species. Some of the most threatened species are carnivores, and this ecoregion supports populations of grizzly bears, gray wolves, wolverines, fishers and lynx. More common carnivores include the black bear, cougar, coyote, bobcat, and American marten. While populations for some of these species are stable, others are declining as a result of cumulative impacts from roads and other human uses.

The CRM also contains significant freshwater biodiversity values. This ecoregion includes the headwaters of many of the major rivers in North America (including the Fraser, Saskatchewan, Missouri, and Columbia) and many large natural lakes and reservoirs (Kinbasket, Quesnel, Arrows, and Flathead). Within the ecoregion are populations of white sturgeon (the largest freshwater fish in North America) and salmonids, including anadromous salmon and some of the last remaining strongholds for westslope cutthroat trout and bull trout, as well as a number of endemic species.

Ecoregional Assessment

The Nature Conservancy and Nature Conservancy of Canada convened a multi-jurisdictional team in March 2000 with the objective of employing a science-based approach to design a portfolio of conservation areas for the Canadian Rocky Mountains ecoregion. This assessment is not meant to serve as a protected areas strategy since it is recognized that conservation in this ecoregion will require a wide range of public/private conservation and stewardship strategies. The CRM ecoregional assessment represents a first step in this process by developing a network of conservation areas that with proper management would ensure the long-term persistence of the ecoregion’s species, communities and ecological systems.

Conservation Targets

Conservation targets, the focus of conservation efforts in the CRM, include both coarse-scale (40 terrestrial ecological systems and 77 aquatic ecological systems) and fine-scale targets (75 rare plant communities, 94 plants, and 56 animals). The team selected the fine filter targets based on their imperilment, vulnerability, endemism, declining status, and the inability of coarse-scale measures alone to conserve them. Aquatic and terrestrial ecological systems were used to represent a broader level of biological diversity across the ecoregion. We assumed that a combination of fine-scale and coarse-scale target selection would be a robust way to capture the broadest array of biodiversity in the ecoregion. According to Haufler et al. (2002), this strategy has the advantages of being scientifically defensible and feasible to implement, and allows for the integration of social and economic objectives.

Portfolio Design

The team compiled and analyzed data from numerous sources, including British Columbia, Alberta, Washington, Idaho and Montana Conservation Data Centres and Natural Heritage Programs, the Washington Department of Fish & Wildlife, GAP Analysis Programs, and expert workshops. The team convened 10 expert workshops and meetings, with over 100 participants, to fill data gaps and obtain up-to-date information on conservation targets and places of significance. The team also used biophysical models as tools to identify, evaluate, and represent the natural variability of aquatic and terrestrial systems across environmental gradients within the ecoregion.

A key component of this ecoregion is its full complement of large mammals, in particular wide-ranging carnivores – grizzly bears, gray wolves, wolverines, fishers and lynx. Traditional ecoregional planning methods (special element and ecosystem representation approaches) have struggled with integrating wide-ranging carnivore conservation goals. To address this critical element of conservation planning for the CRM ecoregion, the team coordinated their work with the Rocky Mountain Carnivore Project initiated by World Wildlife Fund Canada with support from The Nature Conservancy. Principle researchers for The Rocky Mountain Carnivore Project included Dr. Carlos Carroll (The Klamath Centre for Conservation Research), Dr. Reed Noss (Conservation Science, Inc.), and Dr. Paul Paquet (World Wildlife Fund Canada)[2] worked with the team to develop a number of static and dynamic models that allowed the CRM team to design a portfolio that would adequately conserve wide-ranging carnivores and their habitat.

After assessing the viability of target occurrences and developing conservation goals for targets, the team used SITES, a computerized algorithm and software program, to select and design a portfolio of conservation areas. The team refined the modeled output through a series of interactive workshops with team members, Conservation Data Centre and Natural Heritage Program scientists, and other experts.

Portfolio of Conservation Areas

A total of 4,836 watersheds were part of the final conservation portfolio, totalling 13,455,793 hectares (33,249,264 acres) and equalling 49.7 % of the ecoregion. Portfolio watersheds were subsequently delineated as Conservation Areas and where possible, individual planning units were aggregated into larger conservation units called Conservation Landscapes. Conservation Landscapes were built by clustering watersheds that were geographically connected and that shared common ecological processes. These groupings were also clustered based on criteria related to conservation opportunity, including tying together areas where land ownership patterns, such as protected areas, created obvious mechanisms for common conservation action. While the bulk of the conservation solution was aggregated into Conservation Landscapes, an additional 20 individual watersheds were selected to meet conservation goals. Typically, these watersheds contain a single occurrence of a conservation target, are geographically isolated, and do not lend themselves well to incorporation into a larger landscape.

[2] For their full report contact World Wildlife Fund Canada (http://www.wwfcanada.org/en/default.asp)

Of the total 74 Conservation Areas in the solution (54 Conservation Landscapes, and 20 smaller, individual watersheds) 27 are entirely within British Columbia, 2 in Alberta, 14 in Montana, 7 in Idaho, 1 in Washington. Seven Conservation Areas were shared between BC and Alberta, 5 between Idaho and Washington, 1 between BC and Montana, 1 between BC and Washington, and 5 between Idaho and Montana. One Conservation Area was common to each of Alberta, BC and Montana, 1 between BC, Idaho and Washington, and 2 between BC, Idaho and Montana. They range in size from 72 hectares (178 acres) to landscapes of 2 million hectares (4.8 million acres). All of the identified Conservation Landscapes meet standards for functional conservation areas, as they include wide gradients of coarse-scale ecological systems and the element occurrences used to identify these landscapes were evaluated for viability. This portfolio represents a first effort at a functional network designed to conserve selected regional-scale species across their range of variability within the ecoregion.

Priority Setting

The CRM assessment team made a preliminary evaluation of conservation area priorities based upon available quantitative measures of conservation value and vulnerability. Conservation value was scored for each planning unit watershed based upon the criteria of richness, rarity, diversity, and complementarity. Vulnerability scores were evaluated for individual planning units based on GIS data layers describing a variety of human impacts and threats.

The mean conservation value and vulnerability scores of the planning units in each Conservation Area were then used for the purposes of comparison and plotted on a graph of conservation value (y-axis) versus vulnerability (x-axis) and the graph divided into four quadrants. The upper right quadrant, labelled Tier 1, included 11 Conservation Areas with higher conservation value and higher vulnerability – areas that may be considered highest priority sites for conservation. The 43 Conservation Areas that fell within the upper left quadrant of higher conservation value but lower vulnerability were labelled as Tier 2 sites. Tier 2 sites may represent an excellent conservation opportunity to protect intact landscapes of high conservation value before they become irreversibly impacted by rapidly proliferating threats. Twenty-one Conservation Areas fell into the two quadrants representing lower conservation value with 4 areas of lower conservation value and higher vulnerability being labelled as Tier 3 sites, compared to 17 Tier 4 sites of lower value and lower vulnerability.

In order to take advantage of the finer scale at which conservation data was developed, each watershed planning unit was also plotted and compared based on conservation value and vulnerability scores. While the total area of the portfolio is 13,455,793 hectares (33,249,265 acres), the analyses shows that only 1,082,062 hectares (2,673,775 acres), or 4% of the ecoregion, falls into the Tier 1 category. Another 6,909,166 hectares (17,072,549 acres) of the CRM portfolio, or 25.8% of the ecoregion, falls into Tier 2. Only 0.3% or 91,204 portfolio hectares (225,365 acres) are classed as Tier 3, while

31.3% of the ecoregion (8,468,591 hectares/20,925,888 acres) are classed as Tier 4 watersheds.

Taking the mean scores of conservation value and vulnerability for each Conservation Areas tended to obscure some of the attributes of the constituent watershed planning units. However, assessing individual watershed planning units did add interpretive power to these results and provided much needed perspective for the scope of the conservation challenge in the CRM ecoregion. For example, the 11 Tier 1 Conservation Areas could be taken on as the initial CRM action sites. However, a more flexible interpretation might involve taking action at Tier 1 watersheds (4% of the ecoregion) wherever they fall within the portfolio. Likewise, as opportunity, leverage and feasibility are assessed, it may be more appropriate to take action at both Tier 1 and 2 watersheds (29.8% of the ecoregion) that fall within the Conservation Areas constituting the optimal, complete ecoregional solution.

Threats Assessment

The objectives of the preliminary threats assessment were to:

1) Identify general threats at each conservation area while keeping individual conservation targets in mind; and
2) Assess and describe patterns across multiple portfolio conservation areas.

This threats assessment was based on site-specific knowledge of the conservation targets at each of the conservation areas, both from Conservancy, Conservation Data Centre, and Natural Heritage Programs staff, with further review by local experts. Comprehensive assessment of all threats (i.e., stresses and sources of stress) at all conservation areas was beyond the scope of this project. Further work through site conservation planning is needed to update and refine threats to targets at the portfolio conservation areas.

The most severe and pervasive threats were identified as incompatible fire management and forestry practices, residential development, invasive species, parasites/pathogens, and recreation uses. These threats were identified as the key sources of stress that are interrupting fundamental ecological processes needed to maintain the conservation targets in the Canadian Rocky Mountains Ecoregion.

Conservation Blueprint

The primary product of this ecoregional assessment can be considered a conservation blueprint— a vision for conservation success—to guide public land managers, land and water conservation organizations, private landowners, and others in conserving natural diversity within this ecoregion. The goal is to conserve the entire portfolio of conservation areas, which will require a combination of strategies, including on-the-ground action at specific conservation areas and multiple-area strategies to abate pervasive threats to targets across the ecoregion.

It is certain that the initial prioritization of conservation areas presented in this plan requires further qualitative assessments based on conservation feasibility, opportunity and leverage. These assessments should be designed to yield a suite of action sites that can then serve as a focus for conservation partners in the immediate future. It is also important to note that some areas not currently within the conservation solution presented here may become more attractive possibilities for conservation in the future. Changes in land ownership and land use designations in particular can dramatically alter the landscape of conservation opportunity. However, the CRM assessment presented here will allow conservation practitioners to quickly put these emerging opportunities into the appropriate ecological context and to take actions that are scientifically defensible and result in the most biodiversity conserved.

D. INTRODUCTION

Background and Purpose

Responding to a growing consensus in the scientific community and to practitioners frustrated by the incremental progress being made to stem the tide of biodiversity loss, The Nature Conservancy (TNC) and the Nature Conservancy of Canada (NCC) have evolved a new approach to their work. Outlined in *Conservation by Design: A Framework got Mission Success* (TNC 1996), the new approach focuses on strategic planning for site-based conservation actions within the context of ecologically defined areas called *ecoregions*. From a conservation planning perspective, ecoregions are defined as: large areas of land and water that have similarities in faunal and floral composition due to large-scale, predictable patterns of solar radiation and moisture (Bailey 1998). These communities (1) share a large majority of their species, dynamics, and environmental conditions, and (2) function together effectively as a conservation unit at global and continental scales.

The Canadian Rocky Mountains ecoregion planning area boundary was cross-walked between the U.S. Forest Service ECOMAP (Bailey 1995; 1998a) and Ecoprovince/ecoregion delineations established by the Province of British Columbia (Demarchi 1996). The ultimate product of an ecoregional planning process is the *"portfolio of conservation sites," which are* those areas identified *as the most important for* the long-term survival of conservation targets over time, including the ecological processes and patterns of biological diversity that sustain these targets.

Conservation Goal for the Canadian Rocky Mountains (CRM) Ecoregion

The conservation goal for the Canadian Rocky Mountains ecoregion Conservation Plan is to:

> *Identify the suite of conservation sites and strategies that ensure the long-term survival of all viable native plant and animals species and natural communities in the ecoregion.*

However, at present, we lack the scientific understanding necessary to confidently state how much is enough. There is very little theory and no scientific consensus regarding how much ecological system or habitat area is necessary to maintain most species within an ecoregion. Therefore, in more realistic terms, the purpose of this assessment is to identify the areas of greatest importance and opportunity for conserving the biodiversity of the Canadian Rocky Mountains Ecoregion.

Planning Process And Results

This report documents the planning process and results of the portfolio design for the ecoregion. The main products of this ecoregional plan are:

(1) a portfolio of sites that collectively conserve biological diversity in the Canadian Rocky Mountains ecoregion; (2) thorough documentation of the planning process, portfolio design methods, and data management, so that future iterations can efficiently build upon past work; (3) an assessment of multi-site threats and priorities for conservation action; (4) a summary of the

lessons learned during the planning process and any innovative practices that came out of the exercise and; (5) identification of obvious portfolio design limitations and important data gaps that would improve the comprehensiveness and quality of the next iteration.

E. CANADIAN ROCKY MOUNTAINS OVERVIEW

Description of the Ecoregion [3]

The Canadian Rocky Mountains ecoregion extends over a large portion of the Rocky Mountains from southeastern British Columbia and southwestern Alberta to northern Idaho and northwestern Montana. Elevation ranges from 915 m to 3,954 m (3,000 ft to 12,972 ft), with Mt. Robson (BC) being the highest peak in the ecoregion. Geologically, this ecoregion is very complex, containing bedrock of sedimentary, igneous, and metamorphic origin; and characterized by steep glaciated over thrust mountains with sharp alpine ridges and cirques at higher elevations. Historic and current glaciation has sculpted the mountainous landscape filling many of the intermountain valleys with glaciofluvial deposits and moraines.

Climate in the ecoregion is heavily modified by elevation resulting in major influences from such factors as rain shadows and thermal inversions. The northern part of the ecoregion is characterized by a cooler, more boreal climate, while in the west there is a moderating maritime influence, and in the east, drier continental conditions prevail. Mean annual precipitation ranges from 500 to 800 mm (20 to 31 in.) in the valleys, to >1,000 mm (>39 in.) at higher elevations (Ricketts et al. 1999). The majority of precipitation falls as snow in the fall, winter, and spring months, while summers are generally dry. The natural disturbance regimes are predominantly fire, periodic flooding, and insects and disease outbreaks.

The dominant vegetation community is coniferous forest with structure largely dictated by elevation. Low- and mid-elevation conifer forests consist of Douglas-fir, western hemlock, western redcedar, western white pine, and western larch. Lodgepole pine stands are common where stand-replacing fires have occurred. Higher elevation forests are dominated by Engelmann spruce and subalpine fir. Important timberline species include limber pine and whitebark pine. At the highest elevations, alpine tundra dominated by sedges and dwarf shrubs are common. Lower elevations merge into the Montana Valley and Foothill Grasslands ecoregion, which is dominated by fescues, wheatgrasses, and oatgrasses. Valley rivers and streams are often lined with willows and cottonwoods.

This ecoregion is best recognized for its mountainous terrain and full complement of large mammals. It is one of the few places in North America where they still exist. Elk, Rocky Mountain bighorn sheep, mountain goats, mule deer, white-tailed deer, moose, and woodland caribou are among the large ungulate species. One of the most threatened groups is carnivores, and this ecoregion supports populations of the grizzly bear, gray wolf, wolverine, fisher and lynx. More common carnivores occurring in the ecoregion include black bear, cougar, coyote,

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[3] Landscape descriptions were generously shared by the Conservation Biology Institute from its Pacific Northwest Conservation Assessment Report by Jim Strittholt. For more information refer to http://www.consbio.org/cbi/pacnw_assess/assess-main.htm

bobcat, and American marten. While populations for some of these species are stable, some are declining as a result of the cumulative impacts from roads and other human uses.

The ecoregion also supports both anadromous and freshwater fish species; including Chinook salmon, burbot, white sturgeon, rainbow trout (both native and introduced populations), brook trout (introduced), Dolly Varden, bull trout, mountain whitefish, mottled sculpin and Yellowstone cutthroat trout.

Ecoregional Context

South of the Canada/U.S. border the Canadian Rocky Mountains ecoregion is defined by Bailey et al.'s (1995; 1998) hierarchy of landscapes for North America as the regional-scale Northern Rocky Mountains Forest-Steppe-Coniferous Forest-Alpine Meadow *Ecoregion*, within the continent-scaled Dry *Domain* and the Temperate Steppe *Division*[4]. However, in Canada, the term "*Ecoregion*" in this context denotes a different classification level than that used by the U.S. Forest Service (USFS) and The Nature Conservancy. According to the BC Ecoregion Classification System, the term "*Ecoregion*" as defined by USFS/TNC (Bailey 1995; 1998) is roughly equivalent to the BC "*Ecoprovince*" level of classification. For the purposes of this document, the term *"Ecoregion"* will continue to be used to define the planning area.

The CRM is surrounded by the Middle Rockies and Columbia Plateau ecoregions to the south, the Okanagan to the west, the Central Interior and Boreal Plains to the north, and the Aspen Parklands, and Fescue-Mixed Grass Prairies to the east (See Map 1).

Ecoregional Subdivisions

Shining Mountains

In finding the appropriate ecological criteria for stratifying its assessment of the ecoregion, the planning team had the benefit of using the Shining Mountains mapping project. The British Columbia Ministry of Environment, Lands and Parks developed the Shining Mountains Project for the purpose of determining the distribution and extent of regional and zonal ecosystems that British Columbia shares with the various jurisdictions surrounding the province[5]. The Shining Mountains mapping and classification includes British Columbia and adjacent areas from 45° 45' North latitude to 61° North latitude, and from the Pacific coast east to the 110° West meridian. This area encompasses two provinces, parts of two territories, and all or part of 5 US states. Several government agencies cooperated in this project, including, Agriculture and Agri-Food Canada, the USDA Forest Service - Alaska Region, the US National Park Service - Alaska Region, the BC Ministry of Forests - Research Branch, the Montana Department of Fish, Wildlife and Parks, and the Yukon Department of Renewable Resources. In addition, habitat data used in the project was provided by several US agencies including the USDA National Forests, Idaho and Montana State Forests, and the Indian tribes in Montana, Idaho, and eastern Washington.

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[4] See US Forest Service "Ecological Subregions of the Unites States: Section Descriptions" web page: http://www.fs.fed.us/land/pubs/ecoregions/ch45.html

[5] For more information on this project refer to the BC Ministry of Sustainable Resource Management, Terrestrial Information Branch webpage: http://srmwww.gov.bc.ca/rib/wis/bei/shine/

Sections and subsections

Although the Canadian Rocky Mountains Ecoregion is consistent in terms of broad climate, physical, and biological patterns, it is remarkably diverse when viewed at finer scales. Assessing the conservation needs of species and communities requires that we take into account these intra-regional ecological gradients. Accounting for the inherent variability of species and communities, and providing redundancy must be incorporated into the portfolio design process (Anderson et al. 1999; TNC 1999). The simplest way to achieve this was to stratify the ecoregion into sections and set conservation goals for each section. There are ten sections and 29 subsections in the Canadian Rocky Mountains ecoregion[6], listed below in Table 1. These sections and subsections are based on the hierarchical structure of the Province of British Columbia's Shining Mountains mapping and classification project (Demarchi 1996). This classification is concentrated at two levels: a regional ecosystem or the Ecoregion level, in order to place continental and regional ecosystems into perspective; and a zonal level in order to place the local ecosystems into a regional perspective. Note that the term "*Ecoregion*" in this context denotes a different classification level than that used by The Nature Conservancy and Nature Conservancy of Canada. The term "*Ecoregion*" as defined by TNC/NCC (Bailey 1995; 1998) is roughly equivalent to the BC "*Ecoprovince*" level of classification. The Province of BC's hierarchical classification levels are defined as follows:

Ecodomain - an area of broad climatic uniformity, defined at the global level; ***Ecodivision*** - an area of broad climatic and physiographic uniformity, defined at the continental level; ***Ecoprovince*** - an area with consistent climatic processes and relief defined at the sub-continental level; ***Ecoregion*** - an area with major physiographic and minor macroclimatic variation defined at the regional level; ***Ecosection*** - an area with minor physiographic and macroclimatic variation, defined at the sub-regional level.

Table 1. Sections and subsections in the Canadian Rocky Mountains ecoregion (Demarchi 1996).

Section Name	Subsection Name	Hectares (Acres)	% of CRM
Columbia Highlands	Bowron Valley	626,103 (1,547,099)	2.3
	Quesnel Highland	785,958 (1,942,102)	2.9
	Shuswap Highland	1,455,186 (3,595,765)	5.3
Northern Columbia Mountains	Cariboo Mountains	1,398,563 (3,455,849)	5.1
	Northern Kootenay Mountains	1,639,092 (4,050,197)	6.0
	Central Columbia Mountains	1,591,964 (3,933,742)	5.9
	Southern Columbia Mountains	1,761,112 (4,351,709)	6.5
Eastern Continental Ranges	Front Ranges	1,639,291 (4,050,689)	6.0
	Banff-Jasper Parkway	2,109,024 (5,211,397)	7.8
Northern Continental Divide	Porcupine Hills	296,617 (732,942)	1.0
	Border Ranges	1,155,675 (2,855,673)	4.2
	Crown Of The Continent	626,379 (1,547,783)	2.3
	Swan-Mission Ranges	803,280 (1,984,905)	3.0
	East Front Mountains	492,103 (1,215,987)	1.8
Selkirk – Bitterroot Foothills	Selkirk Foothills	1,313,545 (3,245,771)	4.8

[6] Equivalent to the Province of BCs Southern Interior Mountains Ecoprovince (Shining Mountains) (Demarchi 1996)

Table 1 cont'd:

Section Name	Subsection Name	Hectares (Acres)	% of CRM
Selkirk – Bitterroot Foothills	Coeur D'Alene Mountains	1,594,649 (3,940,377)	6.0
	Clearwater Mountains	1,235,921 (3,053,960)	4.6
Western Continental Ranges	Northern Park Ranges	730,708 (1,805,579)	2.7
	Central Park Ranges	794,646 (1,963,569)	2.9
	Southern Park Ranges	1,197,658 (2,959,413)	4.4
Southern Rocky Mountain Trench	Upper Fraser Trench	248690 (614512)	1.0
	Big Bend Trench	117,718 (290,882)	0.4
	East Kootenay Trench	541,708 (1,338,561)	2.0
Kootenai Mountains	Clark Fork Valley	733,612 (1,812,756)	2.7
Montana Valley and Foothills	Clark Fork-Flathead	556,133 (1,374,205)	2.0
	Flathead Basin	378,580 (935,471)	1.4
	Clark Fork Basin	369,031 (911,876)	1.4
Purcell Transitional Ranges	Eastern Purcell Mountains	628,918 (1,554,056)	2.3
	McGillivray Ranges	262,554 (648,770)	0.9
Total		**27,084,419 (66,925,598)**	**100**

Section descriptions for the CRM [7]

The **Columbia Highlands** section is a rolling highland area that rises from highlands and isolated ridges on the west and south to culminate in higher mountains along the northeastern margin. Moist Pacific air rising over these highlands brings intense precipitation to this section. This section contains 3 subsections: **Bowron Valley, Quesnel Highland,** and **Shuswap Highland**.

The **Northern Columbia Mountains** section is a rugged, often ice-capped mountainous area that rises abruptly from the Southern Rocky Mountain Trench to the east. The mountains, composed of a series of ranges and alternating trenches, contain many peaks higher than 3000 m (9,843 ft). This block of mountains intercepts eastward flowing precipitation, making these the wettest mountains in the interior of BC. This section contains four subsections: **Cariboo Mountains, Central Columbia Mountains, Northern Kootenay Mountains,** and **Southern Columbia Mountains**.

The **Eastern Continental Ranges** section covers the Rocky Mountains of Alberta incorporating the eastern flanks of the Continental Ranges. The major peaks on the continental divide cluster around the Columbia Icefield, the largest ice field in the Rocky Mountains. Southward, the

[7] See "Southern Interior Mountains Ecoprovince Descriptions" on BC MSRM, Wildlife and Wildlife Habitat Inventory web page: http://srmwww.gov.bc.ca/rib/wis/eco/bcecode3.html; "Narrative Descriptions of Terrestrial Ecozones and Ecoregions of Canada" on Environment Canada web page: http://www.ec.gc.ca/soer-ree/English/Framework/Nardesc/; "Ecological Subregions of the United States, July 1994" on US Forest Service web page: http://www.fs.fed.us/land/pubs/ecoregions/toc.html

mountains are generally lower. This section contains two subsections: **Front Ranges** and **Banff-Jasper Parkway**.

The **Northern Continental Divide** section is an area of wide valleys and rounded mountains that is interspersed with higher ridges of less erodable bedrock. This high elevation, mountainous ecoregion spans the Alberta–British Columbia boundary and into Montana. Much of the ecoregion lies at 1200–2000 m (3937 – 6562 ft) elevation. Winter temperatures are moderated by frequent Chinooks, especially on the eastern slopes. Cold Arctic air may influence this area from both the Southern Rocky Mountain Trench to the west and the Interior Plains to the east. This section contains five subsections: **Border Ranges, Crown of the Continent, Porcupine Hills, Swan-Mission Ranges,** and **East Front Mountains**.

The **Selkirk - Bitterroot Foothills** section is an area of rounded mountains and wide valleys. This area lies between the warm moist highlands to the west and wet cool mountains to the east. It is a complex of subalpine and moist montane vegetation zones. This section contains three subsections: **Selkirk Foothills, Coeur D'Alene Mountains,** and **Clearwater Mountains**.

The **Western Continental Ranges** section has high, rugged mountains, usually with deep narrow valleys, where elevations rise to over 3000 m (9,843 ft) along the continental divide. This section is predominantly composed of subalpine and alpine ecosystems and a few major valley systems covered by montane forests. It includes the western portion of the Columbia Icefield as well as the highest mountain in the CRM, Mount Robson, at just over 3900 m (12,972 ft). The climate is cool and moderately dry. It contains three subsections: **Central Park Ranges, Northern Park Ranges,** and **Southern Park Ranges**.

The **Southern Rocky Mountain Trench** section is a long, wide, flat-bottomed valley that dissects the CRM. Cold Arctic air from the sub-boreal part of BC is able to move down the Trench easily, while in the summer months the southern part of the Trench is the driest part of the ecoregion. This section is a long, narrow complex of ecosystems that occupy the valley of this major geological fault that runs between the Columbia Mountains and the Rocky Mountains. The headwaters of a number of large rivers lie in the Trench. Climate tends to become warmer and drier moving from north to south. It contains three subsections: **Big Bend Trench, East Kootenay Trench,** and **Upper Fraser Trench.**

The **Kootenai Mountains** section contains complex and high, steep mountains with sharp alpine ridges and cirques at higher elevations, glacial and fluvial valleys, lacustrine basins, and alluvial terraces and floodplains. Steep slopes, sharp crests, and narrow valleys are characteristic. Elevation ranges from 763 to 1,983m (2,500 to 6,500 ft) in valleys and 1,220 to 3,050 m (4,000 to 10,000 ft) in the mountains. Most of the precipitation in the fall, winter, and spring is snow and growing season conditions are dry. This section contains one subsection: **Clark Fork Valley**.

The **Montana Valley and Foothills** section contains high mountains, gravel-capped benches, and intermontane valleys bordered by terraces and fans. Plains and rolling hills surround isolated mountain ranges. Most of the precipitation occurs in the spring and fall, winter precipitation is snow and summers are dry. Temperature extremes are common throughout the winter months and strong winds are common throughout the year. This section contains three subsections: **Clark Fork-Flathead, Flathead Basin,** and **Clark Fork Basin.**

The **Purcell Transitional Ranges** section is an area of subdued ridges located in the southeast. It is a mountainous area with high valleys located leeward on the Purcell Ranges and is within a distinct rain shadow. It has a relatively dry climate. This section contains two subsections: **McGillivray Range** and **Eastern Purcell Mountains**.

Ecological Drainage Units

The minimum standard we apply for aquatic ecoregional planning is to represent freshwater diversity at multiple levels of biological organization across multiple spatial scales. For practical reasons, most ecoregions will not have biologically defined aquatic communities and aquatic ecosystems as targets. Instead we rely on surrogates developed using a multi-scale, landscape-based classification framework for freshwater ecosystems.

The first step in aquatic ecoregional planning is to develop Ecological Drainage Units (EDUs) by gathering information about the variety and distribution of aquatic ecosystem types and general patterns of species distribution. EDUs are groups of watersheds (in the US, 8-digit catalogue units as defined by USGS) that share a common zoogeographic history and physiographic and climatic characteristics. We expect that each EDU will contain sets of aquatic system types with similar patterns of drainage density, gradient, hydrologic characteristics, and connectivity. Identifying and describing EDUs allows us to stratify the ecoregion into smaller units so we can better evaluate patterns of aquatic community diversity. Additionally, EDUs provide a means to stratify the ecoregion to set conservation goals.

EDUs in the Canadian Rocky Mountains ecoregion were defined based on two main sources of information: (1) *zoogeography* from Hocutt and Wiley (1986), World Wildlife Fund's freshwater ecoregions (Abell et al. 2000), the US Forest Service (Maxwell et al. 1995), and ABI databases (L. Master, pers. com.); and, (2) *ecoregional/ecozone attributes* as defined by the US Forest Service/EPA (Pater et al.1998) and Environment Canada. Additional data consulted include: US National Marine Fisheries Service (ESU boundaries for salmonids), Haas (1998), and McPhail and Carveth (1994). Map 5 shows EDU's for the CRM, which are further described in Table 2.

Table 2. EDUs in the Canadian Rocky Mountains ecoregion.

EDU	Physiography	Climate	Zoogeography (from Maxwell et al., 1995)	Stream Types
Upper Fraser	High glaciated mountains (some > 3000m (>9,843 ft) a.s.l. composed of a series of ranges and alternating trenches. Active glaciers present.	Highly variable with elevation; moderate precipitation (700–1100 mm/yr (28-43 in./yr))	Upper Fraser	High gradient, glacially fed streams underlain predominantly by glacial features, folded sedimentary and volcanic strata and massive metamorphic rocks, with intrusions of igneous and volcanic rocks.

Table 2. cont'd:

EDU	Physiography	Climate	Zoogeography (from Maxwell et al., 1995)	Stream Types
Middle Fraser – Nechako	Plateau and interior foothills east of the Coastal Mountains; broad, rolling plateau generally lies 1150–1800 m (3773-5906 ft) a.s.l.	250–600 mm/yr (10-24 in./yr); east 600–800 mm (24-32 in./yr)	Upper Fraser	Surface deposits include glacial till with well-developed drumlinoid features, pitted terraces, simple and compound eskers, and areas of glacial lake (lacustrine) deposits.
Thompson	Predominantly rolling plateaus and major valleys with higher glaciated Columbia Mountains in east.	Warm and dry in west; low to moderate precipitation 250-1016 mm/yr (10-40 in./yr) varies with elevation.	Upper Fraser	Large river system with many lakes draining volcanic rocks and glacial deposits in west; headwaters are in a mountainous glaciated landscape of complex geology.
Columbia – Kootenay Headwaters	Mid- to high elevation glaciated mountains, composed of a series of ranges and alternating trenches; active glaciers in eastern portion.	Varies greatly with elevation; generally moderate precipitation (~762 mm/yr (~30 in./yr))	Upper Columbia	Glacially influenced high gradient streams with large sediment load; underlain by limestone and quartzites; glacial lakes predominate
Great Lakes – Columbia Mountains	Mid- to high elevation glaciated mountains, composed of a series of ranges and alternating trenches.	Varies greatly with elevation; generally moderate precipitation (~762 mm/yr (~30 in/yr))	Upper Columbia	Confluence of three large river systems (Columbia, Kootenay, Pend Oreille) and associated large glacially formed oligotrophic lakes; lower energy systems than in headwaters.
Clark Fork-Flathead	High-elevation glaciated mountains with glacial and lacustrine basins.	Cool temperate with some maritime influences; highly variable precipitation (406-2,540mm/yr (16 – 100 in./yr))	Upper Columbia	Small, medium, and large (e.g., Clark Fork) river systems in predominantly metasedimentary geology; most systems have relatively stable hydrologic regimes due to groundwater and timing of snowmelt; many lakes, including Flathead
Clearwater River	Glaciated, mid- to high elevation mountains.	High precipitation (~762 –1272 mm/yr (~30-50 in./yr), mostly as snow; dry summers	Lower Snake	Flashy small to medium river systems; predominantly granitic substrate with some sedimentary and carbonate material

Table 2. cont'd:

EDU	Physiography	Climate	Zoogeography (from Maxwell et al., 1995)	Stream Types
Smoky-Upper Athabasca	High elevation glaciated mountains; lower elevation valleys to east.	Varies greatly with elevation; generally moderate precipitation (~762 mm/yr (~30 in./yr))	Upper Mackenzie /Arctic	Glacial influence
Upper North Sask.	High elevation glaciated mountains; lower elevation valleys to east.	Varies greatly with elevation; generally moderate precipitation (~762 mm/yr (~30 in/yr))	Upper Saskatchewan/ Hudson Bay	Glacial influence
Upper South Sask.-Red Deer-Bow	High elevation glaciated mountains; lower elevation valleys to east	Varies greatly with elevation; generally moderate precipitation (~762 mm/yr (~30 in/yr))	Upper Saskatchewan/ Hudson Bay	Glacial influence
Milk-Marias-Sun	High elevation glaciated mountains (~1676-2591 m (~5500-8500ft.))	Cold continental; highly variable precipitation (~381-2,540mm/yr (~15-100 in/yr)); dry summers	Upper Missouri	Small headwater systems and glacial lakes in complex geology; predominantly snowmelt driven

Anthropogenic Influence

Although this ecoregion does not contain many urban areas, human activities are continually eroding the region's ecological integrity. Modern human use has impacted many areas - especially at lower elevations. Incompatible forest management, altered fire regime, road building, and mining have had the most widespread ecological impacts. While the number of protected areas is higher here than in many other ecoregions, most are centred on the higher elevations where species richness is low. A number of east-west highway corridors (Highway 2, Highway 3, and I-90) fragment regional habitat connectivity for wide-ranging species, especially large carnivores. Many of the intermountain valleys have either already been degraded or are being degraded by new construction, mines, and incompatible timber harvesting. As an example, the Clark Fork River was recently given most endangered river status by American Rivers largely due to mining activity. Dams, water diversion, and release of exotic species (e.g., stocking of fish to pristine alpine lakes) negatively impact aquatic species and are conservation issues in the ecoregion.

Land Ownership and Management

The Canadian Rocky Mountains Ecoregion covers approximately 27.1 million hectares (66.9 million acres) and straddles three states and two provinces. Just over half of the planning area falls in British Columbia while only 2.5% of the ecoregion is within the borders of Washington State. Table 3 contains the total hectares/acres and percentage of land distribution by state and province in the ecoregion.

Table 3. Land area in the Canadian Rocky Mountains Ecoregion by state and province

State or Province	Hectares	Acres	Percent
British Columbia	13,797,610	34,094,496	51.0
Montana	4,854,188	11,994,911	17.9
Alberta	4,672,052	11,544,845	17.3
Idaho	3,056,597	7,552,985	11.3
Washington	675,030	1,668,029	2.5
TOTAL	**27,055,478**	**66,855,267**	**100.0**

Most of the ecoregion is public land managed for various purposes by provincial, federal and state agencies (Table 4). By far, the largest land manager in the ecoregion is the Province of British Columbia, which controls 46.4% of the land base in the form of multiple use Crown Lands, Timber Supply Areas and Provincial Parks. The second largest land manager is the U.S. Forest Service, which manages 16.6% of the ecoregion, followed by the Province of Alberta with 9.6% and Parks Canada with 8.4% of the ecoregion's land area under their jurisdiction. Only 13.1% of the ecoregion is privately held. Aside from a few mining claims in the mountains, private land occurs in the valley bottoms containing the best soils and access to water.

Table 4. Major Landowners within the Canadian Rocky Mountains Ecoregion.

Major Owner	% of ecoregion owned
Province of BC	46.4%
USDA Forest Service	16.6%
Private	13.1%
Province of Alberta	9.6%
Parks Canada	8.4%
USDI Bureau of Indian Affairs Trust or Tribal Land	1.3%
State of Idaho	1.1%
Water	0.7%
State of Montana	0.6%
USDI Bureau of Land Management	0.2%
State of Washington	0.2%
Mixed Ownership	0.1%
USDI Fish and Wildlife Service	0.1%
First Nations Reserve	0.1%
USDI Bureau of Reclamation	0.1%
Non-Governmental Organizations	0.1%

Socio-Economic History and Trends

First Inhabitants
Humans have lived in the Canadian Rocky Mountains ecoregion since the last great Ice Age. Approximately 15,000 years ago as the Continental and Cordilleran ice caps retreated, native communities living in the south began to slowly move north, along the Rocky Mountain Front and into the interior valleys and plateaus. During the Late Prehistoric Period, which began around 1 A.D. and lasted until European contact, indigenous peoples continued a slow migration north to where they live today. First Nations in the area include the Cree, Slavey, Beaver, Sarcee, Stoney, Blood, Blackfoot, Kutenai, Shuswap, Flathead, Kootenai, Coeur d'Alene, Nez Perce, Peigan, Flathead, Salish, Thompson, Okanogan and Crow. Many of these Nations differ significantly in their history, culture, and language - reflecting the diverse environments in which they live. Today, many Native Americans are involved in complex and politically charged negotiations with all levels of government. These negotiations include not only financial compensation for past wrongs, but also land claim negotiations and rights to both renewable and non-renewable resources.

European Contact
The arrival of explorers from the east coast in the early 1700's brought horses, manufactured goods and small pox to the ecoregion and resulted in many changes in both the territories and cultures of the tribes. The eventual settlement of the west by Europeans led to further change. As the fur trade advanced westward through the 1700's, outposts began to spring up throughout the region. Where once only trappers and buffalo hunters ventured, a new influx of settlers and farmers followed. Much of the exploration of the region by non-native Americans didn't take place till the early 1800's and was sparked by increased competition for resources. Searching for new fur-trading territory in the early 1800's David Thompson of the North West Company surveyed the Columbia River, the Kootenay River and other parts of British Columbia, Montana, Idaho and Washington (Rasker and Alexander 1997).

The Early Years of Settlement
Between 1850 and 1875, prospectors from the depleted gold fields of California and the south descended on the region in search of instant riches; responding to reports of large gold finds in the Wild Horse and Barkerville areas of southeast British Columbia. Along with this influx of people came dramatic impacts on timber (used for fuel, building supplies and mining operations), and fish and game (utilized to support the new population). By 1875 the easily gathered gold was gone and many of the newcomers moved on. Placer mining for gold significantly changed the riparian and aquatic zones of some watersheds.

In the 1880's, the building of two transcontinental railways through the mountains permanently broke the economic isolation of the region. The Northern Pacific Railway crossed the continent just south of the U.S.-Canada border in 1883, and the Canadian Pacific Railway line was built through the mountains of Canada in 1885 The industrialization of North America and the construction of railways and telegraph lines created an enormous demand for metals throughout the region and beyond. This demand led to increased prospecting throughout the region. In subsequent years, important mineral deposits including lead, zinc, silver and copper were discovered and developed - as was coal mining toward the turn of the century. Mining continues to make a significant contribution to the regional economy.

After the turn of the century, the economy of the region began to diversify beyond fur trading and mining. The timber industry had developed in response to an increasing demand for timber for mining operations, railway and canal construction, and construction of new towns. Concurrently, the prairies to the east were experiencing an enormous housing boom as new cities were established and populated by new immigrants. By 1920, much of the easily accessible valley bottom timber had been extracted and lands once forested were being converted for agricultural purposes. The timber industry also continues to be a significant driver in the regional economy.

Agricultural production began in earnest around the turn of the 20th century. This included both crop production (including fruit) and ranching. The first wave of agricultural expansion was to feed railway workers and the miners coming into the region. In turn, many of these new workers settled farms in the region. In the early years, the settlement and agricultural activity were closely related and helped to form the basis of today's settlement patterns. Vegetable, fruit, dairy and grain farming developed to meet local needs, but the main agricultural activity was cattle ranching. This industry served not only local needs, but also an increasing demand from the east. Cattle ranching continues to be widespread in the ecoregion.

Mining, timber extraction, and agriculture continued to expand throughout the 20th century. From humble beginnings grew large, complex and increasingly efficient industries. The construction booms during and following World War I and World War II, dramatically increased demand for products in all three sectors. Technological advances also made the production and distribution of these products easier. Oil and gas exploration also became increasingly important in some parts of the region during this period. Tourism, although started in the late 1890's, began to flourish in the 20th century and now accounts for a significant portion of the regional economy (Rasker and Alexander 1997).

Population and Economic Growth

The region and adjacent regions have experienced rapid population growth and drastic changes in land use over the last 50 years. Traditional industries and occupations throughout the region now co-exist with non-traditional activities in an economy based increasingly on service and knowledge. Much of the recent population and economic growth has been stimulated by business owners, retirees and entrepreneurs who have decided that living in the Rocky Mountains is important to their quality of life. However, the current economy, although increasingly diverse, is still dependent on traditional resource extraction industries and tourism. In the last three decades, the development of hydroelectric power projects has also had a major impact on both the regional economic outlook and the landscape. Where other regions have developed manufacturing, high-tech and secondary/tertiary industries, limitations based on geography and technology have impacted the speed of this change within the ecoregion. The tourism sector, including skiing, hiking, hunting, fishing, water sports, and biking, has shown the most substantial growth resulting in increased commercial/recreational developments and associated vacation home/retirement communities. As an example, the economic impact of visitor expenditures to Alberta's Rocky Mountain National Parks (Banff, Jasper, Waterton) was estimated at $954 million in 1998 (Rasker and Alexander 1997).

Biodiversity Status

For the purpose of this planning framework, "biodiversity" is defined as the variety of living organisms, the ecological complexes in which they occur, and the ways in which they interact with each other and the physical environment (Redford and Richter 1999). This definition characterizes biodiversity by its three primary components: composition, structure, and function (Groves et al. 2002). At least 62 plants, animals and plant communities are known to be endemic to the CRM, meaning they are not known from anywhere else in the world. Endemic species include invertebrates such as the Rocky Mountain Capshell (*Acroluxus coloradensis*) and Longmouth Pondsnail (*Stagnicola elrodiana*), mammals such as the Selkirk Least Chipmunk (*Tamias minimus selkirki*) and Creston Northern Pocket Gopher (*Thomomys talpoides segregatus*), plants such as the Lake Louise Arnica (*Arnica louiseana*), Case's Corydalis (*Corydalis caseana var. hastata*), Woolly Fleabane (*Erigeron lanatus*) and the Alpine Glacier Poppy (*Papaver pygmaeum*), and rare plant communities such as the Hybrid White Spruce/Western Skunk Cabbage Forest (*Picea (engelmannii X glauca, engelmannii)/Lysichiton americanum forest*) and the Black Cottonwood/Red-osier Dogwood/Nootka Rose community (*Populus balsamifera ssp. trichocarpa/Cornus stolonifera/Rosa nutkana community*). There are 56 known globally imperilled (G1-G2) species - e.g., Meltwater Lednian Stonefly (*Lednia tumana*), Flathead Pondsnail (*Stagnicola elrodi*), the Spacious Monkeyflower (*Mimulus ampliatus*), Clearwater Phlox (*Phlox idahonis*), and the Whitebark Pine/Pinegrass Woodland community (*Pinus albicaulis/Calamagrostis rubescens woodland community*). There are 6 species federally listed as threatened or endangered (*U.S. Endangered Species Act* and the *Committee On the Status of Endangered Wildlife In Canada (COSEWIC)*), e.g., Bald eagle (*Haliaeetus leucocephalus*) - Grey Wolf (*Canis lupus*), and Woodland Caribou (*Rangifer tarandus caribou*), the Southern Maidenhair-fern (*Adiantum capillus-veneris*), the Mexican Mosquito-fern (*Azolla mexicana*) and the Phantom Orchid (*Cephalanthera austiniae*). Another 7 are of special concern due to their vulnerable, declining, endemic, and/or disjunct status- e.g., the Ferruginous Hawk (*Buteo regalis*).

This ecoregion is recognized for its full complement of large mammals. Elk, mountain sheep, mountain goats, black-tailed deer, white-tailed deer, moose, and woodland caribou are among the large ungulate species. One of the most threatened groups is carnivores, and this ecoregion supports populations of grizzly bears, gray wolves, wolverines, fishers and lynx. More common carnivores present in the ecoregion include the black bear, cougar, coyote, bobcat, and marten. While populations for some of these species are stable, some are declining as a result of the cumulative impacts from roads, mines, and other human uses.

The CRM also contains significant freshwater biodiversity values. This ecoregion includes the headwaters of many of the major rivers in North America (including the Fraser, Saskatchewan, Missouri, and Columbia) and many large natural lakes (Kinbasket, Quesnel, Arrows, and Flathead). The ecoregion contains populations of white sturgeon (the largest freshwater fish in North America) and salmonids, including anadromous salmon and some of the last remaining strongholds for westslope cutthroat trout and bull trout, as well as a number of endemic species, including burbot. Unlike many other regions in North America, there still remains an opportunity to protect many intact systems within the CRM.

F. ECOREGIONAL PLANNING PROCESS

Background

The Nature Conservancy and the Nature Conservancy of Canada carried out this assessment guided by the methodology outlined in *Designing a Geography of Hope: A Practitioner's Handbook to Ecoregional Conservation Planning* (TNC 2000). Participants included staff from The Nature Conservancy, the Nature Conservancy of Canada, Natural Heritage Programs in Montana, Idaho, Washington, and Alberta, the British Columbia Conservation Data Centre, and the Washington Department of Fish and Wildlife, with input and assistance from many other individuals and agencies (see Acknowledgements and Appendix 10.0). This ecoregional planning process involved the compilation and analysis of the most up-to-date biological and physical data on the location and quality of conservation targets (e.g., species, communities, and ecological systems) and cutting edge research on wide-ranging carnivore modeling.

Ecoregional Planning Steps

Ecoregional planning is an iterative process built around five key steps:

1. Select conservation targets (e.g., species, communities, and ecological systems) to be the focus of conservation efforts within the ecoregion.

2. Set conservation goals in terms of number and distribution of the targets to be captured in the portfolio. These goals were primarily a device for assembling an efficient conservation portfolio, and should not be interpreted as guaranteeing the necessary and sufficient conditions for long-term survival of species, plant communities, or ecological systems.

3. Assess viability of individual target occurrences to determine which sites currently support viable target occurrences.

4. Identify a portfolio of conservation areas that effectively meets conservation goals.

5. Identify preliminary threats to targets at conservation areas and identify action steps to conserve the portfolio.

This type of rigorous analysis employs thousands of pieces of detailed information. It requires location-specific information for conservation targets as well as the past, current, and potential future status of lands where they occur. The team used the best available information for this assessment. However, given the quantity and quality of information involved—and the reality of ecological change—our knowledge will remain incomplete. We therefore approach this assessment with the intention of clarifying and filling information gaps over time, and to periodically revisit our analysis with new information that becomes available.

G. DATA SOURCES AND INFORMATION MANAGEMENT

Information Management

Data management was co-handled by the Nature Conservancy of Canada's B.C. Region and an independent contractor and supported by The Nature Conservancy's Western Resources Office, the Freshwater Initiative, and the Montana Natural Heritage Program. Data were largely managed using Microsoft Access, Excel and ESRI Geographic Information System (GIS) software products such as ArcView 3.2 and Arc/Info.

Conservation partners and outside scientific experts contributed to the data collection and management process by providing input on conservation targets, goal setting, and formative review of the draft portfolio. Botany, zoology and ecology sub-teams were formed early in the planning process in order to efficiently identify conservation targets for the ecoregion. See Table 5 for a list of sub-teams and members.

Data Sources

Numerous data layers were obtained from a variety of sources for the project. Examples of basic data included transportation, hydrography, digital elevation models (DEMs), ecoregional and political boundaries, land ownership, and geology. Biodiversity information layers included, but were not limited to, conservation target locations, vegetation coverage, and habitat models. Threat layers included, but were not limited to, city growth projections, locations of mines, dams and Superfund sites, land protection status, and fire condition.

Data for terrestrial and aquatic targets were made available from Natural Heritage Programs and Conservation Data Centers in Montana, Idaho, Washington, Alberta, and British Columbia. In order to fill in data gaps, experts were consulted throughout the planning process via both workshops and one-on-one interviews (see below). Additionally, habitat models for each of the plan's wide-ranging carnivore targets were created based on habitat values and resource selection functions (RSFs) derived from satellite imagery.

Information for terrestrial ecosystems was derived from the Shining Mountains mapping project, a transboundary mapping project that provided a "wall to wall" coverage for vegetation and sectional classifications (Demarchi 1996). The British Columbia Ministry of Environment, Lands and Parks originally developed the Shining Mountains Project for the purpose of determining the distribution and extent of regional and zonal ecosystems that British Columbia shares with the various jurisdictions surrounding the province. The ecological systems map was also refined at the experts workshops.

An aquatic ecosystem classification was created for the CRM by TNC's Freshwater Initiative using GIS data layers made available by a variety of federal, state and provincial agencies including:

- 1997 US Federal study of the Interior Columbia Basin Ecosystem (e.g., Digital Elevation Model, hydrography, geology, fisheries, existing conservation priorities)

- US Geological Survey (hydrography, flow gauges)
- USEPA (hydrography, water quality)
- University of Montana (fisheries)
- Departments of Environmental Quality in US (water quality)
- British Columbia Ministry of Sustainable Resource Management (hydrography, hydrologic data, fisheries data)
- University of British Columbia (fisheries data)
- Environment Canada (ecoregionalization)
- Pacific Rivers Council (existing conservation priorities)

The aquatic classification was also informed by over 30 experts that were interviewed and asked to review and comment on the targets, supply appropriate data sets for use in planning, and aid in identification of critical areas for conservation.

Table 5. Technical groups and participate lists for the CRM

Technical Groups	Targets	Participants
Botany	Vascular and non-vascular plants	Bonnie Heidel, Steve Shelly, George Douglas (BC Conservation Data Centre), Sharon Hartwell (BC Conservation Data Centre), Joyce Gould (Alberta Natural Heritage Information Centre), Michael Mancuso (Idaho Conservation Data Center), Peter Lesica (private consultant), Ksenija Vujnovic (Alberta Natural Heritage Information Centre)
Zoology	Rare terrestrial animals	Paul Hendricks (Montana Natural Heritage Program), Syd Cannings (BC Conservation Data Centre), Dan Casey (American Bird Conservancy, Partners In Flight), Drajs Vujnovic (Alberta Natural Heritage Information Centre), Leah Ramsay (BC Conservation Data Centre), Chuck Harris
Aquatic	Rare aquatic animals; Aquatic macrohabitats	Steve Carlson (Montana Department of Fish, Wildlife and Parks), Marc Porter (University of British Columbia; now at the Department of Fisheries and Oceans, Canada), Linda Ulmer (US Forest Service), Bruce Reimer (US Forest Service), Dale Becker, Tony Cheong (BC Fisheries), Jack Stanford (University of Montana), Chris Frissell (University of Montana; now with Pacific Rivers Council), Gordon Haas (BC Fisheries; now at University of Alaska), Dave Tredger (BC Fisheries), Dan Mayhood (Freshwater Research Ltd)

Table 5. cont'd:

Technical Groups	Targets	Participants
Aquatic (cont'd)	Rare aquatic animals; Aquatic macrohabitats	Nathan Hitt (University of Montana), Marcy Mahr (Yellowstone To Yukon Initiative)
Plant Ecology	Rare plant communities; Ecological systems	Steve Cooper (Montana Natural Heritage Program), Peter Achuff (Parks Canada), Samantha Flynn (BC Conservation Data Centre), Lorna Allan (Alberta Natural Heritage Information Centre), Pete Lesica (private consultant), Mable Jankovsky-Jones (Idaho Conservation Data Center), Rex Crawford (Washington Natural Heritage Program)

Experts Workshops

The planning team held a series of experts workshops in all of the jurisdictions within the CRM. The goals of the workshops were to:

1. Review and refine the preliminary lists of conservation targets
2. Identify and gather information for areas that contain populations/occurrences of the conservation targets, and obtain information about viability of the targets and threats to the conservation areas or targets
3. Obtain expert opinion for use in developing conservation goals for the targeted species, communities, and ecological systems
4. Identify gaps and inventory/research needs for conservation targets and geographical areas.

An experts workshop on terrestrial vegetation was hosted by the BC Conservation Data Center in Victoria, BC on February 27, 2001. Participants consisted of TNC and NCC ecoregional planning staff and BC and Alberta terrestrial ecosystems scientists. Over a hundred locations were nominated during the workshop. Each location was attributed with at least one ecological system or rare plant community target. When possible, information was supplied that would help determine the viability of the ecological system.

Subsequently, NCC staff hosted many formative reviews following the first draft portfolio, gathering new locations of places important for conservation and receiving valuable feedback regarding preliminary mapping products. Workshops were held in Canmore Alberta, Victoria BC, the Heather Mountain Lodge in Glacier National Park BC, Waterton Lakes National Park, Glacier National Park (Canada), Radium Hot Springs BC, Cranbrook BC, Nelson BC, and Spokane WA. In addition, workshops were held in Coeur d'Alene, Idaho and a number of experts were interviewed on a one-on-one basis in Montana. In total, we consulted with over 100 experts during the course of this planning project. . See Appendix 10.0 for a list of workshop participants and experts consulted.

H. PROTECTED AREAS ASSESSMENT[8]

The CRM has one of the most extensive protected area systems of any conterminous North American ecoregion. A combination of rugged topography and public ownership is largely responsible for the high percentage. Several large wilderness areas account for most of the total, but there is an extensive system of smaller public and private reserves throughout the ecoregion.

Overall, protected areas occupy approximately 23.8% of the ecoregion. A detailed study of protected status carried out for this ecoregional plan identified 358 protected areas and reveals that approximately 2.2% of the ecoregion is managed strictly for biodiversity values (equivalent to GAP Status I), and 21.0% is moderately protected (equivalent to GAP Status II). Finally, 0.6% of the ecoregion falls into parks or protected areas that are, in fact, managed for high impact activities (equivalent to GAP Status III). For Gap Status definitions, see Table 6.

Major protected areas include the Waterton Lakes - Glacier National Park, which forms the center for the Crown of the Continent Biosphere Reserve. Glacier and Waterton Lakes were both placed on the World Heritage List in 1995. A number of other national parks on the Canadian side of the ecoregion include Yoho, Banff, Jasper, and Revelstoke. Large provincial parks include Wells Gray, Bowron Lake, and Mt. Robson. Outside of Glacier National Park, the U.S. side has two very large Wilderness Area complexes. Most notable of these is the Bob Marshall in Montana. Other wilderness areas include the Selway-Bitterroot Wilderness Area in western Montana and east-central Idaho, the Salmo/Priest Wilderness in Washington, and a portion of the Frank Church River of No Return Wilderness in Idaho.

Table 6. Land Status Categories of the GAP Analysis Program.

GAP Category	Definition
Category 1	An area having permanent protection from conversion of natural land cover and a mandated management plan in operation to maintain a natural state within which disturbance events (of natural type, frequency, intensity, and legacy) are allowed to proceed without interference or are mimicked through management.
Category 2	An area having permanent protection from conversion of natural land cover and a mandated management plan in operation to maintain a primarily natural state, but which may receive uses or management practices that degrade the quality of existing natural communities, including suppression of natural disturbance.
Category 3	An area having permanent protection from conversion of natural land cover for the majority of the area, but subject to extractive uses of either a broad, low-intensity type (e.g., logging) or localized intense type (e.g., mining). It also confers protection to federally listed endangered and threatened species throughout the area.

[8] Kimball, S. 2000. Methods for Existing Conservation Areas Assessment in the Canadian Rocky Mountain Ecoregion. Prepared for The Nature Conservancy.

Table 6 cont'd:

GAP Category	Definition
Category 4	There are no known public or private institutional mandates or legally recognized easements or deed restrictions held by the managing entity to prevent conversion of natural habitat types to anthropogenic habitat types. The area generally allows conversion to unnatural land cover throughout.

I. CONSERVATION TARGETS

Conservation by Design identifies all viable native species and communities as the elements to be represented in an ecoregional portfolio of sites (TNC 1996; 1997). This represents the coarse filter/fine filter approach to biodiversity conservation developed by The Nature Conservancy (Noss 1987) and refined through experience and planning (see Geography of Hope, TNC 2000). The coarse filter is a community-level conservation strategy whereby natural community types are used as conservation targets to represent 85-90% of species and many ecological processes, without having to inventory and manage each species individually. Given the status of our knowledge, however, this ecosystem approach cannot be counted on to maintain and protect all biodiversity. Some species, especially the rarest, will fall through the screen of the coarse filter. Therefore, a fine filter for rare species conservation planning is needed as a complement to the coarse filter approach (Noss and Cooperrider, 1994). See Table 7 for summary of conservation targets.

Table 7. Target Summary for the Canadian Rocky Mountains Ecoregional Assessment.

Conservation Targets	#	Data Source	Goal Description
FINE FILTER TARGETS			
Plants	**94**		
Non-Vascular Lichens & Mosses	*28*	EOR data from WA, ID, MT, BC and AB Heritage & Conservation Data Centers	Goals expressed as # of occurrences, stratified by subsection and vary depending on rarity, spatial pattern and distribution of target.
Vascular	*66*		
Terrestrial Animals	**31**		
Wide Ranging Carnivores	*5*	Habitat Modeling (Carroll, Noss and Paquet)	Goals for wide ranging species based on percent of habitat value and stratified by subsection based on results from PATCH modeling.
Invertebrates	*7*	EOR data from WA, ID, MT, BC and AB Heritage & Conservation Data Centers	Goals expressed as # of occurrences, stratified by subsection and vary depending on rarity, spatial pattern and distribution of target.
Amphibians	*7*		
Birds	*6*		
Mammals	*6*		
Aquatic Animals	**25**	EOR's and StreamNet	Goals expressed as # of occurrences, stratified by Ecological Drainage Unit.
Insects	5	EOR	
Mollusks and Snails	5	EOR, expert contributions	
Fish	15	EOR and StreamNet	
Rare Plant Communities	**75**	EOR and expert workshop	Goals expressed as # of occurrences, stratified by subsection and vary depending on rarity, spatial pattern and distribution of target.
Total Fine Filter Targets	**225**		

Table 7 cont'd:

COARSE FILTER TARGETS			
Aquatic Ecosystems	**77**	Modeled by stream reach using Freshwater classification methodologies	Goals expressed as % of known historical extent of system by stream length, stratified by Ecological Drainage Unit
Terrestrial Ecosystems	**40**		
Small patch ecological systems	12	Shining Mtns. vegetation map project and ELU's used as surrogates along with expert nominated locations	Goals expressed as # of occurrences, stratified by subsection and will vary depending on rarity, spatial pattern and distribution of target as indicated in Table 10.0
Matrix & large patch systems	28	Shining Mtns. vegetation map project and ELU's used as surrogates along with expert nominated locations	Goals expressed as percent of known historical distribution, stratified by subsection.
Total Coarse Filter Targets	**117**		
Total Number of Targets	**342**		

Coarse Filter Targets

Both terrestrial and aquatic coarse-filter targets were used in designing the portfolio of conservation sites for the Canadian Rocky Mountains ecoregion. The planning team's strategy with coarse filter conservation was to develop a landscape portfolio of sites that captures the size and extent of natural communities and terrestrial habitats so that natural processes such as fire, avalanche and flood can continue to function across the ecoregion.

Terrestrial Coarse Filter

Ecological systems are groups of ecological communities that share underlying environmental features or gradients and similar processes such as disturbance; and serve as surrogates for terrestrial communities. They are dynamic complexes, but form a robust, cohesive, and distinguishable unit. The ecological systems described for the Canadian Rocky Mountains ecoregion are used to represent the full range of terrestrial habitats. Systems are organized along an elevation gradient, from highest to lowest, and are structured in parallel (where possible) with the *Biogeoclimatic Zones* and the *Shining Mountains* mapping units. Several sources of information were used to identify and describe ecological systems: *An Alliance Level Classification of Vegetation of the Conterminous Western United States* (Reid et al 1999); *A National Ecological Framework for Canada* (ESWG 1995); *Ecosystems of British Columbia* (Meidinger and Pojar (eds) 1991); *Natural Regions, Subregions and Natural History Themes of Alberta* (Achuff 1992); and plant association descriptions from various Canadian national park vegetation classifications. See Appendix 3.0 for complete descriptions of ecological systems. Table 8 outlines the spatial pattern used to describe ecological systems and plant communities.

Table 8. Spatial Pattern Used to Describe Ecological Systems and Plant Communities (from Anderson et al. 1999)

Spatial pattern	Characteristics
Matrix	Vegetation communities form extensive and contiguous cover 2,000 to 500,000 ha in size. Occur on ecoregion's most extensive landforms and typically have ecological tolerances; aggregate of all matrix communities covers 70-80% of ecoregion; often influenced by large-scale processes.
Large Patch	Vegetation communities with interrupted cover ranging in size from 50-2,000 ha. Aggregate of all large patch communities may cover as much as 20% of the ecoregion.
Small Patch	Vegetation communities that form small, discrete areas of cover one to 50 ha in size. Occur in very specific ecological settings, such as on specialized landform types or in unusual microhabitats. May contain disproportionately large percentage of ecoregions total flora, and also support a specific and restricted set of specialized fauna.
Linear	Communities occur as linear strips. Often represent ecotone between terrestrial and aquatic systems. Aggregate of all linear communities covers only a small percentage of the natural vegetation of the ecoregion. Local scale processes, such as river flow regimes, strongly influence community structure and function, leaving communities highly vulnerable to alterations in the surrounding land and waterscape.

We also developed a list of terrestrial natural vegetation community types native to the CRM and nested these within the ecological system framework. This group of plant association targets includes 477 terrestrial and wetland communities aggregated into 40 ecological systems. Riparian systems were divided into four elevation bands with the following titles: *Alpine Riparian Shrubland and Meadows*; *Subalpine Riparian Forest and Shrublands*; *Montane Riparian Forest and Shrublands;* and *Foothill Riparian Forest and Shrubland.* See Appendix 1.2 for a complete list of terrestrial coarse filter targets.

Finally, in order to ensure that the full range of environmental variability and gradients were being targeted within the broad ecosystem types identified, a model was created to depict known driving abiotic variables such as insulation, temperature, soil moisture, and nutrients. These variables (or indirect measures) were combined with a vegetation map to characterize and assess biophysical variation in terrestrial ecological systems. Given available spatial data on elevation, landform, and substrate characteristics, the team mapped terrestrial ecological land units (ELUs) for the ecoregion. ELUs are mapping units used in large-scale conservation planning projects that are defined by two or more environmental variables such as elevation, geological types, and landform. Variables used to develop ELUs were derived from documented knowledge of driving ecological factors within the ecoregion (e.g., Weaver 1970, DeVelice et al. 1986, Kaufman et al. 1992, Dick-Peddie 1993, Peet 2000). Appendix 2.0 provides a full description of the process used for developing these units.

Aquatic Coarse Filter
As no existing freshwater community or ecosystem classification exists within this ecoregion, we developed coarse filter targets using the hierarchical classification framework described in Appendix 4.0. This multi-scale, landscape-based classification framework for freshwater ecosystems is based upon hierarchy theory, and key principles of empirical studies in freshwater ecology. [9]

Aquatic ecosystems (1) occur together in an aquatic landscape with similar geomorphological patterns (2) are tied together by similar ecological processes (e.g., hydrologic and nutrient regimes, access to floodplains and other lateral environments) or environmental gradients (e.g., temperature, chemical and habitat volume) and (3) form a robust, cohesive and distinguishable spatial unit. Using a GIS platform, macrohabitats were classified based on variables of size, geology, gradient, elevation, and upstream/downstream connectivity. Aquatic ecosystem types for the CRM were created using multivariate analysis to group neighboring macrohabitats that share similar patterns.

Over 5000 watersheds were classified into 77 aquatic ecosystem types which served as surrogates for coarser-scale patterns in freshwater biodiversity, common species, and key ecological processes; and mapped in a GIS for each of the EDUs as described previously in Section E: Canadian Rocky Mountains Overview. This work was checked against ecological theory, expert review, and existing studies both in Canada (e.g., the Aquatic Ecozone classification) and the US (e.g., Interior Columbia Basin Ecosystem Management Project (ICBEMP) assessment). Additionally, 11 large drainages were identified to stratify the CRM into smaller watersheds that captured biogeographic differences and major climatic and physiographic gradients important to freshwater biodiversity (Appendix 4.0 and 5.0).

Fine Filter Targets

As per guidelines set out in *Designing a Geography of Hope: A Practitioner's Handbook to Ecoregional Planning* (TNC 2000), fine filter conservation targets were selected based on the following criteria:

Imperilled species are species (or subspecies) that have a global rank of G1-G2 (T1-T2), meaning that they are recognized as imperilled or critically imperilled throughout their ranges by Natural Heritage Programs/Conservation Data Centers. Regularly reviewed and updated by

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[9] Much research has been done on this topic. For example, local patterns of aquatic physical habitats and their biological components are the product of a hierarchy of regional spatial and temporal processes (Tonn 1990; Angermeier and Schlosser 1996; Angermeier and Winston 1999; Mathews 1998; Frissell et al. 1986). Continental and regional aquatic zoogeographic patterns result from drainage connections changing in response to climatic and geologic events (e.g., Hocutt and Wiley 1986). Regional patterns of climate, drainage, and physiography determine aquatic ecosystem characteristics [morphology, hydrologic, temperature and nutrient regimes] that in turn influence biotic patterns (Hawkes et al. 1986; Maret et al. 1997; Poff and Ward 1990; Poff and Allan 1995; Pflieger 1989; Moyle and Ellison 1981). Within regions, there are finer-scale patterns of stream and lake morphology, size, gradient, and local zoogeographic sources resulting in distinct aquatic assemblages and population dynamics (e.g. Maxwell et al. 1995; Seelbach et al. 1998; Frissell et al. 1986; Rosgen 1994; Angermeier and Schlosser 1995; Angermeier and Winston 1999; Osborne and Wiley 1992; see Mathews 1998 for extensive review). The overall basis for our approach stems from an expert workshop that TNC held in 1996 (Lammert et al 1997).

experts, these ranks take into account number of occurrences, quality and condition of occurrences, population size, range of distribution, threats and protection status.

Endangered and threatened species are federally listed or proposed for listing under the Endangered Species Act (also includes proposed and petitioned species) and by the Committee On the Status of Endangered Wildlife In Canada (COSEWIC).

Species of Special Concern are species or subspecies ranked G3-G5 by Natural Heritage Programs/Conservation Data Centres, but fit one or more of the following criteria:

- *Declining species:* Declining species exhibit significant, long-term declines in habitat and/or numbers, are subject to a high degree of threat, or may have unique habitat or behavioral requirements that expose them to great risk. Determination of which species were declining was based on Partners in Flight ranks, Breeding Bird Survey trends, expert opinion, and data from the Natural Heritage Program Network.

- *Endemic species:* Endemic species are restricted to the ecoregion (or a small geographic area within an ecoregion), depending entirely on the ecoregion for survival, and are therefore more vulnerable than species with a broader distribution.

- *Disjunct species*: Disjunct species have populations that are geographically isolated from other populations.

- *Peripheral species*: Species that are more widely distributed in other ecoregions but have populations in the CRM at the edge of their geographical range.

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

- *Focal species*: Focal species have spatial, compositional, and functional requirements that may encompass those of other species in the region and may help address the functionality of ecological systems. Focal species may not always be captured in the portfolio through the coarse filter. Several types of focal species can be considered, including wide-ranging and keystone species. Wide-ranging species are regional-scale species that depend on vast areas. These species often include top-level predators (e.g., wolves, wolverine, grizzly bear), wide-ranging herbivores (e.g., caribou), and wide-ranging omnivores (e.g., black bear) but also migratory mammals, anadromous fish, birds, bats and some insects. Wide-ranging species can be especially useful in examining the need for linkages among conservation areas and creating a functional network of areas.

- *Species aggregations:* These are unique, irreplaceable habitats for the species that use them, or are critical to the conservation of a certain species or suite of species.

- *Globally significant examples of species aggregations* (i.e., critical migratory stopover sites that contain significant numbers of migratory individuals of many species).

A full listing of fine filter targets for the CRM ecoregion is available in Appendix 1.0. Below is a summary by taxa groups.

Vascular and Non-Vascular Plants
The botany technical team identified 66 vascular and 28 non-vascular plants as conservation targets in the ecoregion (Appendix 1.0). These are primarily ranked G1- G3, with the exception of several disjunct species and/or species believed to be in decline. Of these 94 fine filter plant targets, 19 species (23%) are endemic or near endemic to the ecoregion. Two plant conservation targets, Water howellii (*Howellia aquatilis*) and Spalding's campion (*Silene spaldingii*) are listed as '*Threatened*' by the US FWS; Southern maidenhair-fern (*Adiantum capillus-veneris*) is '*Endangered*' and Missouri iris (*Iris missouriensis*), Phantom orchid (*Cephalanthera austiniae*) and Mexican mosquito-fern (*Azolla mexicana*) are listed as '*Threatened*' by COSEWIC (2001). Three Palouse species are experiencing habitat loss and were selected as targets: Jessica's aster (*Aster jessicae),* smallhead goldenweed *(Pyrrocoma liatriformis)* and Spalding's campion *(Silene spaldingii).*

Rare Plant Associations
The terrestrial team identified 75 rare plant associations in the ecoregion (Appendix 1.0) that were found in uncommon environments and would not be adequately represented using the more broadly defined ecological systems. These included all G1 and G2 plant communities from the National Vegetation Classification System (NVCS), as well as those S1 and S2 plant communities recognized by either British Columbia or Alberta CDC programs that did not cross walk to existing types currently in the NVCS.

Amphibians
Seven amphibians were selected as targets. These include two salamanders, Coeur D'Alene salamander (*Plethodon idahoensis*) and Idaho Giant Salamander (*Dicamptodon anterrimus*); both are regional endemics. Two species with high G-Ranks were chosen as targets due to declining habitat or breeding sites: Western toad (*Bufo boreas*) (G4) and Northern leopard frog (*Rana pipiens*) (G5).

We did not select *Rana pretiosa* (Oregon spotted frog - G2G3) as a target because this species has undergone taxonomic revision that is not reflected in the database. The Rocky Mountain form (*Rana luteiventris)* (G4) is widespread and presumably stable; the Cascade form is believed to be in decline. Since *Rana luteiventris* is known from 241 element occurrence records in the ecoregion, the team decided not to include the Oregon spotted frog as a fine filter target.

Mammals
Of the 11 mammals, 5 are wide-ranging carnivores (grizzly bear, lynx, wolverine, fisher, gray wolf) and another, the caribou, is a wide-ranging herbivore. Two of the small mammals selected as targets: the Selkirk least chipmunk (*Tamias minimus selkirkii*) (G5T1T3), a subspecies known only from the type locality in the Purcell Mountains, BC (1940); and Creston northern pocket

gopher (*Thomomys talpoides segregatus*), a subspecies known only from the type locality on the benchlands of Goat Mountain near Wyndel, above the Kootenay River, BC. Both are presumably vulnerable due to their localized distribution (Hafner et al. (eds) 1998). Townsend's big-eared bat (*Corynorhinus townsendii)* (G4) was selected as a target because this species is believed to be declining.

Wide-Ranging Carnivores
This ecoregion is best recognized for its full complement of large mammals, in particular the wide ranging carnivores –grizzly bears, gray wolves, wolverine, fisher and lynx. Traditional ecoregional planning methods (special element and ecosystem representation approaches) have struggled with the best way to integrate carnivore conservation goals and the protection of other conservation targets. To address this critical element of conservation planning for the CRM, the planning team coordinated their work with the Rocky Mountain Carnivore Project initiated by World Wildlife Fund Canada with support from The Nature Conservancy. Principle researchers for The Rocky Mountain Carnivore Project included Dr. Carlos Carroll (The Klamath Center for Conservation Research), Dr. Reed Noss (Conservation Science, Inc.), and Dr. Paul Paquet (World Wildlife Fund Canada)[10]. Dr. Carroll was an active participant throughout the entire ecoregional planning process and worked closely with our data manager, Bart Butterfield.

The planning team incorporated static models (species distribution and habitat characteristics) for 5 carnivore species, grizzly bear, gray wolf, lynx, wolverine, and fisher. The static models for these species were determined by the Carnivore Project leaders to be the best available information on a region-wide basis. Species distribution data included sightings, denning, and trapping records of fisher, lynx, and wolverine, grizzly bear radio telemetry locations, and boundaries of wolf pack territories. Habitat data included vegetation, satellite imagery metrics, topography, climate, and human impact variables.

Invertebrates
A total of 7 terrestrial invertebrates were selected as targets including three mountains snails (*Oreohelix* spp. & *Oreohelis* spp.) endemic to the ecoregion.

Birds
A bird target list that included conservation goals for bird habitat were compiled which included species of conservation concern as identified by the Partners in Flight (PIF) program (Ritter 1999; D. Casey pers. comm.). PIF recommendations were made for both fine filter and coarse filter targets. Suitable habitat to maintain long-term viability for coarse filter species was met through the ecological system and other fine filter conservation targets.

Aquatic Animals
A total of 25 species, fish, mollusks, insects were chosen using the criteria of high natural rarity, severe threat, and overall declining distribution. Included on the target list were white sturgeon, Upper Fraser River populations of anadromous salmonids (sockeye, pink, coho, steelhead, chinook) as well as westslope cutthroat trout and bull trout. Two data sets were used to compile the list (1) CDCs/Heritage Programs, generally represented as points, and (2) state/provincial/federal datasets, represented generally as presence/absence by watershed.

[10] For their full report contact World Wildlife Fund Canada (http://www.wwfcanada.org/en/default.asp)

J. CONSERVATION GOALS

Background

Conservation goals represent the end toward which we direct conservation efforts for targeted species, communities, and ecosystems. Goals provide the quantitative basis for identifying and prioritizing areas that contribute to the reserve network. Reserve design is appropriately dictated by target goals, thus creating a vision of landscape functionality at a regional scale. Establishing conservation goals is among the most difficult - and most important - scientific questions in biodiversity conservation (e.g., How much is enough? How many discrete populations and in what spatial distribution are needed for long-term viability?). There is no scientific consensus regarding how much is enough. As some have pointed out (e.g. Noss 1996, Soule & Sanjayan 1998), these questions can't really be answered by theory, but require an empirical approach, target-by-target, and a commitment to monitoring and continual re-evaluation over the long-term.

Goals for conservation targets define the number and spatial distribution of on-the-ground occurrences. As a general rule, our goal is to conserve multiple examples of each target, stratified across its geographic range in such a way that we capture (1) the variability of the target and its environment, and (2) redundant occurrences to provide a high likelihood of persistence in the face of environmental stochastically.

We define a **viable species** or **population** as one that has a high probability of continued existence[11] over a specified period of time. Conservation goals should support the target species in continually changing ecosystems, looking into the future at least 100 years or 10 generations. While that concept of viability could be said to apply to all targets, in practice we use several closely related, though distinct, groups of targets. It is important to distinguish "fine filter" (*species*) targets from "coarse filter" (*communities* and *ecosystems*) targets in terms of conservation strategies. Fine filter strategies appropriately emphasize maintenance of multiple occurrences or viable populations. . In addition to species viability, coarse filter strategies emphasize the conservation of ecosystem functions (e.g. air, water, nutrient cycling, etc.), perhaps better characterized as **ecological integrity** at an ecoregion scale (Pimentel et al. 2000). While conservation goals for species emphasize representation and redundancy, coarse filter goals focus more strongly on capturing the full range ecological variability and environmental gradients.

Conservation Goals for Terrestrial Species

Goals for terrestrial species are described in Table 9 and are based on spatial pattern and ecoregional distribution. Rarity is a factor in so far that for G1-G2 taxa, the goal was to maintain all potentially viable occurrences and to develop strategies for their recovery with the ecoregion. All terrestrial goals were stratified by subsections as delineated by Demarchi et al. (1996) so that at least 2 occurrences per subsection were required (where possible) in attaining the overall ecoregional goals.

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[11] 95% certainty of surviving 100 years and/or 10 generations

Table 9. Ecoregional Conservation Goals for Terrestrial Species

Spatial Pattern[12]	**Regional**[1]	**Coarse**[2]	**Intermediate**[2]	**Local**[2]
Distribution[13]				
Endemic	Maintain core areas for dispersal and connecting habitat for wide ranging mammals.	10	18	25
Limited		5	9	13
Disjunct		5	9	13
Widespread		3	5	7
Peripheral		1	2	3

[1] Target-by-target, range-wide (multi-ecoregional) goals are applied. Targets represented within each ecoregion by "potentially occupied" core and connecting habitat components.
[2] Ecoregional goals stratified by subsection for fine filter terrestrial and aquatic targets.
* Separation distance for each target occurrence specified, or default of 10 km. Many naturally rare and endemic G1-G2 species may have historically occurred with fewer than 25 populations. In these cases, the goal is 'all potentially viable occurrences up to 25.'

Conservation Goals for Terrestrial Ecosystems

Conservation goals for terrestrial ecological systems and rare communities considered the target's distribution relative to the ecoregion and their typical spatial pattern (Anderson et al. 1999). For ecological systems, we selected ecologically based representation goals for each of the 40 system-types. These goals are expressed by minimum size, distribution and number of examples. Table 10 describes these goals. Our objective was to ensure that each ecological system was represented in the portfolio. The coarse filter thus captures a sample of each terrestrial habitat type, spread across the ecoregion. Where we sought to protect known, specific sites, they are captured in the fine filter, as described below.

Table 10. Ecoregional Conservation Goals for Terrestrial Ecosystems [14]

Distribution Relative to Ecoregion	Conservation goals for selected *large patch* and *small patch* systems (expressed as a number of occurrences) and for remaining *large patch*, *matrix* and *linear* vegetation systems.	
	Spatial Pattern in Ecoregion	
	Selected Large Patch and all Small Patch Systems	*Matrix, Large Patch, and Linear Systems*
Endemic	25 occurrences	30% Known historical distribution
Limited/Disjunct	13 occurrences	
Widespread	7 occurrences	
Peripheral	3 occurrences	

[12] Regional: > 1,000,000 acres, migrate long distances; Coarse: 20,000 – 1,000,000 acres; Intermediate: 1,000 – 50,000 acres; Local: > 2,000 acres.
[13] Restricted / Endemic targets occur primarily in the ecoregion. Limited: targets typically occur within the ecoregion but also occur within a few adjacent ecoregions. Widespread: targets widely distributed in several to many ecoregions. Disjunct: occurs in ecoregion as a disjunct from the core of its distribution. Peripheral: more commonly found in other ecoregions
[14] Ecological systems are described in ***Section G – Target Selection*** and described in Appendix 4.0 and 5.0.

Conservation Goals for Aquatic Species and Ecosystems

The nature of the distribution and spatial configuration of aquatic species data made it difficult to apply the same goal rules for aquatic fine filter targets. As such, aquatic species goals were based on global rarity (both G and T ranks) and goals for all targets were stratified by 10 large watersheds (EDUs) - each of which has a distinct climate and zoogeography. Table 11 describes the goals for aquatic fine-filter targets and coarse-filter ecosystems.

Table 11. Conservation Goals for Aquatic Fine-filter Targets and Ecosystems

Target	Goal
G1/T1 species	All occurrences.
G2/T2 species	All occurrences up to 10 per EDU for endemics, 8 per EDU for non-endemics.
G3/T3 species	All occurrences up to 5 per EDU when occurring in more than one EDU, 10 per EDU when endemic to a single EDU.
G4 and G5 fishes	30% of current distribution within each EDU, with the exception of westslope cutthroat trout, bull trout, and coho salmon, which were set at 50% of current distribution within each EDU because of higher threat/decline in the ecoregion.
Ecosystems	30% of historical distribution within each EDU

Conservation Goals For Wide-Ranging Carnivores

Goals for the carnivore species were expressed as a percentage of the total habitat "value" in the region. This was more realistic than the common approach of classifying areas into just two classes of unsuitable and suitable habitat. Habitat value was measured by the output of the resource selection function (RSF) model (Carroll et al. 2002). The RSF is proportional to the number of animals that can be supported in an area. Thus, a goal of 30% of the RSF value might be expected to conserve 30% of the potential regional population. The RSF values for lynx, fisher, and wolverine were based on non-modeled data. Because the conservation goals for grizzly bears and wolves were based on conceptual models and not RSF values, conserving 30% of modeled habitat "value" would actually protect more than 30% of their populations. Some additional percentage of the population would also be present on non-reserve (portfolio) lands. It was thought that wide-ranging carnivore modeling would be particularly applicable in the CRM because the region still retains well-distributed populations of all carnivore species (unlike the Middle Rockies or Southern Rockies ecoregions).

With little information as to what constitutes a threshold amount of habitat for insuring viable populations, and because we did not want to ignore such factors as connectivity, we ran SITES solutions with differing levels of habitat as goals and compared the ability of the resulting SITES terrestrial portfolios to conserve viable populations, using the PATCH model (Schumaker 1998). The PATCH model takes static data (spatial data like prey availability, mortality risks) and dynamic models (non spatial data like carrying capacity) and provides an evaluation of population survival over a period of time. The evaluation was performed for two carnivore species, the grizzly bear and wolf, for which we had the most developed and accurate PATCH models (Appendix 6.0).

The PATCH analyses revealed that there were no significant thresholds or breakpoints in goal setting and that future populations of wolf and grizzly had a linear positive response to increases in habitat goals. Analyses also showed that the current network of protected areas were insufficient for preventing declines in carnivore populations over the next 25 years (see Table 12). The planning team ultimately decided to set a goal of capturing 40% of habitat values for all targeted wide-ranging carnivores in the conservation portfolio—a solution that PATCH modeling indicated would yield a slight increase in carnivore populations over the next 25 years.

Table 12. Evaluation of SITES solutions using the PATCH model (Carroll et al. 2002).

SITES solution	**% of region (parks included)**	**% of RSF habitat value (including parks)**		**share of current carrying capacity (PATCH model)**		**total regional carrying capacity 2025 (as % of 2000 capacity)**	
		GRIZZLY	WOLF	GRIZZLY	WOLF	GRIZZLY	WOLF
no action (parks alone)	22.6	25.5	23.5*	32.9	27.9	92.9	92.7
carnivore goal 0%, parks not locked [1]	41.1	44.5	43.4	49.1	46.2	102.2	107.1
carnivore goal 0%, parks locked in [2]	42.3	44.5	43.7	49.0	46.4	106.7	116.8
carnivore goal 30%, parks locked in	42.8	45.2	44.5	49.8	47.3	106.7	114.0
carnivore goal 50%, parks locked in	46.8	49.8	49.5	53.9	52.3	109.2	118.8
carnivore goal 40%, parks locked in	52.2	55.6	56.0	58.8	58.3	112.8	125.6
* approximate due to areas of missing data							

1. Indicates carnivore population response to the conservation portfolio created from a coarse/fine filter approach that does not specifically target carnivores and set goals for capturing carnivore habitat
2. Refers to the same conditions, as note 1, but the resulting portfolio would also include all current protected areas as part of the solution.

K. VIABILITY ASSESSMENT

The element occurrence (EO) ranks given by CDC and Natural Heritage Programs were used for determining occurrence viability of species targets when available. EO ranks of A (excellent), B (good), C (fair) were all considered as viable while database records were deleted where EO Rank = F, O, H, X, D. We also removed records where the EO Type = extirpated population, probable sighting and unconfirmed sighting. Animal records older than 20 years old were deleted, with the following exceptions: one occurrence each for Preble's Shrew (*Sorex preblei*), Selkirk least chipmunk (*Tamias minimus selkirki*), and Creston northern pocket gopher (*Thomomys talpoides segregatus*). Plant records older than 40 years old were also deleted.

There were many unranked element occurrences. The SITES model is programmed to select for the best records first before moving on to find lower ranked examples (Appendix 7.0). Not wanting unranked records to have equal weight and not knowing the viability of these records, we ranked them as 'C'. In addition to unranked occurrences, much of the biodiversity information used in the planning process included wide-ranging species models and coarse filter classifications that had no direct viability rankings. As such, surrogates for viability information were incorporated into a suitability index during portfolio design using SITES (see Section L for a description of the Suitability Index). The suitability index itself provided an indirect measure of ecological integrity for ecological systems, where no expert opinion was available.

L. PORTFOLIO ASSEMBLY

Portfolio Design Methods

The overall goal of this assessment was to identify a portfolio of conservation areas that, with proper management, would ensure the long-term survival of the species, plant communities, and ecological systems, and the ecological processes needed to maintain them.

The team used the following principles, based on guidelines outlined in *Designing a Geography of Hope: A Practitioner's Handbook to Ecoregional Planning* (TNC 2000), to assemble the portfolio.

- Coarse-scale focus: Represent or capture in conservation areas all coarse-scale targets that exist in the ecoregion or are restorable followed by targets at finer scales.
- Representative-ness: Capture multiple examples of all conservation targets across the diversity of environmental gradients appropriate to the ecoregion (e.g., ecoregional section, ecological land units, and ecological drainage units).
- Efficiency: Give priority to occurrences of coarse-scale ecological systems that contain multiple targets at other scales.
- Integration: Give priority to areas that contain high-quality occurrences of both aquatic and terrestrial targets.
- Viability/Integrity: Ensure that all areas in the portfolio are functional or feasibly restorable to a functional condition. Functional areas maintain the size, condition, and landscape context within the natural range of variability of the conservation targets.
- Completeness: Capture all targets within functional landscapes.

Conservation areas were identified using the most reliable and up-to-date information through a combination of computer-assisted and manual processes that evaluated the following data:

1. Element-occurrence and site information from Conservation Data Centres and Natural Heritage Programs of British Columbia, Alberta, Montana, Idaho and Washington (only viable records and records since 1980 for animals and 1960 for plants);
2. Occurrence and area information from experts workshops;
3. Existing and nominated conservation areas;

4. Additional spatial data sets depicting distributions of ecological systems;
5. Habitat-suitability models for selected wide-ranging mammals;
6. Indices of biophysical variation from biophysical models; and
7. Land conservation status along with indices of landscape integrity and conservation suitability.

SITES Optimization Tool

The CRM ecoregional data set was compiled and analyzed with the goal of developing a comprehensive and strategic conservation blueprint. Because of the large number of conservation targets, the relatively large data set, and the complexity of the ecoregion, the CRM team decided to use SITES (Andelman et al. 1999), a site-selection software program developed by the National Center for Ecological Analysis and Synthesis, University of California at Santa Barbara, specifically for ecoregional assessment. The SITES program enabled the team to assemble and compare alternative portfolios. See Appendix 7.0 for more details regarding the portfolio design methods.

The overall objective of the portfolio selection process is to minimize the cost of the portfolio while ensuring that all conservation goals have been met. SITES selects areas to meet goals for conservation targets while balancing objectives of efficiency, defined as the greatest number of goals met for the lowest cost or least amount of suitable land. This set of objectives is summarized in the following equation (Andelman et al. 1999):

Total Portfolio Cost = Cost of Selected Areas + Target Penalty + Boundary Length

Where *Total Portfolio Cost* is the objective (see below) to be minimized, *Cost of Selected Areas* is the number of hectares in all units of analysis selected for the portfolio (see suitability index discussion below), *Target Penalty* is a cost of not meeting conservation goals for each target, and *Boundary Length* is a cost of spatial dispersion of the selected sites as measured by the total boundary length of the portfolio. The algorithm seeks to minimize the *Total Portfolio Cost* by selecting a set of conservation areas which covers as many targets as possible as cheaply as possible in as compact a set of areas as possible. The solutions depend on how site cost is measured, on the target levels, on the penalty cost for each target, and on how heavily the boundary lengths are weighted. The modeling program compares millions of possible portfolio designs to determine the most efficient or "optimal" portfolio.

Suitability Index

The team developed a suitability index, an integration of methodologies employed by TNC (2000) and techniques used by the wide-ranging carnivore team in their development of focal species models (Carroll et al., 2002). The index was derived from a variety of land use factors, such as road density, mines, dams, natural land cover, projected future urban development, and minimum land area, to represent the cost associated with conserving an area. The suitability index was used as a comprehensive, albeit indirect, measure of environmental conditions on the landscape. While not a direct measure of ecological integrity, it provided a useful complement to ranked occurrences in determining which areas might be most suitable for meeting conservation goals. The team also set different levels of perimeter in an attempt to reduce fragmentation of the portfolio and increase clustering of the conservation areas (i.e., adjusting boundary length).

Units of Analyses

Data on species distribution and viability were attributed to 3rd Order watersheds cross-walked to 6-unit HUCS on the U.S. side of the planning area. The SITES optimization tool was then used to generate a series of potential conservation "solutions" based on the data attributes of each watershed.

Expert Review

In order to evaluate the various scenarios being generated by the SITES tool, results were taken to a series of expert workshops and interviews in order to generate constructive feedback. These reviews helped to identify planning units selected by SITES that were based on modeled data but that had few on-the-ground values in actual fact. Additionally, through this review process, experts were able to identify many important landscapes that were being missed by SITES because of insufficient data inputs. In particular, connectivity values were underrepresented as a result of the limitations of the optimization tool. To compensate, the team embedded into the solution expert identified landscapes with high connectivity and/or exceptional habitat values into subsequent SITES runs.

Aggregation of Planning Units

A total of 4,836 watersheds were part of the final conservation portfolio (see below) and these were then aggregated into 54, larger "*Conservation Landscapes*". Conservation Landscapes were built by clustering watersheds that occurred together and shared common ecological processes. These groupings were also clustered based on criteria related to conservation opportunity such as areas where protected areas created obvious mechanisms for common conservation action among portfolio watersheds. Conservation Landscapes were delineated in such a way that they also included watersheds not selected within the portfolio. These areas—landscapes not essential to the conservation solution but rather swept into the Conservation Landscape for strategic or practical purposes--are referred to as "*landscape linkage areas*."

M. PORTFOLIO RESULTS

Background

The portfolio of conservation areas represents a rigorously established vision for biodiversity conservation with the best available data. The iterative nature of ecoregional assessment 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" data set. We intend to clarify and fill information gaps over time, and to revisit/refine the portfolio as new information becomes available.

Nearly all conservation targets are represented in the portfolio, and many had sufficient numbers to meet conservation goals. Others will require additional field inventory and research in order to finalize and/or meet conservation goals. Many previously undocumented occurrences will undoubtedly be found with further field survey work within portfolio conservation areas.

Alternative Portfolio Scenarios

The CRM planning team took advantage of the flexibility provided by the SITES algorithm to test various conservation solutions for the ecoregion. In particular, efficiencies were explored with regards to incorporation of the current protected areas network and with combining and separating terrestrial and aquatic solutions. Initial test runs of SITES were performed solely on terrestrial targets, comparing SITES runs where protected areas were "locked in" or forced into the conservation solution to solutions without such constraints. The locked in solution yielded a conservation portfolio that covered 48% of the ecoregion compared to 39% in SITES runs that were unconstrained by protected areas.

SITES runs for aquatic targets yielded a portfolio covering 44% of the ecoregion. When the aquatic solution was overlaid with the terrestrial solution with protected areas locked in, 66% of the ecoregion was needed for the conservation solution compared to 61% when the aquatic solution was overlain with the terrestrial solution unconstrained by the current protected areas network.

In either case, these solutions were viewed as inefficient in terms of total area occupied by the portfolio and efficiencies were sought by combining aquatic and terrestrial targets into a single sites run. This improved the "locked in" efficiency by reducing the area needed from 66% of the ecoregion down to 62%. However, the greatest improvement came from combining aquatic and terrestrial targets in a conservation solution unconstrained by the current protected areas network—total area needed for the solution dropped to just under 50% of the ecoregion.

Testing various scenarios proved invaluable for finding efficiencies and also allowed the planning team to solicit expert opinion on the merits of various portfolio configurations. For example, to the team's surprise, several park managers registered their disapproval with assuming current protected areas should be part of the conservation solution. Instead, they expressed a desire to see the portfolio unconstrained so that the results would better inform them as to the contribution parks were making to biodiversity conservation in the region. Unconstrained results informed managers as to which parts of parks held more conservation values than others, as opposed to "locked in" scenarios that assumed all parts of a park equal to the conservation solution for the ecoregion. Details of the final conservation portfolio are discussed below.

Final Portfolio

A total of 4,836 watersheds were part of the final conservation portfolio for the totalling 13,455,793 hectares (33,249,264 acres) and equalling 49.7 % of the ecoregion. The seemingly large portfolio size can be attributed to several factors: 1) the types of conservation targets selected, which included matrix-forming ecological systems and wide-ranging mammals; 2) the existing natural variability and the desire to represent variability across all environmental gradients within the ecoregion; and 3) manual over-rides of the original SITES output based on additional knowledge about conservation areas. See Map 14 for the portfolio of conservation areas.

Conservation Landscapes

The majority of the 4,836 selected portfolio watersheds were subsequently aggregated into larger conservation units called "*Conservation Landscapes*". Conservation Landscapes were built by clustering watersheds that were geographically connected and that shared common ecological processes. These groupings were also aggregated according to conservation opportunity including tying together areas where protected areas created obvious mechanisms for common conservation action among portfolio watersheds. Conservation Landscapes were delineated in such a way that they also included watersheds not selected within the portfolio. These areas—landscapes not essential to the conservation solution but rather swept into the Conservation Landscape for strategic or practical purposes—are referred to as "*landscape linkage areas*."

While the bulk of the conservation solution was aggregated into Conservation landscapes, an additional 20 individual watersheds were selected to meet conservation goals. Typically, these watersheds contain a single occurrence of a conservation target, are geographically isolated, and do not lend themselves well to incorporation into a larger landscape. See Appendix 8.0 and Map 14 for detailed information on these watersheds.

Of the total 74 Conservation Areas in the solution (54 Conservation Landscapes, and 20 smaller, individual watersheds) 27 are entirely within British Columbia, 2 in Alberta, 14 in Montana, 7 in Idaho, 1 in Washington. Seven Conservation Areas were shared between BC and Alberta, 5 between Idaho and Washington, 1 between BC and Montana, 1 between BC and Washington, and 5 between Idaho and Montana. One Conservation Area was common to each of Alberta, BC and Montana, 1 between BC, Idaho and Washington, and 2 between BC, Idaho and Montana. They range in size from 72 hectares (178 acres) to landscapes of 2 million hectares (4.8 million acres). All of the identified Conservation Landscapes meet standards for functional conservation areas, as they include wide gradients of coarse-scale ecological systems and element occurrences used to define these landscapes were assessed for viability. This portfolio represents a first effort at a functional network designed to conserve selected regional-scale species across their range of variability within the ecoregion.

The portfolio of conservation areas produced during this assessment represents the current state of our knowledge using the best available information about where to conserve biodiversity in the ecoregion. The assessment results were incorporated into a series of maps and tables, descriptions of the portfolio of conservation areas, and different analyses of the portfolio, including levels of conservation value, threat status, and activity.

While these conservation areas were designed with knowledge of the size requirements of conservation targets, these areas do not specifically describe the lands/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.

Protected Status

Approximately 30% of the 33.2 million acre portfolio is in currently designated protected areas. Assuming the portion of the portfolio within parks is already protected, an additional 33.9% of the ecoregion requires some form of conservation action in order to conserve the full portfolio. A full breakdown of the protected status of the portfolio is found in Table 13.

Table 13. Protected Areas within the CRM conservation portfolio.

GAP Category	Hectares (Acres) in Ecoregion	% of Ecoregion	Hectares (Acres) in Portfolio	% of Portfolio
Category 1	601,713 (1,486,834)	2.2	340,446 (841,260)	3
Category 2	5,779,637 (14,281,484)	21.0	3,436,243 (8,491,142)	26
Category 3	191,173 (472,389)	0.6	94,353 (233,150)	1
Total	**6,572,524 (16,240,707)**	**23.8**	**3,871,042 (9,565,552)**	**30**

Landownership Patterns

The patterns of land ownership and management within the portfolio of conservation areas generally follow the overall pattern for the ecoregion (see Table 14). Public lands, both federal and state/provincial, make up the majority of the ecoregional portfolio; 55% of the portfolio is provincial land and 2% is state land. The two largest land managers are the Province of BC (42%) and the US Forest Service (16%). Private lands encompass approximately 12% of the portfolio conservation areas.

Table 14. Land ownership within the CRM conservation portfolio.

Owner	% in Portfolio	Hectares (Acres) in Portfolio
Province of BC	42	5,684,795 (14,047,128)
US Forest Service	16	2,165,152 (5,350,090)
Province of Alberta	13	1,780,488 (4,399,587)
Private	12	1,556,000(3,844,876)
Parks Canada	10	1,355,358 (3,349,090)
First Nations/Tribal Lands	1	160,975 (397,769)
State of Idaho	1	139,901 (345,696)
Total	**95**	**12,842,669 (31,734,236)**

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 represent them (vegetation, elevation, landform, riverine characteristics, geologic substrate, etc.). This should help buffer the conservation targets against the impacts of climate change. Terrestrial and aquatic systems were represented using expert derived occurrences and spatial models. Additional field verification is needed for occurrences of terrestrial and aquatic ecological systems, emphasizing the evaluation of their quality and condition. Additional data collection will likely refine the classification of freshwater aquatic ecological systems.

Eighty-three percent of the terrestrial ecological systems, 100% of the aquatic ecological systems, 49% of the rare plant communities, and 34% of the species met stated conservation goals. For the species groups: 71% of the amphibians, 80% of the birds, 87% of the fishes, 82% of mammals, 4% of non-vascular plants and 26% of the vascular plants met stated conservation goals (see Table 15). Unfortunately, goals for none of the invertebrate targets were achieved. Finally, habitat goals were entirely satisfied for each of the six wide-ranging carnivore species. See Appendix 8.1 for conservation goals for all targets.

A number of plants and rare plant communities are currently only known from one to five occurrences and therefore the goal could not be met until further inventories reveal more occurrences. Another group of 169 targets (78 animals, 54 plants, 32 plant communities, and 5 terrestrial systems) have no documented occurrences or data are lacking regarding the distribution and viability. Future work should focus on systematic inventory of these conservation targets not meeting goals or with no representation in the portfolio. With additional knowledge of target distributions and quality, we will further refine conservation goals for conservation targets.

Table 15. Summary of goal performance for CRM Taxa Groups.

Target Group	# of Targets	# of Targets Meeting Goals	% of Targets Meeting Goals
VASCULAR PLANTS	66	17	26
NON-VASCULAR PLANTS	28	1	4
BIRDS	10	8	80
INVERTEBRATES	17	0	0
AMPHIBIANS	7	5	71
MAMMALS	11	9	82
RARE PLANT COMMUNITIES	75	37	49
FISH	15	13	87
TERRESTRIAL SYSTEMS	40	33	83
AQUATIC SYSTEMS	77	77	100

N. PRIORITY SETTING

Background

The portfolio design phase of the CRM identified a very large proportion of the ecoregion as Conservation Areas. With almost half the ecoregion included in the results it was necessary to apply a prioritization scheme to help distinguish which Conservation Areas need conservation action more immediately than others, and to also try and determine which areas within those Conservation Areas require the most focus for implementing conservation strategies.

The assessment described below is intended as a means of presenting conservation strategists within the CRM with an evaluation of priorities based upon quantitative measures emerging from the CRM assessment. This work was based on criteria established in TNC's *Geography of Hope* (2000) and methods applied by Noss *et al*. in the Utah-Wyoming Rocky Mountains ecoregional plan (2001). A more thorough evaluation of priorities is required and will need to build on the quantitative summary presented here with more subjective qualitative measures related to conservation feasibility, opportunity and leverage.

Conservation Value

A key concept in conservation planning is irreplaceability (Pressey et al. 1994, Margules and Pressey 2000, Pressey and Cowling 2001). Irreplaceability provides a quantitative measure of the relative contribution different areas make toward reaching conservation goals, thus helping planners choose among alternative sites in a portfolio. As noted by Pressey (1998), irreplaceability can be defined in two ways: 1) the likelihood that a particular area is needed to achieve an explicit conservation goal; or 2) the extent to which the options for achieving an explicit conservation goal are narrowed if an area is not conserved. For the CRM, irreplaceability was rolled into a broader measure of Conservation Value that was applied to each watershed unit of analysis. Conservation value was calculated as a composite measure, scaled between 0 and 1, based on the following four criteria:

> **Rarity** – the degree to which rare elements are represented within the planning unit. Rarity was calculated by assigning a rarity score of 1 to all G3 targets, 2 to all G2 targets, and 3 to all G1 targets. Targets that did not have G-ranks were assigned rarity scores of 1 for all Limited, Disjunct and Peripheral targets and 3 for Endemic targets. The rarity scores were then summed and scaled from 0 to 1.
>
> **Richness –** a measure of the overall abundance of target elements and systems within the planning unit. Richness was quantified by first calculating the total amount of each target in the planning unit (number of occurrences, hectares, stream length etc.) and expressing that as a proportion of the total amount found within the entire ecoregion. The richness score for the planning unit was then taken as the mean proportion of the total amount available in the ecoregion, for each target.

Diversity – an assessment of the variety of elements and systems within a planning unit. Diversity was scored according to the number of different target types (see Appendix 8.1) present within the planning unit.

Complementarity – a measure based upon the principle of selecting conservation areas that complement or are "most different" from sites that are already conserved. The spatial configuration of the CRM portfolio was optimized for complementarity using the SITES algorithm. Subsequently, the score for planning unit complementarity was generated from the 'sum runs' of portfolio SITES analysis. Sum runs is the number of times each planning unit was selected by SITES in our 20 SITES runs.

Watershed planning units were then assigned a conservation value by adding all four factors together and rescaling the result from 0 to 10. The results of this evaluation are displayed in Map 16.

Vulnerability

Another key consideration in conservation planning is threat or vulnerability (Margules and Pressey 2000). It can be argued that the more vulnerable or threatened an area is, the greater the urgency or need for conservation action. Based on available quantitative threat data (e.g., human population growth, development trends, road density), a coarse vulnerability score for each watershed planning unit was created (see Appendix 9.0 for a full list of measures). The results of this evaluation are displayed in Map 15.

Conservation Area Evaluation

The next step in this evaluation of conservation priorities was to calculate the mean conservation value and vulnerability scores of the planning units in each Conservation Area. These scores were then plotted on a graph of conservation value (y-axis) versus vulnerability (x-axis) and the graph divided into four quadrants, similar to the procedure of Margules and Pressey (2000). The upper right quadrant, which includes Conservation Areas with higher conservation value and higher vulnerability, potentially comprises the highest priority sites for conservation. This top tier of Conservation Areas is followed by the upper left and lower right quadrants (Tier 2 and Tier 3, which could be ordered differently depending on needs of planners), and finally, by the lower left quadrant, Tier 4, comprising areas that are relatively replaceable and face less severe threats.

Tier 1 – Areas of Highest Conservation Value and Highest Vulnerability
Tier 2 – Areas of Highest Conservation Value but Lower Vulnerability
Tier 3 – Areas of Lower Conservation Value and Highest Vulnerability
Tier 4 – Areas of Lower Conservation Value and Low Vulnerability

As per Noss *et al*. (2001a, 2001b), the CRM assessment team differs from Margules and Pressey (2000) in giving higher weight to the upper left quadrant (our Tier 2, their quadrant 3) over the lower right quadrant, because we feel that sites of very high and irreplaceable biological value merit conservation action even if not highly threatened today. That is, it is a good idea to protect these sites while they are still reasonably intact. In the CRM, at least, the private lands in these areas are generally less expensive to protect than more threatened sites, because they are usually in areas with lower population growth and development pressure.

The conservation value vs. vulnerability prioritization resulted in 11 Conservation Areas totalling 368,666 hectares (910,605 million acres) in the Higher Value/Higher Vulnerability Tier 1 (Fig. 1, Map 17). Forty-three conservation areas in Tier 2 (Higher Value/Lower Vulnerability) cover 8,713,698 hectares (21,522,834 million acres); 4 conservation areas in Tier 3 (Lower Value/Higher Vulnerability cover 61,708 hectares (152,419 million acres); and 4 conservation areas in Tier 4 (Lower Value/Lower Vulnerability cover 4,311,470 hectares (10,649,330 million acres).

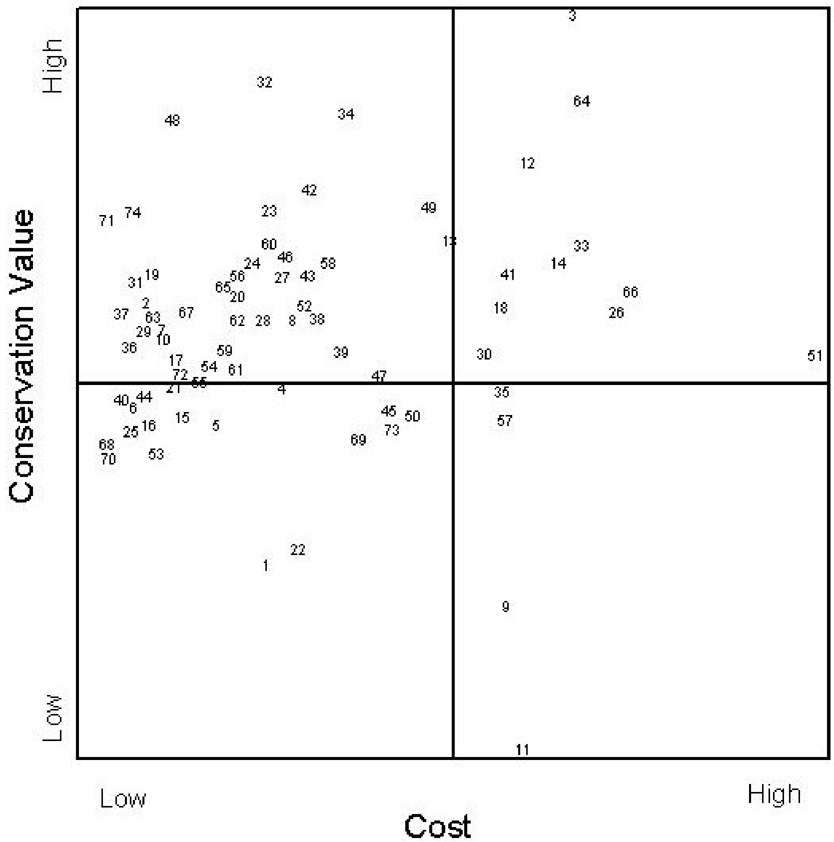
Comparison of Conservation Value and Vulnerability Among Planning Units

In order to take advantage of the finer scale at which conservation data was developed, each watershed planning unit was also plotted and compared based on conservation value and vulnerability scores. From these results, the team was able to review the distribution of planning units within Conservation Areas according to the tiered ranking system (Map 18). While the total area of the portfolio is 13,455,541 hectares, the analyses shows that only 1,082,062 hectares, or 4% of the ecoregion, falls within Tier 1 (Table 16). Another 6,909,166 hectares of the CRM portfolio, or 25.8% of the ecoregion, falls into Tier 2. Only 0.3% or 91,204 portfolio hectares are classed as Tier 3, while 31.3% of the ecoregion or 8,468,591 portfolio hectares are classed as Tier 4 watersheds.

Table 16. Distribution of Planning Unit Area according to Tiers.

Watershed Planning Unit Tier	Area within Ecoregional Portfolio (Hectares)	% Ecoregional Area
1	1,082,062	4.0%
2	6,909,166	25.5%
3	39,400	0.1%
4	5,424,913	20.1%

Figure 1. Comparison of conservation value and vulnerability (i.e., cost) amongst CRM Conservation Areas



1 = Adams River
2 = Ahbou Lake
3 = Bitterroot Mountain Snail EO
4 = Bitterroot Range (Middle Clark Fork)
5 = Bull River / Cabinet (Bull Lake/East Cabinets)
6 = Bull Trout Spawning Site
7 = Burbot Spawning Site
8 = Camas Prairie
9 = Cougar Bay
10 = Crown of the Continent
11 = Cusick
12 = Cyr Culch Bald Eagle Nest EO
13 = Dayton / Hog Heaven
14 = Dishman Hills / Mica Peak
15 = East-West Connectivity North
16 = East-West Connectivity South
17 = Elk River Valley
18 = Flathead Lake and Wetlands
19 = Fleabane / Salmon Driven
20 = Fraser River Headwaters
21 = Granby
22 = Hixon Creek Headwaters
23 = Hunt Girl Creek
24 = Jocko River
25 = Kakwa / Willmore
26 = Kootenai River
27 = Kootenay River A
28 = Kootenay River B
29 = Kootenay River C
30 = Lake Pend Oreille
31 = Landslide
32 = Least (Selkirk) Chipmunk
33 = Little Bitterroot River
34 = Little NF CDA Trib Model Data
35 = Lower Coeur d'Alene
36 = Lower Columbia A
37 = Lower Columbia B
38 = Lower Columbia C
39 = Mabel Lake
40 = Middle Columbia
41 = Mission Valley
42 = Moffat Creek
43 = Moody Creek Model Data
44 = Mountain Parks
45 = Moyie R Headwaters Model Data
46 = Murphy Creek Model Data
47 = North Thompson River
48 = Orofino / Ford Creeks
49 = Palouse
50 = Pend Oreille River
51 = Pleasant Valley
52 = Purcell Mountains
53 = Red Cedar Stand on Snowshoe Cr
54 = Rocky Mountain Front
55 = Rocky Mountain Trench A
56 = Rocky Mountain Trench B
57 = Salmo / Priest / Selkirks
58 = Salmo River
59 = Scotchman Peak
60 = SF Lolo Creek Model Data
61 = Shuswap Highlands
62 = Slender-Spike Manna Grass EO
63 = Slocan River
64 = Spirit Lake
65 = St. Joe / Clearwater
66 = Swamp Creek Model Data
67 = Thompson / Lower Clark Fork
68 = Torpy River Model Data
69 = Upper Coeur d'Alene
70 = Wapiabi Cave
71 = Weitas Creek
72 = Wells Gray / Bowron
73 = Wolf Creek Model Data
74 = Wooly Daisy EO

Discussion

Taking the mean scores of conservation value and vulnerability for each Conservation Areas tended to obscure some of the attributes of the constituent watershed planning units. As a result, most Conservation Landscapes were lumped together in Tier 2, the Higher Value/Lower Vulnerability category, while smaller areas constituting one to five planning units, tended to fall within Tier 1. However, the assessment amongst watershed planning units did add interpretive power to these results and provided much needed perspective for the scope of the conservation challenge in the CRM ecoregion. For example, the 11 Tier 1 Conservation Areas could be taken on as the initial CRM action sites. However, a more flexible interpretation might involve taking action at Tier 1 watersheds (4% of the ecoregion) wherever they fall within the portfolio. Likewise, as opportunity, leverage and feasibility are assessed, it may be more appropriate to take action at both Tier 1 and 2 watersheds (29.8% of the ecoregion) that fall within the Conservation Areas constituting the optimal, complete ecoregional solution (Map 19). In order to aid interpretation of these results at the Conservation Area scale, a map of Conservation Area watershed tiers is provided with each Conservation Area description in Volume 3 of this Assessment.

In practice, the results of this assessment need to be improved upon via a more rigorous qualitative assessment of conservation opportunity, feasibility and leverage—a task that is to be undertaken by a CRM implementation planning team. Further, site-specific factors considered in planning exercises, more detailed and fine-scale than the regional assessment described here, will be required to evaluate the relative values of different areas that may be scored in close proximity by our method.

O. CONNECTIVITY/LINKAGE ZONES

One of the defining characteristics of the CRM is the presence and persistence of wide-ranging species, in particular the large carnivores. Their presence is a testimony to relatively low levels of development and human populations and the high degree of intact, functional landscapes. Intact, functional landscapes imply a great deal of habitat connectivity. Connectivity can be defined as the relative degree to which individual animals and genes can move across a landscape. Natural landscapes have an inherent degree of connectivity to which species have adapted over time. The concept of landscape connectivity has been accepted by conservation biologists who recognize that connected populations have the highest likelihood for persistence over time (see Noss 1991). In the last decade, researchers and conservationists have focused on threats to connectivity, in particular habitat fragmentation. At the landscape or larger scale, many populations of wide-ranging species are at risk because of habitat fragmentation and the loss of connectivity.

Habitat fragmentation is the process of separating populations of animals and their habitats into smaller and smaller units. Small, fragmented populations of any species are less likely to survive. The main factor causing habitat fragmentation is human development, especially when development occurs in a linear fashion. Development in mountain valleys and transportation systems such as highways and railroads are common problems for wildlife. Maintaining connectivity or "linkage" between potentially isolated populations could prevent the many detrimental consequences of habitat fragmentation. Identifying areas important for connectivity or linkage to other habitats are an important component of carnivore conservation. Connectivity or linkage zones are broad areas of seasonal habitat where animals can find food, shelter, and security cover and provide connectivity between areas of core habitat (Servheen et al. 2001).

Relevant Research

Identifying and maintaining landscape "connectivity" within the CRM is the focus of current research and conservation efforts. This issue is being addressed by a number of scientists and conservationists within the ecoregion. Most efforts focus on federally listed species, such as the grizzly bear, as part of the recovery efforts. Little information on connectivity or linkage zones is available for other wide-ranging species, such as wolverine, fisher, caribou, and Canada lynx (although see Apps 2001). The Interagency Grizzly Bear Committee (a committee of US state, federal, and Canadian agencies) is working cooperatively to implement the Grizzly Bear Recovery Plan. They support the concept of linkage zones and have identified several sites within the CRM. These sites include linkage areas between Cabinet/Yaak and the Bitterroot recovery areas; Cabinet/Yaak and Selkirk recovery areas; Northern Continental Divide Ecosystem and Bitterroot recovery areas; and between the Northern Continental Divide Ecosystem and Cabinet/Yaak recovery areas. They also identified potential linkage areas between Cabinet Mountains and the Yaak River drainage. Predictive models identified the areas within these linkage zones where grizzly bears and other species movements are most likely successful because human activity is relatively low (Servheen et al. 2001).

Richard Walker and Lance Craighead, supported by American Wildlands through their Corridors of Life project, developed GIS analysis of core reserve and corridor habitat in the Rockies Mountains of Montana and Idaho using effectiveness (least cost) models for 3 species: elk, mountain lion and grizzly bear (Walker and Craighead 1998). Within the CRM, their models identified a corridor between the Salmon/Selway (ID)-Northern Continental Divide (MT) Ecosystems. This corridor lies at the southern end of the CRM and the northern end of the Middle Rockies ecoregion and connects (roughly) our Crown of the Continent Conservation Area and the Bitterroot Mountains/Middle Clark Fork Conservation Area.

Dr. John Weaver, Wildlife Conservation Society, identified the Transboundary Flathead region as a critical linkage zone for carnivores occupying the Glacier/Waterton area and connecting the protected National Parks land with public lands in both Montana and southeast British Columbia (Weaver 1997). The USFWS recently completed a study documenting the connectivity values for carnivores in the Middle Fork of the Flathead River (Waller pers. communication).

Canadian researches have been studying the same concepts in the BC and Alberta portion of the CRM. Dr. Mike Gibeau and Dr. Steven Herrero have researched grizzly bear security areas and connectivity within Banff, Yoho and Kootenay National Parks (Gibeau and Herrero 1998; Gibeau 1998). Dr. Shelley Alexander and Dr. Paul Paquet with the University of Calgary (AB) and the Miistakis Institute analyzed the impacts of human development on wolf and cougar movement in the Canmore Corridor Project (www.rockies.ca). The Eastern Slopes Grizzly Bear Project (AL) principle researchers, Dr. Gibeau and Dr. Herrero documented movement of bears along the Kananaskis region of the Rocky Mountains (Gibeau and Herrero 2002). Identification of grizzly bear linkage zones along Highway 3 corridor of southwest Alberta was the focus of studies by Dr. Clayton Apps (Apps 1997).

How did the CRM team deal with connectivity issues?

The team recognized that the SITES program analysis used to develop the draft portfolio does not adequately identify or address connectivity areas for wide-ranging species. We addressed the conservation gap in four ways: 1) PATCH analysis of carnivore persistence with a draft terrestrial portfolio; 2) including expert nominated sites known as important linkage areas for carnivores or prey species (BC); 3) increasing the carnivore RSF goals to 40% to provide greater habitat inclusion in the final portfolio; and 4) comparing our portfolio results to identified linkage zones from other studies and identifying gaps in connectivity.

The team, through Dr. Carlos Carroll's PATCH analysis (see Appendix 6.0), reviewed the portfolio at different goal levels for the carnivore resource selection function. By increasing the goals for carnivore resource selection function to 40% during the portfolio analysis, our actual portfolio increased in size and resulted in larger aggregated sites in the Conservation Areas. The resultant portfolio contained larger portfolio areas with greater assumed connectivity for wide-ranging species.

During various workshops in Canada, we obtained site-specific information on important areas for both prey (ungulates) and carnivores. These corridors or linkage areas were included in the SITES runs as expert identified sites and therefore showed up in the final portfolio. In particular, three areas in British Columbia specifically addressed connectivity – the Elk River Valley Conservation Area (based upon an earlier proposed provincial Southern Rockies Management Area), the East/West Connectivity North Conservation Area, and the East/West Connectivity Area South.

Finally, team members reviewed the aggregated portfolio watersheds within Conservation Areas and compared them to existing known or predicted linkage areas. In many cases, the Conservation Areas included identified linkage zones. In a few cases where the linkage zones were not included in the Conservation Areas, the team decided to show these as separate layers over the Conservation Areas. The results are as follows:

Montana and Idaho– we compared our portfolio watersheds and the aggregated Conservation Areas to the Grizzly Bear Linkage Zones identified by Servheen et al. (2001). Dr. Servheen and colleagues analyzed potential linkage areas within and between ecosystems identified for the grizzly bear recovery plan.

Connectivity between Cabinet/Yaak and Bitterroot Ecosystems
Areas along Interstate 90 and Montana Highway 200 were identified as potential fracture zones between the Cabinet/Yaak and Bitterroot Ecosystems.

1) Four Linkage Zones were identified along Montana Highway 200 between the Plains, Montana and the Idaho border. All zones were embedded within the Thompson/Lower Clark Fork/Bull Rivers Conservation Area.
2) Three Linkage Zones were identified along Interstate 90 between St. Regis, Montana and Lookout Pass on the Idaho border. Two linkage zones (Haugen to Saltese and St. Regis) were embedded within the Bitterroot Mountains/Lower Clark Fork River Conservation Area. The Lookout Pass Linkage Zone was outside the portfolio watersheds.

Connectivity between the Cabinet/Yaak and Selkirks Ecosystems
Severe habitat fragmentation has occurred in the broad valley between Colburn and the Idaho-Canada border along Highway 95 and Idaho Highway 1, however, Servheen et al identified a few areas that may allow movement between these two ecosystems.

1) The McArthur Lake Linkage Zone along Highway 95 north of Elmira, Idaho is embedded within the Salmo/Priest/Selkirk Conservation Area.
2) The Moyie River Linkage Zone along Idaho Highway 1 east of Copeland is embedded within the Kootenai River A Conservation Area.
3) North Priest Lake Linkage Zone northeast of Nordman, Idaho is embedded within the Salmo/Priest/Selkirk Conservation Area.

Connectivity between the Northern Continental Divide and the Bitterroot
Fragmentation along Interstate Highway 90 between Missoula and Superior, Montana and along US Highway 93 north of Missoula impact connectivity between core habitat in the Northern Continental Divide ecosystem and the proposed reintroduction area within the Selway/Bitterroot ecosystems.

1) The Evaro Hill Linkage Zones along Highway 93 north of Missoula is embedded within the Jocko River Conservation Area.

2) Four Linkage Zones along Interstate Highway 90 between Missoula and Superior are embedded with the Bitterroot Mountain/Middle Clark Fork River Conservation Area.

Connectivity between the Northern Continental Divide and the Cabinet/Yaak
There area two primary obstacles to movement of bears between these two ecosystems – US Highway 93 and US Highway 2.

1) The Sunday Creek Linkage Zone along Highway 93 between Olney and Trego, Montana was embedded within both the Purcell Mountain and the Crown of the Continent Conservation Areas.

Connectivity between the Yaak and the Cabinets Ecosystems
US Highway 2 separates the Cabinet Mountains and the Yaak River watershed and Montana Highway 56 separates the West Cabinet Mountains from the East Cabinet Mountains.

1) Two Linkage Zones (Burrel/Dad Creeks and confluence of Yaak River/Kootenai River), along US Highway 2 between Libby and Troy, Montana are embedded within the Kootenai River and Purcell Mountain Conservation Areas.

2) The Lower Bull River Linkage Zone along Montana Highway 56 is embedded within the Thompson/Lower Clark Fork/Bull Rivers Conservation Area.

Connectivity within the Northern Continental Divide Ecosystem
Primary fracture zones within the Northern Continental Divide Ecosystem include the US Highway 2 corridor along Marias Pass between Glacier National Park and the Great Bear/Bob Marshall Wilderness Complex and Montana Highway 83 between the Bob Marshall Wilderness and the Mission Mountain Wilderness.

1) Seven potential Linkage Zones along the Middle Fork of the Flathead River and US Highway 2 were identified. All zones were embedded within the Crown of the Continent Conservation Area.

2) Four potential Linkage Zones along Montana Highway 83 (the Swan Valley) were identified. All zones were embedded within the Crown of the Continent Conservation Area.

In southeast British Columbia and southwest Alberta – (based on work by Dr. Clayton Apps 1997):

Connectivity along the Transboundary Region of US and Canada
Dr. Apps reported that populations are particularly prone to fragmentation where human impacts are concentrated in a linear manner and where there is a trend toward increased and permanent development. Such is the case along Highway 3 southeast British Columbia and southwest Alberta. Dr. Apps identified several important linkage zones along this transportation corridor.

1) Three linkage zones were identified in the area between Creston and Cranbrook, including the Kitchener and Goatfell area, the Yahk and Moyie Lake area, and the Cranbrook to Lumberton area. The Yahk/Moyie Lake linkage zone was embedded in the Purcell Mountains Conservation Area but both of the other linkages zones were not captured in conservation areas.
2) Three linkage zones were identified in the area known as the Elk River/Crow's Nest Pass area, including the Morrissey Creek/Lizard Range site, the Sparwood/Hosmer area, and the eastern extent of Crow's Nest Pass. These linkage zones were embedded in the Elk River and Rocky Mountain Front Conservation Areas.

East-West Connectivity in Southeast British Columbia
A few areas were identified during expert workshops as important connectivity between river systems such as the Columbia River and Kootenay River and areas across the Rocky Mountain Trench. These areas were treated as expert identified sites and were included as actual Conservation Areas.

Summary

Areas that were considered important linkage zones for connectivity were generally captured in our broadly defined Conservation Areas. However a few linkage zones as identified by researchers, did not show up in conservation areas and should be further refined or included during the conservation area planning process.

P. THREATS ASSESSMENT

The objectives of the preliminary threats assessment were to: 1) identify general threats at each conservation area while keeping individual conservation targets in mind; and 2) assess and describe patterns across multiple portfolio conservation areas. Threats analyses at the level of site conservation planning typically include evaluation of both the *stress* (something that impairs or degrades the size, condition and landscape context of a target, resulting in reduced viability) and the *source of stress* (activity or factor causing the stress). However, for purposes of this broad-brush ecoregional threats analysis, the team decided the most meaningful factor to evaluate threats to species, communities, and systems at conservation areas was the source of stress- the cause of destruction, degradation, fragmentation, or impairment of conservation targets at a conservation area.

Understanding the threats to targets at specific conservation areas and patterns of threats across multiple areas helps to determine which conservation areas are in urgent need of conservation action, and to inform the development of multi-site strategies. This threats assessment was based on site-specific knowledge of the conservation targets at each of the conservation areas, both from Conservancy staff and Natural Heritage Programs, with further review by local experts. Comprehensive assessment of all threats (i.e., stresses and sources of stress) at all conservation areas was beyond the scope of this project. Further work through site conservation planning is needed to update and refine threats to targets at the portfolio conservation areas.

Severity and Urgency

Degree of threat was considered to be a function of the severity and urgency of the threat to the conservation targets at conservation areas. Using the best available information, the core team identified and refined the key threats to each conservation area (where known) and ranked them according to their severity and urgency. The team did not rank the degree of threats to individual conservation targets but developed ranks for the conservation areas with the primary targets in mind. Definitions and ranks are provided below.

Severity: What level of damage to the primary target(s) at a conservation area can be expected within 10 years under current circumstances?

- High: stress is likely to seriously degrade, destroy or eliminate the target(s) over some portion of the targets' occurrence at the site
- Medium: stress is likely to moderately degrade the conservation target(s) over some portion of the targets' occurrence at the site
- Low: stress is likely to slightly impair the conservation target(s) over some portion of the targets' occurrence at the site

Urgency: How urgent is the threat within the conservation area or portion of area.

- High: threat exists now or is likely to exist within next 2-4 years
- Medium: threat is likely to exist within 5-10 years
- Low: threat is not likely to exist within 10 years.

Data for conservation area threats analysis were gathered from Core Team members on their respective states or provinces. Additional information for threats in Idaho and Montana was obtained from the U.S. Forest Service Region 1 Cohesive Strategy for both information on fire and invasive species (www.fs.fed.us/r1/cohesive_strategy/). The current fire condition class map was used as an indicator of the severity of the fire management threat to the targets at each conservation area. The map delineates the degree of departure from the historic fire regime (high: missed multiple return intervals; medium: moderately altered, missed one or more return intervals; and low: near historic return intervals). Data for the Montana and Idaho conservation areas are presented in Appendix 9.0. Similar data on fire condition was not available for British Columbia and Alberta.

Results of Threats Assessment

While further documentation, research, and analysis of threats to targets at each area is needed, the results of this threats assessment represent a good starting point for addressing issues that cross site and political boundaries (e.g., invasive species). This analysis was not intended to be exhaustive but represents the knowledge, experience, and observations of the team members and interviewed experts. Other new threats not identified here may also have an impact on the targets. See Table 17 for a summary of major threats at Conservation Landscapes (by number of areas with high severity and urgency) and the complete threat analysis is located in Appendix 9.0.

Table 17. Summary of Major Threats to CRM Conservation Landscapes

Threat	# of areas with high severity and urgency	% of areas with high severity and urgency	# of areas impacted by threat	% of areas impacted by threat
Invasive species – plants	15	28%	26	48%
Fire management	14	26%	25	46%
Forestry practices	13	24%	39	72%
Recreation (all sources combined)	12	22%	42	78%
Dam construction or operation of dams	11	20%	19	35%
Residential development	11	20%	26	48%
Point/non-point sources of pollution	9	17%	18	33%
Recreational infrastructure development	7	13%	15	28%
Transportation/utility corridors	7	13%	13	24%
Landownership patterns	5	9%	10	19%
Mining practices	5	9%	12	22%
Small population size and distribution	5	9%	7	13%
Conversion to agriculture or silviculture	4	7%	12	22%
Invasive species - animals	4	7%	12	22%
Recreational use	4	7%	16	30%
Commercial/industrial development	3	6%	6	11%
Oil or gas drilling	3	6%	5	9%

Table 17 cont'd:

Threat	# of areas with high severity and urgency	% of areas with high severity and urgency	# of areas impacted by threat	% of areas impacted by threat
Over fishing	3	6%	8	15%
Channelization of rivers or streams	2	4%	13	24%
Ditches, dikes, drainages and diversions	2	4%	13	24%
Grazing practices	2	4%	16	30%
Road Density	2	4%	16	30%
Stream bank/Shoreline stabilization	2	4%	5	9%
Management of/for certain species	1	2%	4	7%
Recreational vehicles	1	2%	11	20%
Stream sedimentation	1	2%	6	11%
Wastewater treatment	1	2%	1	2%
Crop production practices	0	0%	10	19%
Livestock production practices	0	0%	4	7%
Multi-jurisdictional policies don't match	0	0%	4	7%
Poaching or commercial collecting	0	0%	2	4%

The analysis reflects the widespread nature of the major threats impacting conservation areas within the ecoregion. The most severe and urgent threats across landscapes were invasive plants, fire management, forestry practices, and parasites/pathogens. Recreational uses/development, hydrologic alterations and residential development also scored as severe and urgent threats. These threats also tended to be pervasive throughout the CRM's Conservation Landscapes. Most notably, recreation based threats were identified at 78% of CRM Conservation Landscapes and incompatible forestry practices were listed as a source of stress to conservation targets at 72% of landscapes.

These threats or sources of stress are interrupting fundamental ecological processes needed to maintain the conservation targets in the Canadian Rockies Ecoregion. A brief description of the pervasive and urgent/severe threats is below (listed in alphabetical order).

Fire Management Practices

Fire management practices, activities that significantly change the natural fire regime, were identified as a threat within 46% of the conservation areas) and ranked high for both severity and urgency at 26% of the areas. In the fire-adapted ecosystems of the Canadian Rockies, fire is undoubtedly the dominant process in terrestrial systems that influences vegetation patterns, habitats, and ultimately species composition. Fire management practices interact with several other threats to conservation areas. For example, altered natural fire regimes can lead to invasion by non-native fire adapted plants, or forests that are more prone to insect and disease impacts (Stark and Hart 1997).

For thousands of years, western forests have been under the influence of burning. Frequent, low-intensity, small fires once cleared out brush and small trees, leaving a mosaic of seral stands and openings. In the past 150 years, humans have significantly altered fire regimes, both in terms of setting fires and suppressing them, changing both the severity and frequency across the landscape.

Before Euro-Americans settlement, most fires in the low and mid-elevation forest were non-lethal (does not kill the dominant layer of plants). Forests and grasslands benefited from the frequent, surface fires, which thinned vegetation and favored growth of fire-tolerant trees. Lethal or stand-replacing fires played a lesser role in the landscape. Lethal fire regimes now exceed non-lethal fire regimes in forested areas throughout the ecoregion. Rural development, fire suppression and exclusion, slash and burn timber harvest techniques, and invasion by non-native fire adapted plants have contributed to these changes. (Quigley et. al. 1997)

As a result, several range and forest characteristics have changed dramatically. Native grasslands and shrublands have declined. Noxious weed spread is expected to accelerate dramatically. Tree species mix and age classes have changed. For example, historically, there were older and mixed age class stands. Now uniform stands of middle-aged trees predominate. (Quigley et al. 1997) Since the early 1900's, fire suppression in the interior northwest has resulted in a successional replacement of seral species such as, ponderosa pine (*Pinus ponderosa*) and western larch (*Larix occidentalis*) to stands of Douglas-fir (*Pseudotsuga menziesii*). This successional replacement has profound ecological implications, including alteration of water, nitrogen, and carbon cycles. Fire suppression has also resulted in overcrowded forests. Crowded forest stands are less diverse and their trees have less vigor. They're more susceptible to insect outbreaks, large forest fires and disease.

When fires occur outside a range of historical or natural variability—too much, too little or the wrong kind—ecosystems often undergo wholesale changes, including loss of biodiversity at several levels. "Fire-adapted" ecosystems possess a structure, composition and function resilient over time to repeated fire, and include many native fire-dependent species. When fire is excluded, vegetative succession occurs. Seral species are lost. Flammable fuels accumulate, ultimately resulting in large and destructive wildfires. In contrast, "fire-sensitive" ecosystems rarely experience natural fire. In these ecosystems, large, intense wildfires lead to dramatic reductions in diversity and conversion of plant communities. Thus, threats are of two primary types:

Fire exclusion in fire-adapted ecosystems
Leading causes include: national or local suppression policies geared toward protecting property; incompatible grazing and forestry practices that alter fuels; landscape-level fragmentation that hinders fire spread; escalating encroachment of humans and human infrastructure into wildlands; misperceptions about the benefits of fire; and lack of prescribed fire capability.

Indiscriminate burning in fire-sensitive ecosystems
Leading causes include: escaped agricultural fires; fires set to clear forests or burn logging slash (legal and illegal); invasion by non-native fire-adapted plants; lack of policy or enforcement; lack of understanding and knowledge; and lack of suppression capability.

Across the ecoregion, natural fire regimes are significantly altered, posing major threats to biodiversity. The threat posed to biodiversity by altered fire regimes is both severe and vast. Millions of acres of highly diverse lands are at risk from inappropriate fire regimes: too much fire, too little fire, fire in the wrong season, or fire at an inappropriate intensity and scale. Altered fire regimes can inflict devastating wounds, from the loss of a single fire-dependent species to wholesale ecosystem change. Inappropriate fire suppression techniques pose an additional threat.

Fire—as an ecologically beneficial or harmful *process*—is a local phenomenon, occurring at the scale of landscapes and individual land ownerships. The *sources* of fire-related threats, however, originate at local, as well as regional and global scales, including trends in politics, economics and wet/drought cycles. Because the scope of the problem is enormous, unprecedented interagency cooperation and public support, along with strong science, will be key to addressing the challenge.

Forestry Practices

Forestry practices were identified as a threat to the conservation targets at 72% of the areas (ranked as high severity and urgency at 24% of the areas). Poor forestry practices, including inappropriate harvest prescriptions and fire suppression, have contributed to the serious decline in forest health throughout the ecoregion. Poor historic practices have resulted in change in forest compositions and the introduction of damaging diseases, insects or vegetation. Historical and current logging practices have eliminated most low-elevation, old growth forests, particularly of ponderosa pine, Douglas-fir, and mixed coniferous forests (Shinneman et al. 2000). In addition, forest logging practices often create different temporal and spatial patterns than natural disturbances such as wind throw and fire (Sousa 1984).

While there are demonstrated ecologically beneficial uses for some harvest prescriptions, the inappropriate use of harvest prescriptions such as shelter wood harvests, even- age management, and single species selective harvests have significantly contributed to the reduction of forest health in areas throughout the ecoregion. Fortunately, vast areas of the ecoregion still exhibit intact forests of native tree species. However, in some areas, species compositions have changed substantially, in part due to poor forestry practices, as provided for in the two examples below:

Ponderosa Pine

Historically, ponderosa pine forests predominated on warm-to-hot, dry sites at the lower elevations along the east slope of the mountains and in major river valleys. Mature ponderosa pine forests were commonly quite open, a condition that was maintained by intermittent low intensity fires averaging every 5 to 25 years. These surface fires consumed the needle duff and killed most understory trees. Bark beetles killed individual or small groups of aging or stressed trees, which were eventually replaced by regeneration that had survived the fires.

Ponderosa pine is now less common, having been replaced by denser forests of Douglas-fir or grand fir. The change is a result of fire suppression and timber harvesting. Without fire, the more shade-tolerant Douglas-fir and grand fir become established and out compete the ponderosa pine.

Early species-selective harvesting of ponderosa pine accelerated the shift in composition toward Douglas-fir and grand fir. The net result has been a change from predominantly semi-open, mature ponderosa pine forests to dense, younger forests, many of which are multi-storied, shade tolerant species more susceptible to fire and disease.

Western White Pine

Until about 50 years ago, western white pine was an abundant forest type. Prior to European settlement, the landscape pattern consisted of large mosaics of many thousands of acres, major portions of which were of a similar age class, a legacy of mixed-severity and large stand-replacement fires. White pine forests of 200 or more years of age were common. The combination of poor historic forestry practices, fire suppression and the white pine blister rust has nearly eliminated mature western white pine stands. White pine was and still is a highly prized wood product. The forestry practice of harvesting the oldest and best white pine significantly contributed to its decline. Additionally, fire suppression allowed western redcedar, western hemlock, or grand fir species to eventually take over white pine stands and dominate many sites. The primary agent of change is the white pine blister rust. The rust, a disease of white pines, did not formerly occur in North America until accidentally introduced into Vancouver Island, British Columbia in about 1910. By the 1940s, the disease was epidemic in the Interior Northwest.

Invasive Species

Invasive exotic plants were identified as threats at 48% of the areas for plants (ranked with high severity and urgency at 28%) and 22% of the areas for animals (ranked with high severity and urgency at 7% of the areas). Some plants such as Canada thistle (*Cercium canadensis*) and cheatgrass (*Bromus tectorum*), and animals such as non-native trout (brown, rainbow) are widespread in the Canadian Rockies. These invasive species often out-compete native species or disrupt natural processes native species need for survival. For example, non-native trout, introduced for sport fishing, out-complete and hybridize with native cutthroat trout, degrading the genetic purity of native trout populations (Oelschlaeger 1995). Invasive species, especially plants, often have a difficult time establishing in pristine, and unfragmented areas. These species often arrive following disturbances or stresses to the landscape such as residential development, roads, utility corridor development, or long-term improper grazing.

All natural vegetation communities are somewhat at risk. The communities most at risk include low-elevation grassland communities and the drier forest types threatened by invasive plant species such as leafy spurge (*Euphorbia esula*), the knapweeds (*Centaurea spp.*) and dalmatian toadflax (*Linaria genistifolia ssp. dalmatica*). Some wetland types are also particularly threatened by invasive species such as purple loosestrife (*Lythrum Salicaria*), and Eurasian water milfoil (*Myriophyllum spicatum*).

The scientific study of invasion is in its infancy. We know enough, however, to be confident that aggressive action is warranted to slow the flow of new invaders and to reduce the impacts of established, habitat-altering species. Many impacts are poorly understood, and these include the long-term impacts of some control methods (e.g., chemical, mechanical, or biological methods) that may themselves pose a threat to native systems.

Of the many non-native species that may be introduced to a native ecosystem, some act as competitors, predators, pathogens, or disrupters of key ecological processes (nutrient cycling, flood or fire regimes, etc.). Others exhibit no clear negative impacts, or may enhance the habitat for certain native species while harming other native components.

Mining Practices

Mining practices were identified as a threat to the conservation targets at 22% of the areas, and ranked high for both severity and urgency at 9% of the areas. Mining, including hard rock mining and gravel mining, historically and currently occurs throughout the Canadian Rockies. There are numerous active or abandoned mines in the region, many of which have degraded downstream aquatic and riparian systems. Mining is British Columbia's third largest industry. The province provides more than half of Canada's coal production, along with a growing range of metals, industrial minerals and structural materials used domestically and exported around the world. Along with coal, British Columbia is a major producer of copper, gold, zinc, silver, lead and non-metallic minerals (http://www.gov.bc.ca/em/).

Leaching of toxic chemicals and heavy metals has destroyed or seriously degraded aquatic systems downstream of release areas. Gravel mining destroys riparian vegetation and alters hydrology. While mining activities are a direct threat to aquatic targets, the associated fragmentation and weed invasion along roads impact many large-scale ecological systems.

Oil and Gas Exploration and Development

Oil and gas exploration was identified as a threat to the conservation targets at 9% of conservation areas (ranked as high severity and urgency at 6% of the areas). The eastern fringe of the Canadian Rockies ecoregion has demonstrated the greatest potential for economic discoveries. This area includes those portions of the Overthrust Belt and the Western Canadian Sedimentary basins. Exploratory activity is occurring in other areas as well. Coal bed methane gas exploration is the latest potential development. While actual habitat loss may be relatively minor, associated impacts with gas and oil development including road construction, seismic lines and access may contribute greater impacts to some conservation targets.

Parasites and Pathogens

Parasites and pathogens were identified as a threat in 50% of the areas and rank high severity and urgency in 24%. The category includes organisms that impact forest vegetation, disturbances by major forest pathogens and insects beyond the natural variability, and organisms that impact to native trout. Diseases and insect pests of conifer trees are important features of forests in the Canadian Rockies. While some level of native insects and diseases play an important role in forests, alien pests and diseases and altered fire regimes and other factors have contributed to changes in the landscape.

Native insects, including Douglas-fir beetle (*Dendroctonus pseudotsugae*), Douglas-fir tussock moth (*Orgyia pseudotsugata*), Mountain pine beetle (*Dendroctonus ponderosae*), western pine beetle (*Dendroctonus brevicomis*) and western spruce budworm (*Choristoneura occidentalis*) may have artificially high populations due to fire exclusion, past inappropriate timber management practices, and drought conditions.

Mountain Pine Beetle
Mountain pine beetle (*Dendroctonus ponderosae*) populations continue to expand and impact lodgepole pine and whitebark pine stands throughout northern Idaho and western Montana. Mountain pine beetle was considered the most damaging pest in British Columbia during 2001 (Westfall 2001). White pine blister rust (*Cronartium ribicola*) causes extensive tree mortality throughout the range of western white pine. Mortality of naturally occurring regeneration has virtually eliminated western white pine from many forests. This has resulted in major changes in historical transitions in forest types over broad areas.

White-pine blister rust
Blister rust is also causing extensive mortality in high-elevation five needle pines. Recent surveys in northern Idaho and western Montana high elevation forests have found infection rates in whitebark pine (*Pinus albicaulis*) regeneration of up to 90%. Whitebark pine is an ecologically important species of the subalpine forest of the Rocky Mountains. There is growing concern that severe losses of large diameter whitebark pine due to mountain pine beetle coupled with regeneration losses due to blister rust may have significant impacts on water and wildlife in these fragile ecosystems (Harris et al. 2002).

Root Diseases
Root diseases are common in the moist Douglas-fir, grand fir and high elevation cool sub-alpine forests in the Rockies. Root diseases have increased significantly over the past several decades. In mixed species stands, disease has a thinning effect by removing susceptible and leaving disease-tolerant species. In stands of susceptible species, the entire stand can be killed. Root diseases are variable in distribution, but can have major effects in some areas. For example, a root disease assessment in the Coeur d'Alene River Basin in the Rockies indicated that 35 % of the basin consisted of Douglas fir or grand fir cover types with root disease (Hagle et al. 1994). Of the infested acres, 62% were rated as severely affected, meaning more than a 20% reduction in canopy had occurred.

Dwarf Mistletoe
Dwarf mistletoes are obligate parasites that survive only on live branches or stems of living trees. Dwarf mistletoes grow in tree bark and wood, absorbing water and nutrients of the host tree that are otherwise used for growth. Dwarf mistletoes influence the health of coniferous forests because they reduce the vigor of heavily infected trees. The infection can kill the affected trees outright or predisposes them to attack by insects and/or other pathogens. Fire suppression efforts and selective harvesting practices have left infected overstory trees above those being regenerated.

Whirling Disease
Whirling disease is a parasitic (*Myxobolus cerebralis*) infection that attacks the nerves and cartilage of small trout, reducing their ability to feed and avoid predators. The disease has been in some eastern states and provinces for many years but was first found in Idaho in 1987 (St. Joe

and Coeur d'Alene rivers) and in Montana (Swan and Clark Fork rivers) in late 1994. It is considered the "greatest single threat to Montana's wild and native trout populations" (Montana Whirling Disease Task Force, www.whirlingdisease.org). Whirling disease has not yet been detected in British Columbia and Alberta.

Point/Non-Point Source Pollution

Point/Non-Point Source Pollution was identified as a threat to the conservation targets at 33% of the areas (high severity and urgency at 17% of the areas). Non-point source pollution (NPS) is when pollution originates from many different sources rather than one specific, identifiable source. NPS occurs when rainfall, snowmelt, or irrigation runs over land or through the ground, picks up pollutants, and deposits them into rivers or lakes, or introduces them into ground water. Not only can it contaminate water, it can also cause adverse changes to the vegetation and affect the shape and flow of streams and other aquatic systems. Examples of non-point source pollution in the Canadian Rockies include heavy metals or toxins (e.g., mining activities, industrial wastes), nutrients (e.g., fertilizers, animal wastes, industrial discharges.), pesticides (e.g., herbicides, insecticides, fungicides), and sediments (e.g., erosion of roads, crops, forest lands).

Point sources of pollution comes from a concentrated originating point that directly discharges wastes into water bodies, such as an industrial factory, sewage treatment plant, or livestock facility. In the CRM, point sources include pulp mills, smelters, domestic sewage, and mining operations.

Recreational Development and Use

Recreation use (all recreation uses combined) was identified as a threat to the conservation targets at 78% of the portfolio areas and was ranked with a high severity and urgency at 22% of the areas. Recreation use, especially off-road vehicles, can degrade or destroy small populations of rare plants, disturb wildlife, modify habitat, spread invasive species, and fragment large-scale ecological systems (Knight and Gutzwiller 1995, Knight et al. 2000). The ecoregion has long been known for its outstanding recreational opportunities. The ecoregion has been and continues to be used intensively for hunting, fishing, camping, horseback riding, skiing, off-road vehicle use, and more recently heli-tours, heli-hiking, and heli-skiing. Recreational use, particularly motorized vehicle use, heli-hiking and heli-skiing of the region's resources are likely to increase over the coming years.

Public policies toward recreation uses will also have a great impact on some conservation targets. A shift toward more commercial recreation permits and tenures in British Columbia will likely cause increases in numbers of recreational users as well as a potential increase in the distribution or location of recreational use.

Residential Development

Residential development was identified as a threat to the targets at 48% of the conservation areas with high urgency and severity at 20% of the areas. The majority of the conservation areas are on public lands, but a significant portion of low-elevation valleys and woodlands, riparian areas, and montane grasslands are in private ownership and susceptible to development.

Urban sprawl and expansion of low-density residential areas into natural landscapes are among the most significant threats to conservation targets in the Canadian Rockies due to the severity of the impacts. Residential development is causing fragmentation and significant changes in land use with the conversion of forested and agricultural lands to development. Residential development and associated infrastructure development (e.g., roads, commercial development, ski area expansion) cause fragmentation and habitat loss, remove and alter native vegetation, degrade wetlands and aquatic systems, increase human activity and recreation, inhibit wildlife movement, and spread invasive species. Additionally, urban development, especially in forested areas is contributing to the alteration of natural fire regimes. When landscapes are developed and human health and property values are at risk, wildfires are controlled, resulting in change to the natural functioning ecosystem process (see Fire Management above).

Comparable data for demographics and residential development in the U.S. and Canadian portions of the Canadian Rockies ecoregion was not available. However, it is clear that some areas within the Canadian Rockies are experiencing rapid growth including the Flathead Valley in Montana, Lake Pend d'Oreille in Idaho, Fernie and the Invermere Valley of British Columbia, and Alberta's East Front of the Rockies. Residential development especially outside the incorporated cities can dramatically impact natural systems and conservation targets by altering environments in the low elevation, easily accessed yet critical habitat areas. As example, in the Flathead Valley, nearly 70% of growth is occurring outside the incorporated cities (Flathead Regional Development Office). Contributing to the growth is an influx of "urban refugees" who choose to retire or run their businesses in a rural setting in the Rocky Mountains. Quality of life and outdoor recreation opportunities contribute to the continuing attraction to newcomers.

Road Density

Road density was identified as a threat to the conservation targets at 30% of the areas (ranked as high urgency and severity at 4% of the areas). Road building is one of the most damaging threats to intact landscapes, particularly regarding hydrological function and habitat fragmentation. Roads are corridors for dispersal of invasive species, inhibit some wildlife movement, and can cause elevated mortality of wildlife species (Knight el al. 2000). In particular, species such as grizzly bear are impacted by road networks that extend into what would be otherwise remote wilderness areas. These roads increases the frequency of human/bear contact—an interaction that often results in a bear being killed either accidentally or purposely (McLellan and Shackleton 1988).

In the CRM, road proliferation is largely a consequence of other threats listed in this section such as forestry operations, residential development, recreational development as well as oil and gas exploration. Public policies on road management will greatly impact several conservation targets including natural communities, aquatic species, and wide-ranging carnivores.

Transportation and Utility Corridors

Transportation and utility corridors were identified as a threat at 24% of the conservation areas (ranked with high urgency and severity at 13% of the areas). These corridors have been specifically highlighted from other threats posed by road density and proliferation, due to the dramatic fragmenting effect large improved highway systems and the associated utility and railway development can have at an ecoregional scale.

Both road density and road/utility corridors threat is critical to the wide-ranging species conservation targets. Carnivores are particularly vulnerable to habitat fragmentation from highway development because of the large spatial requirement of individuals and populations. Highways adversely affect carnivores by an increase in direct and indirect mortality, displacement and avoidance of habitat near highways, habitat fragmentation, direct habitat loss and habitat loss due to associated human developments. The impacts on carnivores resulting from upgrading highways are often permanent and severe (Ruediger et al. 2000).

Several major highway systems impact the Canadian Rockies ecoregion including several that cut east-west such as U.S. Highway 2 (Montana and Idaho), the Trans-Canada Highway 1 and Canada Highway 3 (British Columbia and Alberta), and several more that run north-south including U.S. Highway 95 (Idaho), Highway 93 (Montana) and Highway 95 (British Columbia). Even more ominous are proposed four lane highway expansions for U.S. Highway 2 and Canadian Highway 3. As highways are improved and traffic volumes increase, the impacts of habitat fragmentation, mortality and displacement increase.

Large highway and railway transportation corridors also present different impacts especially since they are generally located near major rivers. Potential for toxic spills exists for both truck and railroad traffic. Some grizzly mortalities along Highway 3 corridor (Montana) can be attributed to direct collisions with trains and indirectly with grain spills attracting grizzlies to the highway/train corridor.

Water Management

Water management practices were identified as a threat to the conservation targets at a total of 69% of areas (dam/reservoir operation at 35% of the areas; ditch, dikes, diversions at 24% of the areas; and channelization at 24% of the areas). Water related threats that ranked with a high urgency and severity were dam/reservoir operation at 20%, ditches and diversions at 4%, and channelization at 4% of the areas. There are dozens of dams in the Canadian Rockies and hundreds of diversions, and ditches which have altered hydrologic functions and reduced water flows and quality, impacting aquatic and riparian systems and flooding natural wetlands and small ponds (Shinneman et al. 2000, Hammerson 1999). The result of these human modifications of watersheds and stream systems has lead to severe impacts on aquatic systems through the ecoregion.

Q. CLIMATE CHANGE

The team addressed potential climate change impacts in this assessment by ensuring that the portfolio as a whole spanned the full range of climatic gradients in the ecoregion and that individual conservation areas spanned the greatest possible altitudinal range within contiguous natural areas. This was accomplished by: 1) classifying terrestrial and aquatic ecosystems and mapping their current distributions in a near-comprehensive manner; 2) establishing minimum size thresholds for each system type to account for a wide potential range of variation in natural disturbance regimes; 3) using sections and Ecological Drainage Units to ensure sub-ecoregion-scale climatic variation was well represented among both terrestrial and aquatic systems; and 4) using ELU's and aquatic macrohabitat models to represent local-scale variability within and among ecological systems in contiguous portfolio areas. The ELU's/macrohabitat models addresses factors of elevation, slope/aspect, hydrologic gradient, stream size, landscape position, geologic substrate, and soil moisture regime. This ensured the inclusion of contiguous ecological gradients, and likely habitat "refugia" with climate changes we have yet to measure. Additionally, as evidenced by major vegetation types, most portfolio areas include wide elevational gradients, many from alpine to foothills.

Climate change was not addressed in the direct analysis of threats to conservation targets by conservation area. The team recognized that climate change could significantly impact biodiversity over time at some level in all of the conservation areas. Specific impacts to conservation targets at conservation areas are highly speculative at this point. While it was not possible for this team to address specifics related to biodiversity conservation and global climate change, regional research provide some clues as to expected impacts to some conservation targets.

Over the 20th century, the region has grown warmer and wetter. Annual average temperature has increased 1-3 degrees over most of the region. Forests of the Canadian Rockies are quite sensitive to climate variation because warm dry summers stress them directly, by limiting seedling establishment and summer photosynthesis, as well as indirectly by creating conditions favorable to pests and fire. The extent, species mix, and productivity of the forests are likely to change, but the specifics of these changes are not known with confidence at this time (US Climate Change Science Program, www.usgcrp.gov and www.climatescience.gov).

Model scenarios project regional warming in the 21st century to be much greater than observed during the 20th century, with average warming about 3 degrees by 2050. A seasonal pattern of wetter winters and drier summers, the projections show the annual precipitation increasing, while water availability decreases. By the 2090's average summer temperature are projected to rise by 7-8 degrees, while winter temperatures rise by 8-11 degrees. Projected annual precipitation increases range from a few percent to 20% and up to 20-50% increase in a Canadian model. The projected warming and drier summer will likely increase summer water shortage because there is less snow pack and because it melts earlier (U.S. Climate Change Science Program, http://www.climatescience.gov/).

What does the projected global climate change mean for western mountains and protecting unique natural resources? An interdisciplinary team of US Geological Survey, National Park

Service, US Forest Service and University of Montana scientists has conducted 9 years of research at Glacier National Park and can provide some insight. Research at Glacier Park (US) has documented ecosystem responses to a warming climate – less than 1/3 of the glaciers present in 1850 exist today and most remaining glaciers are mere remnants of their previous size. The scientists expect a future with a 30% rise in precipitation and slight increase in annual average temperature (currently the most likely scenario for the Glacier National Park area within the next 50 years).

The cedar-hemlock forests are favored to expand in lower elevations but coarse woody debris accumulation and other forest responses increase the frequency of large, stand-replacing forest fires in other areas. Stream temperatures rise earlier in the summer, altering the abundance and distribution of stream organisms while subalpine fir trees become more nitrogen-stressed at tree line.

Stream/wetland complexes possess diverse temperature regimes and have diverse aquatic faunal assemblages containing many rare species. Many of these species have very narrow habitat requirements and respond quickly to thermal changes, as temperature can be a predominant limiting factor.

Modeled interaction of future climate and fire management scenarios at Glacier Park (US) demonstrated that different landscape patterns are likely to dominate in future years, influencing ecosystem process and vulnerability to external stresses. Models indicate a future trend towards larger, homogeneous habitat patches as a result of more frequent stand-replacing fires.

R. DATA GAPS/RESEARCH AND INVENTORY NEEDS

Broad Data Gaps/Research Needs

Species Occurrences

The initial exercise of compiling and analyzing data and selecting targets for the Canadian Rocky Mountains ecoregion illustrated a significant un-evenness in the distribution of available EO data. Three important factors attributing to the unevenness of data are that 1) individual Heritage and CDC programs maintain independent species tracking lists, 2) the longevity of state or provincial programs influence the total number of element occurrence records, and 3) past inventory history (or lack of) in the ecoregion. It was necessary to gather new occurrence data for terrestrial animals, rare plant communities, and small and large patch ecological systems. Efforts should be made to continue to harmonize the operation of CDC and Heritage programs and resources should be found to encourage continued inventories and assessments.

Conservation Goals

Conservation goals need to be tested and assumptions validated. At present, we lack the scientific understanding necessary to confidently state how much is enough. There is very little theory and no scientific consensus regarding how much ecological system or habitat area is necessary to maintain most species within an ecoregion. Inventory efforts should be directed towards targets that did not meet conservation goals, particularly those not represented or documented in the portfolio.

Viability

Viability specifications were developed to rank the viability or integrity of priority species (e.g., G1, G2, S1, S2) and all terrestrial ecological systems. Specifications are needed for all targets (and need to be applied) in the ecoregion. These viability specifications should be refined as new information is obtained on targets and should be validated. Also, field assessments of the viability of a number of conservation targets lacking data are needed.

Verification of Biophysical Models and Species Inventory

The aquatic ecological systems should be one of the highest priorities for systematic and comprehensive inventory—to field validate the initial classification developed through this assessment. Further field validation is also needed for the terrestrial ecological systems, including assessments of integrity (e.g., quality and condition), extent, and threats. A number of conservation targets were not represented in the portfolio or did not meet goals due to lack of data; these targets should be priorities for future inventory efforts (particularly the invertebrates, reptiles, and plants).

Portfolio Design and Analysis

Further refinement of the SITES model is recommended, particularly so that users can easily document what targets are selected at an area and which targets met goals. One important post-portfolio analysis that is needed is to test the coarse filter to see how well it captures common species and watch-listed species. This analysis is particularly important for bird targets wherein, most species have been assumed to be captured through the conservation of habitat in the coarse filter.

Connectivity
A more thorough analyses of the portfolio's connectivity is needed to ensure that the conservation solution presented here is indeed a network of conservation areas suitable to maintaining the long-term viability of targets—particularly the wide-ranging species that are so much a part of this ecoregion's identity. Additionally, it is important to evaluate the connectivity of this portfolio with surrounding ecoregional portfolios. Again, this is of particular importance for ensuring long-term viability of wide-ranging species throughout the Rocky Mountain ecoregions.

Threats
Further analysis is needed to better understand the pattern of multi-area threats, target type, and land ownership. More information about current and future threats is needed for conservation areas. Future efforts might include an experts workshop to obtain more information about threats and policies that might be impacting conservation targets. Levels and impacts of current activities, such as oil and gas exploration, need to be investigated.

Wide-Ranging Mammals
This assessment is a first attempt at a preliminary functional network, based on the targeted wide-ranging mammals. A range-wide approach to these species can be achieved by analyzing wide-ranging mammals at the multi-ecoregional level and incorporating new analyses and information resulting from nearby ecoregions.

Climate Change
Global warming could accelerate a number of the threats to conservation targets within the portfolio, such as spreading of invasive species and increasing the risk of devastating wildfires. While the team designed the portfolio to ensure that it spans the full range of climatic gradients and that individual sites span the greatest possibly altitudinal range within contiguous natural areas, addressing specific impacts of global climate change was beyond the scope of this assessment. Further work is needed to guide conservation efforts in light of different climate change scenarios. For example, it would be useful to predict level of endangerment for certain species (especially in the alpine zone) and ecological systems based on certain global warming scenarios.

S. CONSERVATION STRATEGIES AND ACTION PLAN

NCC and TNC program staff in the ecoregion are currently developing a separate implementation plan to serve as an adjunct to this biodiversity assessment. The implementation plan will draw upon conservation and threats information generated during the ecoregional planning process and will focus on identifying multi-site strategies as well as high leverage strategies for priority conservation areas identified in this plan.

T. SUMMARY AND CONCLUSION

The primary product of this assessment is an ecoregional portfolio of conservation areas, based on the best available and current information, representing the targeted species, natural communities, and ecological systems of the CRM. The portfolio consists of 54 Conservation Landscapes and an additional 20 individual smaller conservation sites. The final portfolio encompasses 33.2 million acres, or roughly 50% of the ecoregion. The ecoregional portfolio is considered a conservation blueprint—a vision for conservation success—to guide public land managers, land and water conservation organizations, private landowners and others in conserving natural diversity within this ecoregion. The goal is to conserve the entire portfolio of conservation areas, which will require a combination of strategies, including on-the-ground action at specific conservation areas and multiple-area strategies to abate pervasive threats to targets across the ecoregion.

The CRM portfolio provides an opportunity to engage in an implementation process that identifies multi-area approaches to implement biodiversity conservation efficiently across the ecoregion. Some priority actions should be taken to assure conservation success within the CRM portfolio conservation areas. These include but are not limited to: 1) ensure that key landowners and land managers are aware of the results of this assessment and the biodiversity significance of the lands they own and manage; 2) develop multi-area strategies to abate pervasive threats, including plant and animal invasives, forest and fire management practices, and parasites/pathogens; 3) develop site conservation plans for portfolio conservation areas in order to determine site specific strategies for threat abatement; and 4) focus inventory efforts on ecological systems and species lacking sufficient occurrence information.

It is certain that the initial prioritization of conservation areas presented in this plan requires further qualitative assessments based on conservation feasibility, opportunity and leverage. These assessments should be designed to yield a suite of action sites that can then serve as a focus for conservation partners in the immediate future. With regard to taking action at priority conservation areas, the planning team recognizes that in the real world, protection opportunities will not arise in an orderly sequence that corresponds to science-based priorities. It is also important to note that some areas not currently within the conservation solution presented here may become more attractive possibilities for conservation in the future. Changes in land ownership and land use designations in particular can dramatically alter the landscape of conservation opportunity. However, the CRM assessment presented here will allow conservation practitioners to quickly put these emerging opportunities into the appropriate ecological context and to take actions that are scientifically defensible and result in the most biodiversity conserved.

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