A SENSE OF PLACE

Issues, Attitudes And Resources In The Yellowstone To Yukon Ecoregion

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Y 2 Y

Yellowstone to Yukon Conservation Initiative

The Yellowstone to Yukon Conservation Initiative (Y2Y) is a binational network of over 170 conservation organizations and individuals that seeks to conserve the beauty, the health and the natural diversity of the Rocky Mountains from the Greater Yellowstone Ecosystem in the south to the Yukon's Mackenzie Mountains in the north. Drawing from the best available science, Y2Y's mission is to restore and maintain landscape and habitat connectivity along 3200 kilometres (1990 miles) of mountains by establishing a system of core protected wildlife reserves that are linked by wildlife habitat and movement corridors. Existing national, state and provincial parks and wilderness areas will anchor the system, while the creation of new protected areas will provide the additional cores and corridors needed to complete it.

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Some mention should also be made of those who helped lay the conceptual groundwork for such a project. We are grateful to the many experts, especially the U.S. and Canadian carnivore biologists, who have long argued that conservation should parallel ecological processes and the movements of species across the 49th parallel. And, we acknowledge Gary Tabor, formerly of the Kendall Foundation, who compiled the first document to assess the potential of the Yellowstone to Yukon Conservation Initiative.

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Preface

Michael Soulé

The Yellowstone to Yukon region occupies the northern reaches of the mountainous backbone of western North America. It is one of the last, big wild places of creation, a natural Eden that is home to an extraordinary diversity of living beings. Great rivers like the Yellowstone, Fraser, Columbia, Missouri, Red Deer, Mackenzie, Yukon, Peace, and Saskatchewan rise in these mountains, carrying nutrients into every ocean except the Indian and the Antarctic. In many parts, returning salmon, assisted by bears and eagles, complete the nutrient cycle by fertilizing the vast forests.

But grand natural symmetries, even at such a scale, are quickly spoiled by modern seekers of economic opportunity, recreation, and aesthetic retirement. It is shocking to realize the speed with which the fabric of such huge, remote areas can unravel. Already, according to this Atlas, the national parks and forests receive nearly 115 million visitor days each year, and this pressure is expected to double soon. Roads are the greatest threats to wilderness and biodiversity, and the region now has a density of roads (0.54 km/km^2) approaching the threshold for significant wildlife damage, and the total kilometres of roads and seismic lines is expected to nearly triple in the next 20 years. The reason? Irresistible oil and gas deposits lie buried beneath bothersome overburdens of sediments.

Destruction always outpaces creation, though like a rocket lifting off, its slow beginnings may lull us into complacency. It was just over two hundred years ago—an ecological moment—when the Scottish explorer Alexander MacKenzie became the first white man to reach the Pacific Ocean by land along a northern route. A decade later Meriwether Lewis and William Clark trekked across a "Louisiana" so wild that the it wasn't yet a "frontier."

At President Thomas Jefferson's optimistic urging, Lewis and Clark went with eyes peeled for mammoths. There were no signs of mammoths, but the land itself was mammoth then. Lewis and Clark were too late for other Pleistocene giants as well, but they passed through forests of giants that had never known a saw. It was beyond their imaginings—let alone the imaginings of the scattered groups of First Nations/Native Americans they encountered—that the wilderness they surveyed could be plowed, polluted, drilled, mined, dammed and logged in just a few generations.

Less than 90 years later, in 1890, the U.S. Census bureau declared that the American Frontier was no more, and wildlife was retreating northward. In southern Canada and the United States endless herds of bison were laid waste, and the passenger pigeon, the most abundant species of bird on the planet, was expunged. Market hunters, bounty hunters, and trappers were quickly eliminating the larger wildlife species, including elk, deer, bears, wolves, most fur-bearers, and waterfowl. Soon engineers would be damming the rivers and building a dense network of roads. Wildness is as vulnerable as a cherry blossom in spring.

200 years after MacKenzie and Lewis and Clark, as we engage in millennial musings about coming technological miracles, living nature below the 50th parallel struggles to survive.

And the pace of destruction still accelerates. Now, 200 years after MacKenzie and Lewis and Clark, as we engage in millennial musings about coming technological miracles, living nature below the 50th parallel struggles to survive. Gone are hundreds of sea run salmon stocks, swimming only in the reminiscences of old timers. Wolverines, lynx, bighorn sheep, and grizzly bears may soon be inviable south of Calgary and Winnipeg. Roadless areas are being violated by natural resource managers hiding political agendas under Smokey Bear hats.

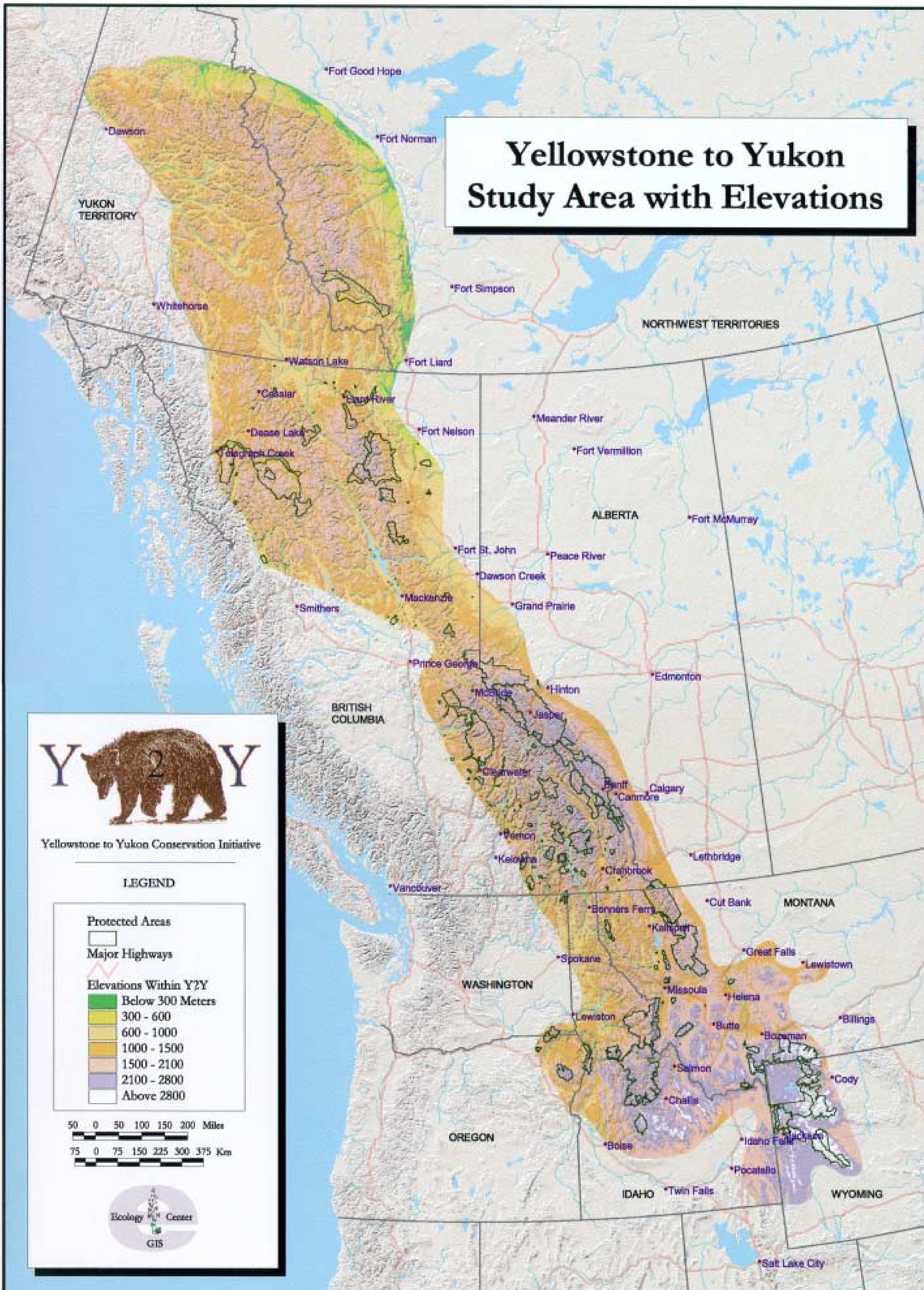
By virtue of their numbers and equipment, even the lovers of nature are unknowingly doing harm. Rafters and kayakers are cleansing the wild rivers of harlequin ducks; backcountry skiers are sweeping the high mountain cirques of mother wolverines and their kits. Forest backpackers frighten off nesting raptors. The riders of all-terrain vehicles and snowmobiles loudly penetrate the last sanctuaries of Canada lynx.

A *Sense of Place* is a new kind of guidebook for those who are exploring the territory of large-scale conservation networks. Not only does the Atlas let us grasp this entire region, but it also opens our eyes to the precious particulars, describing everything from the trends in income to the distribution of vegetation types.

Dr. Michael Soulé is a founder of the Society for Conservation Biology, a fellow of the American Association for the Advancement of Science, retired chair of Environmental Studies at the University of California at Santa Cruz, and President of The Wildlands Project.

Skillfully combining the knowledge of dozens of experts, the Atlas is a critical resource for anyone that wants to save nature in North America. Conservation activists and conservation biologists throughout the continent will profit by applying it, like a template, to their own regions where wildlands planning and reserve designs are underway.

Producing such a volume was a challenge. The editors and contributors were up to the task. Now your work begins. Hurry, dear reader, before it is too late. There is no time to waste in establishing a network of permanent nature reserves for this region, a system that will insure the survival of the wild for the next thousand years.


Yellowstone to Yukon
Study Area with Elevations
Y 2 Y
Yellowstone to Yukon Conservation Initiative
LEGEND
Protected Areas
Major Highways
Elevations Within Y2Y
Below 300 Meters
300 - 600
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2100 - 2800
Above 2800
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Ecology Center
GIS
YUKON TERRITORY
NORTHWEST TERRITORIES
ALBERTA
BRITISH COLUMBIA
MONTANA
WASHINGTON
OREGON
IDAHO
WYOMING
Fort Good Hope
Dawson
Fort Norman
Fort Simpson
Whitehorse
Watson Lake
Fort Liard
Cassiar
Fort Nelson
Meander River
Dease Lake
Telegraph Creek
Fort Vermilion
Fort McMurray
Fort St. John
Peace River
Dawson Creek
Mackenzie
Smithers
Grand Prairie
Prince George
Edmonton
Hinton
McBride
Jasper
Clearwater
Banff
Canmore
Calgary
Vernon
Kelowna
Lethbridge
Cranbrook
Vancouver
Cut Bank
Bonners Ferry
Kalispell
Great Falls
Spokane
Lewistown
Missoula
Helena
Lewiston
Butte
Billings
Bozeman
Salmon
Cody
Challis
Idaho Falls
Jackson
Boise
Pocatello
Twin Falls
Salt Lake City

INTRODUCTION

The Wild Heart of North America: A New Perspective

Louisa Willcox

The Rocky Mountains of Canada and the northern United States offer some of the most spectacular wilderness in the world, including some of the best remaining habitat for species eliminated or drastically reduced in numbers elsewhere. This is particularly true for large carnivores, including such wide-ranging species as grizzly bears, wolves, wolverines, and lynx. Such animals, however, face an uncertain future in the Rockies: the forces that led to their extermination elsewhere—clearcutting, oil and gas development, mining, diversion and damming of rivers, pollution, subdivision, and suburban sprawl—are mounting here, too.

The Yellowstone to Yukon Conservation Initiative (Y2Y) is a bi-national effort to restore and maintain biological diversity and landscape connectivity along the spine of the Rockies, from the Greater Yellowstone Ecosystem in the south to the Mackenzie Mountains in the north. Encompassing over 1.2 million square kilometres, the Y2Y is a huge territory, an ecoregion that hosts not only a rich diversity of wild habitats and creatures, but also native cultures and rural communities that have been shaped by the power of the wild. In short, it is a geography to challenge our ability to understand it, and to dare us to create for it a different future than that slated for the tamed and tilled landscapes of North America.

To explore such new directions, the people involved in this initiative recognized that more comprehensive information on the Y2Y region was necessary. No general assessment of the ecology, economy, and culture of the area had ever been done. The document you hold is a first attempt at such an assessment. Needless to say, creating the document has been a challenge in itself. Trying to convince U.S residents that the Northern Rockies actually lie several hundred miles (kilometres) north of Babb (or is it Banff?) is difficult enough, let alone grappling with political boundaries, conceptual limits, nomenclature, data sets, and scales that vary by state and province.

Comprised of papers that have been written and compiled by experts from Canada and the U.S. over the last year, *A Sense of Place* is the first look at Y2Y in its entirety. Its aim is to:

- describe the Y2Y ecoregion and survey its natural resources;
- provide an overview of the region's current health;
- summarize the region's human-caused threats and habitat trends;
- describe the implications of these threats and trends for the future; and
- foster a common understanding about ecological, economic, and First Nations/Native American issues that will provide a foundation for future discussions on strategies to maintain the integrity of the region in the long term.

As portrayed in the accompanying map, the Yellowstone to Yukon ecoregion can be defined generally as lands in the Rockies above about 1050 m (3500 feet) in elevation, characterized by extensive coniferous forests, and encircled at lower elevations by prairie grasslands. This is headwaters country too, with ten major river systems draining into the Pacific, Arctic, and Atlantic Oceans, supplying water for wildlife and human communities in the prairies, cities, and farms thousands of miles from the rivers' mountain sources. When people think of Yellowstone to Yukon, though, they think first of mountains, and the drama of the region's geol-

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ogy. In fact, Y2Y boasts the oldest rocks found in North America, as well as the largest geological displays of former volcanic activity in the world.

Today, as they have for millennia, fire and ice shape the land. Given such rugged topography and punishing natural processes, it is surprising that so many plants and animals have claimed the Rockies as their home. Some bird species achieve their highest breeding densities in the Rockies, and some of the rarest species found in North America—the grizzly bear, wolf, black-footed ferret and whooping crane—reside here.

And, for at least the last 10,000 years, human beings have also called the region home. Y2Y comprises the traditional territory of 31 First Nations/Native American groups, each with a distinct culture, language, and history reflecting a way of life adapted to the plains, mountain recesses, forests, and grasslands. To native peoples, this was a sacred geography, shared by successive generations that renewed their relationships with the land through story and religious practices. To increasing numbers of people today, Y2Y provides a place for spiritual renewal and reflection in the beauty and solitude of wilderness.

The boundary on the maps should not be interpreted as a sharp delineation based on a crisp ecological difference, but rather as a permeable membrane, through which animals, rivers, and ecological processes cross continually.

Yellowstone to Yukon: real or imagined?

Few would argue that Y2Y is a unique and marvelous place, a topography supported by the backbone of the Rocky Mountains and nourished by the lifeblood of its wild rivers. But is it really a coherent ecological unit?

Ecoregions have been defined as "large areas of the landscape determined by shared climate and geology, which, in turn, affect the kinds of ecosystems and animals and plants found there" (Kinch 1997). Ecoregions can frame our thinking about the land, and about strategies to protect our natural heritage.

Y2Y fits the broad definition of an ecoregion. As explained in Ben Gadd's paper, the landscape shares common geologic, hydrologic and climatic features, which in turn explain the similarities of plants and animals adapted to live here, ranging from caribou and bull trout to boreal and ponderosa pine forests. Certainly Y2Y includes many identifiable ecosystems, such as the Greater Yellowstone, Salmon-Selway, Peel River Basin, interior rainforests of British Columbia, northern Idaho and northern Montana. Each of these is a unique ecosystem, defined as a relatively self-sustaining, dynamic interaction among plants, animals and their physical environment.

An ecosystem, of course, can be as small as a pond or as large as the geographic range of a grizzly bear population. Many distinct smaller ecosystems, each bound together by related ecological processes and each with its own ecological parameters, overlap and form progressively larger ecosystems. A small stream is part of a river system, for example, and a grove of trees stands in a coniferous forest. Thus, ecosystem are bounded somewhat arbitrarily, and can be viewed at multiple scales.

So too, our idea of Y2Y as an ecoregion is something of an artificial construct, for there is no hard separation between what is included within the boundary and the lands outside. The boundary on the maps should not be interpreted as a sharp delineation based on a crisp ecological difference, but rather as a permeable membrane, through which animals, rivers, and ecological processes cross continually. Ideally, the boundaries would expand or contract with the species or the regime being looked at. Y2Y, then, can be viewed as a region comprising smaller connected ecosystems and linked to other large ecoregions such as the prairie grasslands and the arctic barrens.

The difficulty in defining ecosystems precisely should not deter us from using it as a conceptual tool and general ecological guide; indeed, it never stopped the many notable scientists in the region, such as Olaus Murie, John and Frank Craighead, and Valerius Geist, who have made enormous contributions to our understanding of the region's complex and dynamic ecology. Struggling with the slippery notion of an ecosystem, conservation leader Ed Lewis once wryly noted: "An ecosystem is a little like pornography: it's hard to define, but you know one when you see one."

One biological fact that pertains to ecoregions and ecosystems at all scales is that change is inevitable. Big forest fires, like the 1988 Yellowstone fires, can produce big impacts that last for years, while local landslides can alter hydrology and vegetation on local scales. The drought of one summer can lead to a major big game die-off the next winter. Severe winters and deep snow replenish rivers and lakes, and give wolves an advantage in their pursuit of elk and moose. Some parts of ecosystems, such as geologic land forms, change relatively slowly, while others, such as communities of spring beauty and globemallow at the edge of a melting snow field, change almost overnight.

While change from natural forces is the norm, change associated with certain types and levels of human activity can harm the capacity of the broader ecosystem or ecoregion to function well. In Y2Y, road building, clearcutting, oil and gas development, damming and diverting rivers, suburban sprawl and even unfettered recreation are adversely impacting and altering the natural integrity of some parts the ecoregion. Grizzlies and wolves, for example, have been extirpated in all but a few areas of Montana, Idaho, and Wyoming, and their numbers have been greatly reduced in Alberta. Native salmon and westslope cutthroat trout are at precariously low levels throughout the region.

Species abundance, however, is just one measure of ecological health. At risk in certain areas is the ability of the whole ecosystem to function, evidenced by the collapse in species composition and radical simplification of the ecology resulting from toxic waste pollution from mine sites such as the infamous Anaconda mine smelter near Butte, Montana.

Thus, within Y2Y, we are connected as much by our common concerns and problems as we are by the region's common flora, fauna, and natural forces. And because threats such as excessive oil and gas development and suburban sprawl are similar throughout the region, placing them in continental and international contexts provides a useful frame of reference for addressing them. Indeed, many of these threats would be best addressed through a coordinated approach that reflects a comprehensive understanding of ecological relationships across provincial, state, and international boundaries.

Through a close examination of ecosystems which straddle the U.S./Canada border, for example, concerned citizens are learning some important and surprising lessons: first, that the health of wilderness-dependent species such as grizzlies and wolves in Canada is critical to maintenance and recovery of these imperiled species in the U.S., as these animals migrate to the fragmented island ecosystems of the Cabinet/Yaak, Selkirks, and Northern Continental Divide in the U.S.; and second, that Canada should not be seen as an endless repository for such species in light of escalating development and human settlement which are reducing available habitat on the Canadian side of the border. Grizzly expert Stephen Herrero reinforced this point, saying, "The U.S. should not bank on Canadian grizzlies to achieve U.S. recovery; in fact, the reverse might be more true."

In addition to the ecological connections, the human inhabitants of Y2Y are also linked culturally and economically. Yellowstone to Yukon is our home ecosystem: we move up and down the spine of the continent because we are mountain people. We love this place, and we choose to make our living here. The trick, as more and more of us are realizing every year, is to learn to make our living without irretrievably damaging what it is that we love. The ecosystems comprising Y2Y and the organisms that reside here are an integral part of our home; they form our geographic context and the basis of a shared language about who and where we are. In this sense, Y2Y is an ecoregion because it is a force that shapes us as people and communities, binding us together in profound ways.

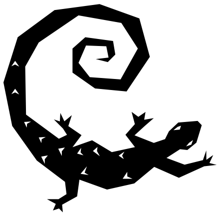
Some biologists may try to turn Y2Y into some mechanistic model, attempting to deal with it as an objective, integrated ecological unit, thus relegating subjective considerations to sociologists, politicians, and poets. That is neither necessary nor justified. The people who have coalesced around the Y2Y idea have done so for subjective reasons, not because Y2Y is a scientific unit unrelated to their personal views. Ultimately, it our concern for the sense of place and the broader vision of a healthy and whole Yellowstone to Yukon that drives us to learn more about this complex ecoregion: how it works, how species live and go extinct here, and how we can protect this marvelous Creation and our natural heritage.

In sum, the term ecoregion, as applied to Y2Y, not only has real scientific meaning, but gives us a framework for understanding our relationships to each other and the land.

Literature cited

Kinch, J. A. 1997. Great Lakes. The Nature Conservancy Magazine, May/June.

Science and Conservation in the Yellowstone to Yukon



Stephen Herrero

Science is fundamental to conservation in the Y2Y region. Large carnivore populations survive and persist, or decline and possibly disappear, depending on land use planning decisions made by human residents of the region. Land use planning is basically a socio-political activity in which people's values are translated into policy, and then into management actions. Political and socio-economic factors shape most land use decisions that influence the persistence and distribution of large carnivore populations. Scientific data, however, often provide at least some of the basis for policy and management decisions affecting large carnivores. The public holds scientists in high esteem, and "scientific results" are more often trusted than political or bureaucratic assessments. Scientific data, because of their objectivity, potential replicability and high acceptance by much of the public, form an important input into land use decisions.

Research on large carnivores is expensive, and many important carnivore/land conservation issues are handicapped by a lack of scientific data, often because of cost, and sometimes because other issues have priority. Large carnivores are secretive in nature, and in the Rocky Mountains they occur at low population densities; they also exist as part of dynamic ecosystems. The combination makes counting them, assessing their status, or predicting the potential impacts of development notoriously difficult. The levels of significance and confidence intervals which a scientist is willing to accept regarding parameters such as population estimates or trends depend partly on current scientific standards, set through the peer review process of scientific journals.

Scientific paradigms

Scientific standards and concepts are firmly embedded in scientific paradigms. A paradigm is a conceptual framework for understanding events. This is not a trivial matter: our interpretations of the world, the questions we ask, the levels of significance we ascribe, and the levels of confidence we accept are all based on the paradigms we hold.

Stephen Kellert's research over the past several decades has clearly defined people's different values, attitudes and actions toward nature (Kellert et al. 1996). The interrelationship of these values, attitudes, and actions can be defined as one's paradigm regarding nature. In the context of carnivore conservation, people generally hold one or the other of two very different paradigms. In one, a person believes nature exists mainly for human use and consumption; in the other, a person believes human beings are a part of nature and that the human use of resources should be carefully regulated not only to conserve the resources, but also because nature has inherent value. Scientists, like all human beings, orient themselves to the world and their work on the basis of their paradigms. In this sense, science is not fully objective.

We also know that scientific paradigms change very slowly. At one time many people believed that science typically advanced by accumulating results from experiments, and that when enough information was gathered, a theory emerged. Thomas Kuhn (1962), in his seminal work on the structure of scientific revolutions, convincingly argued that the questions scientists ask come from theory, and only in rare instances help to create theory. Carnivore researchers in the Rockies ask different questions depending upon their values and theoretical groundings.

Conservation biology: an emerging paradigm

Conservation biology can be viewed as an emerging paradigm. With its mission of encouraging science that helps to maintain biological diversity and natural processes, it places significant inherent value on wild nature. Many of the scientists working on Y2Y subscribe to such a view, and out of that view are asking for longer-term, more protection-oriented planning, and for a conservative interpretation of scientific results so that we do not err and lose carnivore populations. This conservative approach, favoring the ap-

Conservation biology can be viewed as an emerging paradigm. With its mission of encouraging science that helps to maintain biological diversity and natural processes, it places significant inherent value on wild nature. This conservative approach, favoring the application of the "precautionary principle," is based on both values and science.

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plication of the "precautionary principle," is based on both values and science.

With its commitment to maintaining biological diversity and natural systems, conservation biology focuses on different questions and accepts different levels of confidence than do traditional resource use–oriented paradigms. Regardless of a scientist's theoretical grounding, natural systems are complex and are seldom amenable to experimentation. Many researchers working with large carnivores are acutely aware that almost never do we conduct controlled experiments, isolating and trying to understand the effects of one or a few variables at a time. Instead we do largely descriptive work on very complex systems without understanding complex system dynamics. Even in the rare instances where field experiments have been done on large carnivores, such as when Kemp (1976) removed all of the adult male black bears from an area in north-central Alberta, the results were subject to a variety of interpretations due to limitations of experimental design (Garshelis 1994).

Despite the lack of data on many aspects of large carnivore ecology, and the limited predictive value of the research being done, land-use decisions are being made daily that will affect the future of large carnivores and the wildland ecosystems of which they are a part. The insights provided by scientific research, whatever its limitations, are of critical importance to carnivore conservation.

Literature cited

Garshelis, D. L. 1994. Density-dependent population regulation of black bears. Pages 3–14 in M. Taylor, ed., Density-dependent population regulation of black, brown and polar bears. Int. Conf. Bear Res. and Manage. 9: Monograph Series No. 3.

Kellert, S. R., M. Black, C. Rush, and A. Bath. 1996. Human culture and large carnivore conservation in North America. Cons. Biol. 10:977–990.

Kemp, G. A. 1976. The dynamics and regulation of black bear, Ursus americanus, populations in Northern Alberta. Int. Conf. Bear Res. and Manage. 3:191–197.

The Land Conservation Process: A Brief Review

Reed Noss

One of Y2Y's principle objectives is to develop an integrated conservation plan for the Y2Y region. One of the key elements of that plan is the design and implementation of a reserve network of core areas, corridors, and transition zones within a matrix of multiple-use landscapes. In a landscape encompassing over a million km^2 and hundreds of political jurisdictions, the challenge is daunting. Y2Y needs a clear sense of its objectives before specific indicators of ecological integrity or guidelines for design and management of a reserve network can be developed. In beginning to think about such objectives, it may be helpful to consider three broad criteria for maintaining ecological integrity:

1. Sustain key physical, biological, and evolutionary processes within normal ranges of variation, while building a conservation network that is adaptable to a changing environment.
2. Maintain or restore viable populations of all native species in natural patterns of abundance and distribution. A conservation plan emphasizing ecological processes may produce a "healthy" environment, yet fail to maintain biodiversity and integrity if species sensitive to human activities decline.
3. Encourage human uses that are compatible with the maintenance of ecological integrity.

Any conservation plan is an experiment with an uncertain outcome. Thus, flexibility is required in implementing the plan over the years so that managers have the advantage of learning from experience and modifying their practices accordingly.

In deciding which uses are compatible with ecological integrity, the bottom line must be the persistence of the species and processes most sensitive to human activities. In some areas the appropriate human "use" may be strict preservation; in other areas human uses might be limited to hiking, canoeing, environmental education, and non-manipulative research; while in still other areas, they might include hunting, selection forestry, small-scale agriculture, or livestock grazing. Some areas (outside core areas, but perhaps within transition zones) can legitimately be subjected to intensive uses such as plantation forestry or other kinds of agriculture. Consideration of human psychology suggests that conservationists will be most successful when they positively encourage some kinds of human uses rather than simply restrict uses in reserve networks.

After formulating and clarifying goals and objectives, the next step is to determine the general locations of core areas in the overall landscape. Representation is the most central of all criteria used to evaluate areas for protection; if a reserve network fails to represent all habitats, communities, species, or other natural features, it is not fully representative. Perhaps the optimal way to identify core areas for protection is to (1) conduct a gap analysis of enduring features; (2) select sites that optimally capture enduring features in each natural region and among natural regions; and (3) add sites that score highest for any combination (depending on data availability) of criteria judged to be important in particular regions.

The next step, incorporating these sites into a functional reserve network, is a matter of design. Generally, design entails zoning of the landscape into core areas of various kinds, corridors, transition zones and intensive use areas. These areas, collectively, are intended to meet human and nonhuman needs across the region. Selection and design of core areas is the heart of the process; transition zones and connectivity considerations can, in most cases, be factored in later.

Once established, reserve networks must be managed. Sometimes management will be intensive, and in some zones (not core areas) it will involve extraction of timber, minerals, and other resources. In other cases, management will consist mostly of protecting areas from disruptive human influences. Proper management is crucial to ecological integrity.

Finally, any conservation plan is an experiment with an uncertain outcome. Thus, flexibility is required in implementing the plan over the years so that managers have the advantage of learning from experience and modifying their practices accordingly. Ecological monitoring, using quantifiable indicators and operating within a hypothesis-testing framework with a valid experimental design, is essential for measuring progress toward conservation goals and comparing the effects of management practices.

Literature Cited

Noss, R. F., and A. Y. Cooperrider. 1994. Saving nature's legacy: protecting and restoring biodiversity. Defenders of Wildlife and Island Press, Washington, D. C.

Dr. Reed Noss is President-elect of the Society for Conservation Biology, a founder of the Conservation Biology Institute, and the science editor for Wild Earth. A prolific writer, his best known publication is Saving Nature's Legacy.

YELLOWSTONE TO YUKON: A PHYSICAL OVERVIEW

The Yellowstone to Yukon Landscape

Ben Gadd

Y2Y is part of the western cordillera of North America, a region of mountain ranges stretching from southern Mexico to western Alaska. Y2Y covers an area of about 1.2 million square kilometres (460,000 square miles) in the northwestern part of the cordillera.

From Cokeville in west-central Wyoming at latitude 42°, Y2Y stretches northwest for 3200 km (1990 miles) to the Peel River at latitude 66° in the northern Yukon, only 60 km (37 miles) south of the Arctic Circle. The southeastern edge of the region is near Riverton, Wyoming, at longitude 109°; the northwestern tip touches the Yukon/Alaska boundary at longitude 141°. The region is 200–800 km (125–500 miles) wide.

Watersheds And Divides

Between the central American Rockies and the northern Mackenzie Mountains, Y2Y is the backbone of North America. Two continental divides cut across Y2Y, trisecting it into three major watersheds: Atlantic, Pacific and Arctic (see Figure 1).

The western slope of the area drains entirely to the Pacific Ocean. On the eastern slope, the southern part drains to the Atlantic Ocean and the northern part drains to the Arctic Ocean. The Arctic/Atlantic divide meets the Pacific divide at the Snow Dome, a peak on the Columbia Icefield that is the hydrographic apex of North America: the only point on the continent with drainage to three oceans.

Within the Atlantic drainage area, a further divide strikes the Rockies crest at Triple Divide Peak in Glacier National Park, Montana. This divide separates Hudson Bay drainage (Saskatchewan and Nelson systems) from Gulf of Mexico drainage (Missouri and Mississippi systems).

North of the boundary between Banff National Park and Jasper National Park, drainage on the eastern slope of the Rockies is northward toward the Arctic Ocean, via the Athabasca, Slave and Mackenzie rivers.

It should be noted that the Pacific divide does not follow the crest of the Rockies all the way to their north end at Liard River, on the Yukon/B.C. boundary. From McLeod Lake, which is north of Prince George, British Columbia, the Rocky Mountains are entirely within the Arctic drainage area; the Arctic/Pacific divide lies farther west, in the Kaska Mountains.

Topographic Data

Y2Y is rough terrain. The highest point is Gannet Peak, 4207 m (13,804 feet), in the Wind River Range of west-central Wyoming. The Grand Teton, 4197 m (13,771 feet), found not far away near Jackson, runs a close second. The lowest part of the region lies in the Mackenzie Lowlands near Fort Good Hope, Northwest Territories, with elevations along the Mackenzie River of only 60 m (200 feet) above sea level. Subtracting the lowest elevation from the highest gives a total topographic relief of about 4150 m (13,600 feet) for the whole area.

From south to north in Y2Y, typical higher-summit elevations show a general decrease: 3800–4000 m in Wyoming, 3500–3800 m in Montana, 3300–3700 in Alberta and east-central British Columbia, 2800–3200 m in northern British Columbia, and 2500–2800 m in the Yukon and Northwest Territories.

The size of the mountains, meaning the elevation gain from base to top, not the summit elevation, is greatest in central Y2Y. For example, along the western edge of Banff and Jasper national parks, peaks of 3500 m (11,480 feet)

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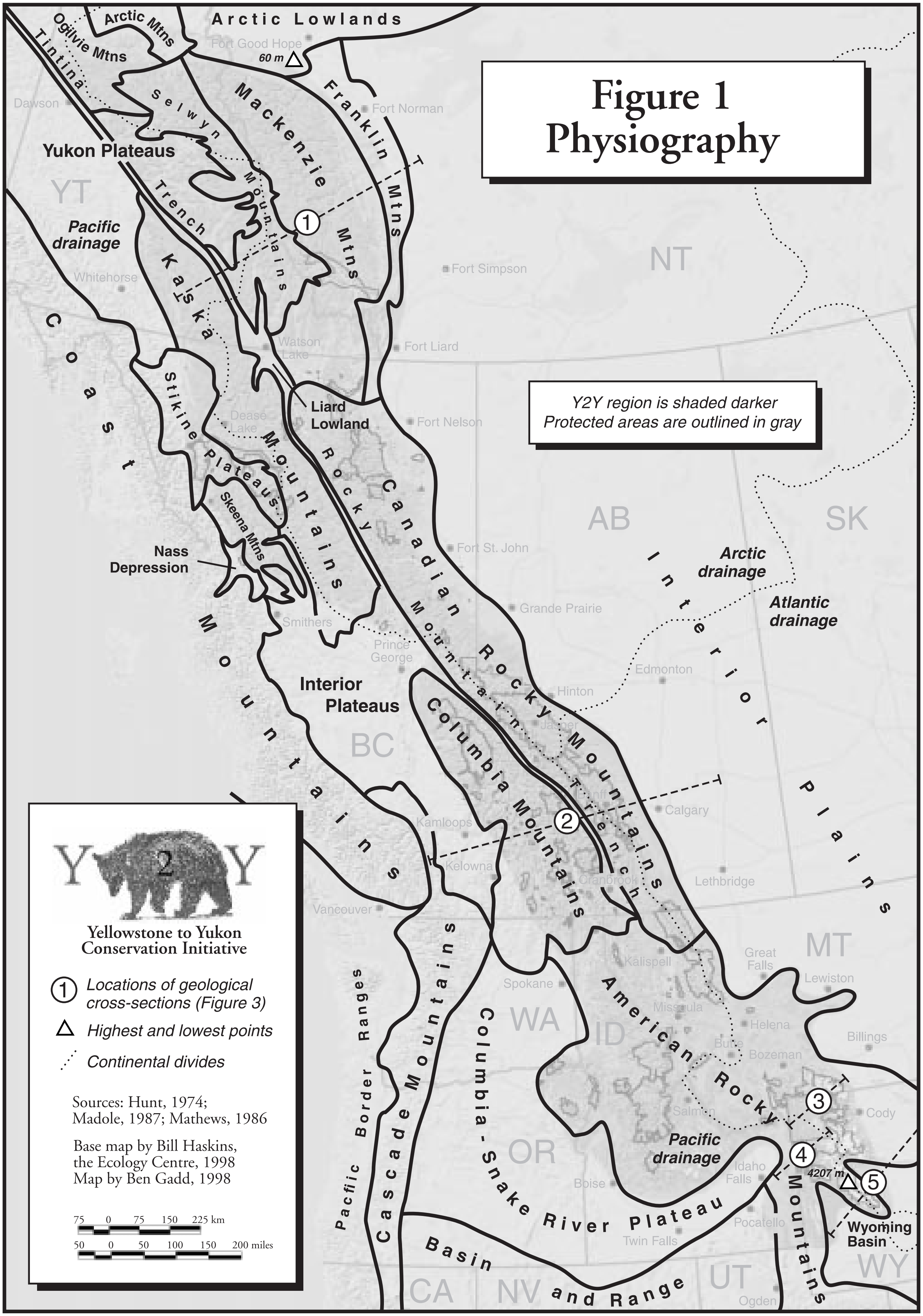


Figure 1
Physiography

and higher stand within 20–40 km (12–25 miles) of the floor of the Rocky Mountain Trench, elevation 750–800 m (2460–2625 feet), for relief of 2750 m (9000 feet). Compare with the relief of the Tetons of northern Wyoming, which is the greatest in Y2Y's American section at 2380 m (7804 feet). The greatest elevation gain anywhere in Y2Y is 3154 m (10,348 feet), measured at Mt. Robson (3954 m, 12,972 feet) west of Jasper.

Geologic Overview And Highlights

To a geologist, Y2Y is part of the Cordilleran Orogen of North America, "orogen" meaning "area of mountain-building." All of the ranges found within the Y2Y area were built, either directly or indirectly, by movements of the plates that make up the earth's crust. Figure 2 shows some of the geological highlights of the Y2Y area. Figure 3 is a series of geological cross-sections that shows north/south variation in what underlies the Y2Y area.

Mountain-building

Most of Y2Y's mountain ranges were crumpled upward when the continent of North America collided with smaller landmasses lying offshore to the west. Some ranges, such as the Tetons of northern Wyoming, are the up-tilted edges of bedrock blocks that moved in response to pulling-apart of the crust, just the opposite of the compressive force generated by the plate collision.

Scattered through the region, mainly in its western half, are volcanoes of all sizes, from hill-sized cinder cones to giant shield-type volcanoes 50 km (30 miles) across. Although Yellowstone National Park is the best-known volcanic feature of the region, Y2Y also takes in the northeastern corner of the far larger Columbia Plateau, a Miocene lava outpouring that covered parts of Idaho, Washington and Oregon with basalt 13–16 million years ago.

Plate collision

All this geological activity can be traced to the mid-Jurassic (175 million years ago), when North America changed its direction of drift from northeastward to northwestward. Meanwhile the Pacific ocean floor continued to move northeastward. The result was a plate crunch along the west coast. The rock of the ocean floor was denser than the rock of the continents, so the ocean floor slipped under the western edge of the continent as the two converged and overlapped.

There were large islands riding on the ocean floor. They were made mostly of light volcanic rock, and rather than being dragged down under the edge of the oncoming continent, the islands struck the North American plate edge to edge. Like a layer of soil being scraped off and piling up ahead of a bulldozer blade, the islands were ripped loose from the ocean floor and added onto the continent.

In northern British Columbia and the southern Yukon, the western half of Y2Y is made up mostly of these added-on volcanic landmasses. The rest of Y2Y is rock that was part of the North American Plate before the landmasses arrived. In the eastern half of Y2Y you find layered rock that had accumulated on North America's western continental shelf for 1.5 billion years—thick layers of limestone, dolomite, shale, quartzite (hardened sandstone), gritstone (coarse, impure sandstone) and slate—while in the western half of Y2Y you find the same layers battered and metamorphosed by the plate collision. In many spots the ancient gneiss and granite of the North American Plate—the "basement," as geologists refer to it—is exposed. Along Y2Y's western edge, and covering half of Y2Y in northern British Columbia, you can see the younger and more varied rock types of the oceanic islands, including lava ejected from volcanoes, metamorphosed oceanic crust and sediments eroded from the islands into the surrounding sea. All these east/west zones are shown in the geological cross-sections of Figure 3.

Y2Y broken into strips

Besides the crumpling of layers, Y2Y has undergone a lot of tearing. Transcurrent faults (the San Andreas is a transcurrent fault) have broken the western part of the region—especially the Canadian portion—into strips of land hundreds of kilometres wide and thousands of kilometres long. These strips are aligned northwest/southeast. They began moving about 100 million years ago in the mid-Cretaceous, and they continue to move today, having carried land that once lay at the latitude of California all the way to Alaska. A person traveling from east to west across British Columbia crosses these strips. Each strip has traveled farther than the one east of it.

Recent research (Johnston et al. 1996) has shown that a region of lava flows and other kinds of volcanic rock originally formed in the Yellowstone area has been moved 1900 km northwestward to the Yukon. This area, which saw an early eruption of Yellowstone's volcanoes 70 million years ago, now lies between Whitehorse and Dawson. Thus, transcurrent faulting has produced a bizarre geological link between the northern and southern ends of Y2Y.

Erosion

Anything sticking up from the sea experiences erosion, and as Y2Y began to rise above sea level it felt the first drop of rain and the first battering of waves along the new shore-

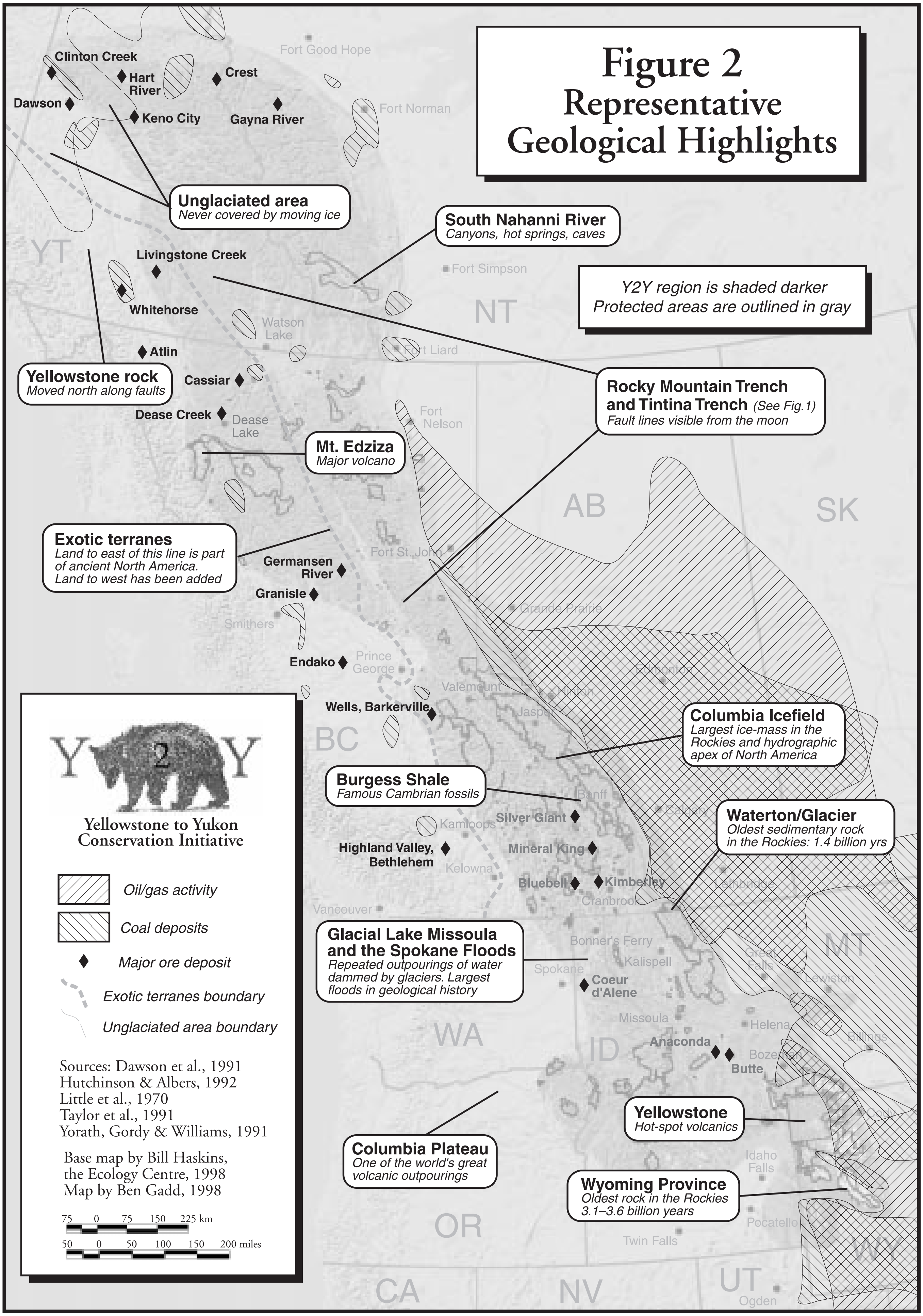


Figure 2
Representative Geological Highlights

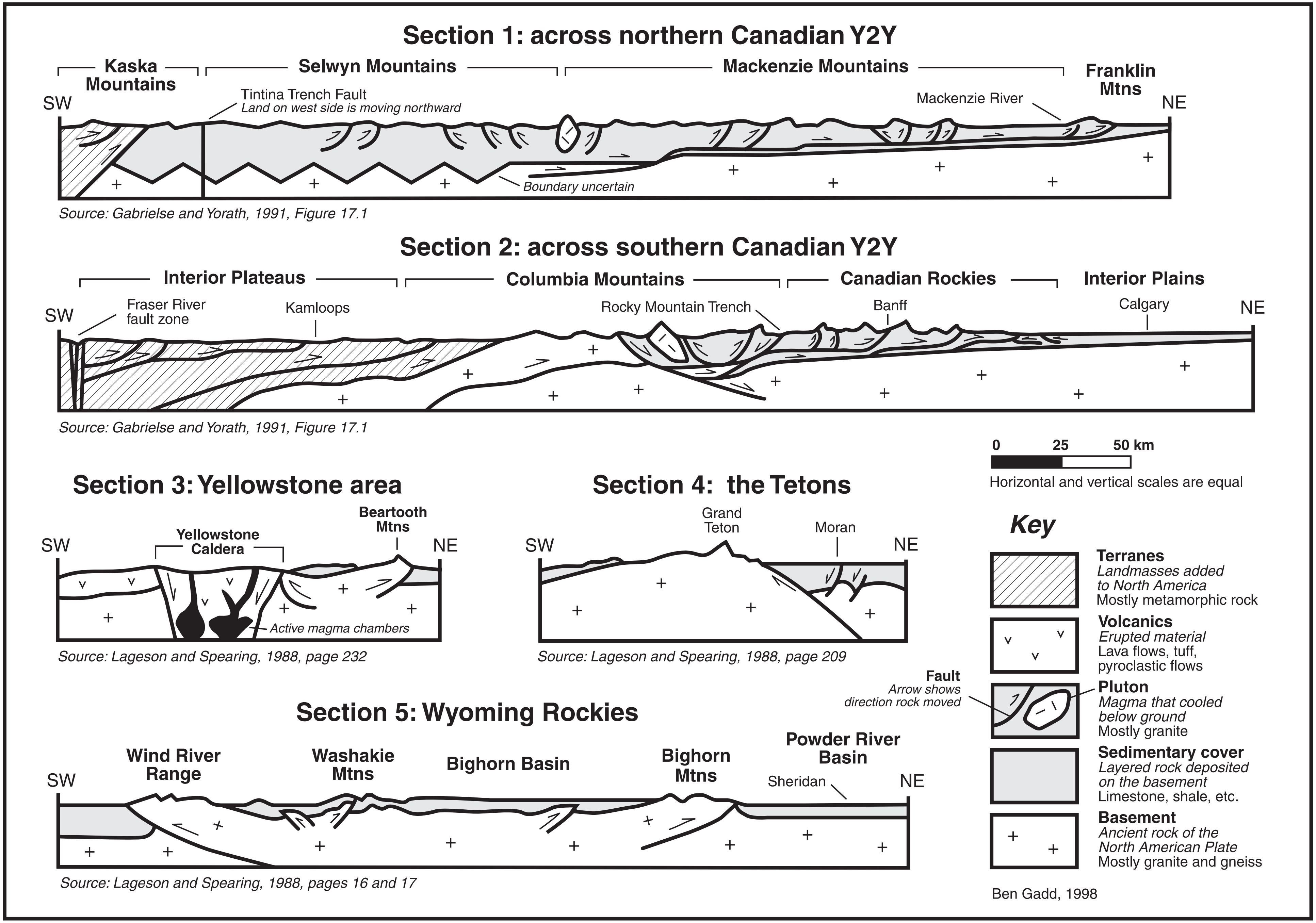


Figure 3: Simplified cross-sections showing the geological variety of the Y2Y area. Locations of the cross-sections are shown on the physiographic map, Figure 1.

line. That was 175 million years ago. Since then, a thickness of 10–20 km (6–12 miles) of rock has been stripped away. Y2Y has been dissolved and carried off by water, split up and ground down by glaciers, and, to a minor extent, removed as dust by the wind.

This is not to say that the mountains of Y2Y were once 20 km tall. The maximum height was probably on par with the modern Andes or Himalayas, that is, 6000–9000 m (20,000–30,000 feet) above sea level. To understand this apparent contradiction, one need only realize that for every metre of elevation gain in the rising mountains, a metre or more of rock was lost to erosion during mountain-building.

Ice ages

Glacial erosion works fast. During the ice ages of the Pleistocene (the past two million years), moving ice has changed the landscape of the Y2Y area considerably. At least five major glacial advances have occurred in the last 500,000 years, each one filling the valleys with ice from central Montana north and spawning glaciers at higher elevations in the south end of the area. Valleys have been widened and straightened; ridges and peaks have been steepened; countless tons of till have been dumped at the limits of glaciation. Ice-dammed lakes have emptied their contents catastrophically, generating enormous floods.

As one might expect, Y2Y's Canadian section has been more extensively glaciated than its American section. Ice buildups have been especially thick in the ranges west of the Canadian Rockies, where most of British Columbia was ice-capped repeatedly. Only the higher peaks stuck up through these enormous ice sheets.

Very rugged glacial topography, complete with modern glaciers as large as 225 km^2 (115 square miles), is found from Waterton/Glacier International Peace Park northward to the Peace River. North of the Peace, however, glaciation has been less extensive. In fact, the far northwestern corner of Y2Y has not been glaciated at all. Right through the ice ages and up to the present, winter snowfalls in the northern Yukon have been so light that all the snow has melted in the short arctic summers, leaving none to accumulate and form glaciers. Paradoxically, the south end of Y2Y (Wyoming's Wind River Range) currently has more glacial ice than the north end does.

Mining, oil and gas

Geologists have found a lot of coal, oil, natural gas, metals, and other valuable minerals in the Y2Y region. Figure 2 shows the locations of coal deposits, oil/gas-producing areas, and major ore deposits, whether the ore is being mined currently or not.

Mining, well-drilling and the like are heavy industrial activities. They typically inflict severe damage on natural ecosystems. Thus, Figure 2 can be interpreted as a map of the areas within Y2Y where conflicts between mineral extraction and ecosystem integrity have occurred in the past and are likely to continue in the future.

Modern Landscape

The main elements of the modern Y2Y landscape are shown on the physiographic map (Figure 1). Some outstanding features of the Y2Y landscape, many of them visible from space, include

- North America's sharpest physiographic boundary (that between the Western Cordillera and the Interior Plains)
- The longest, most topographically obvious fault system on the continent (Rocky Mountain Trench and Tintina Trench)
- One of the larger volcanic outpourings in the world (the Columbia Plateau basalt)
- The largest glacier in the Rocky Mountains (Columbia Icefield)
- The source of the greatest flood known to have occurred on the planet (Glacial Lake Missoula)
- The headwaters of ten major rivers (Snake, Missouri, Saskatchewan, Columbia, Fraser, Athabasca, Peace, Skeena, Stikine, Liard)
- North America's hydrographic apex (Snow Dome, a peak on the Columbia Icefield)
- The continent's longest eagle migration corridor (may extend from the northern Yukon to Mexico)
- The oldest rock found in the United States (Wyoming Province gneiss and schist, over three billion years old)
- The most complete sedimentary record in North America (mid-Proterozoic to recent), with the largest area of unaltered Precambrian sedimentary rock
- The best remaining mountain wildlife habitat on the continent

This last is of special importance to the Y2Y Initiative, with its emphasis on habitat protection.

Landscape factors in ecological integrity and habitat connectivity

The physiography of Y2Y provides habitat features that make the region exceptionally valuable to wildlife: large, ecologically intact expanses of land where natural vegetation predominates, and where ecological processes continue to operate much as they always have. Human activities in Y2Y have compromised this ecological integrity, but much of it could be regained with proper management, so it is worth examining here.

From Missoula north, the mountain ridges are long and the gaps between them are narrow. The climate is cool to cold, with abundant soil moisture. Thus, forest cover below the treeline is nearly continuous.[1] Even low-elevation areas, such as the Nechako Lowland around Prince George and the Liard Lowland around Watson Lake, are hilly and forested. This adds up to a very large amount of connected woodland habitat for those boreal species that also require the varied slope aspects and elevational variety of the mountain environment.

The farther north you go, the cooler the soil temperature becomes and the more alpine tundra lies upslope from the forest. This provides abundant habitat for alpine species.

Such large-scale ecological integrity is good for the maintenance of species, because a single species can be found over a large area. If resident individuals die out in one part of the region, individuals from neighboring areas can move in and repopulate the area. Further, in large unfragmented habitats that can support large wildlife populations, the gene pool for each species is likely to be large, allowing the populations to maintain genetic fitness and adaptability over the long term. Large populations are also more resilient than small ones in the face of disease, environmental disturbances, and other events. This is the opposite of the situation in geographically isolated ecological communities such as those found on islands, where local extinction often means species extinction.

Natural habitat fragmentation and movement barriers

The naturally unvegetated rock surfaces and areas of glacial ice so common in the Y2Y landscape (approximately 50% of Banff National Park, for example, is rock and ice) are marginal wildlife habitat. In such marginal and topographically extreme landscapes, larger home ranges than usual are necessary for some species, such as wolves and bears, to meet their basic needs (Noss et al. 1996; Herrero[2] pers. comm. 1998).

In southwestern Montana, the mountain ranges are smaller in area and the peaks are more clustered than elsewhere in Y2Y. These ranges stand apart from each other, surrounded on all sides by low-elevation zones where the soil temperature is high enough and the soil moisture is low enough to diminish the forest cover. The physiography is more island-like here, and in such terrain, wildlife habitat and movement links between the ranges are especially important for the survival of mountain species.

In addition to the grassy lowlands prevalent in Y2Y's southern area, and the large amount of bare bedrock found throughout Y2Y, there are other barriers to wildlife movement. Notable ones include

- Long, precipitous ridges and steep headwalls generated by glaciation of tough, cliff-forming rock units
- Glaciers and glacial forefields (areas exposed by recent glacial retreat), including a string of icefields (large upland glaciers) along the Alberta/B.C. border
- Rivers 50 m across or wider, of which there are many
- The wide, long lakes and reservoirs of the Columbia Mountains and Kaska Mountains[3]

These barriers are most common in the central segment of Y2Y, where glacial sculpting of the landscape has been the most extreme. Fortunately for wildlife, this same process has eroded deep, gentle passes through the mountains, which serve as cross-divide movement corridors and important conduits for wildlife.

It should also be kept in mind that while a long, wide lake or reservoir may block the movement of wildlife unable to swim across in summer or reluctant to cross the ice in winter, the same lake forms a movement corridor for water-dwelling species such as beavers, otters, muskrats, mink and fishes. The same is true of Y2Y's larger rivers.

Next pages. Photographs of representative landscapes of the Yellowstone to Yukon ecoregion.

[1] But becoming increasingly fragmented by clear-cut logging.

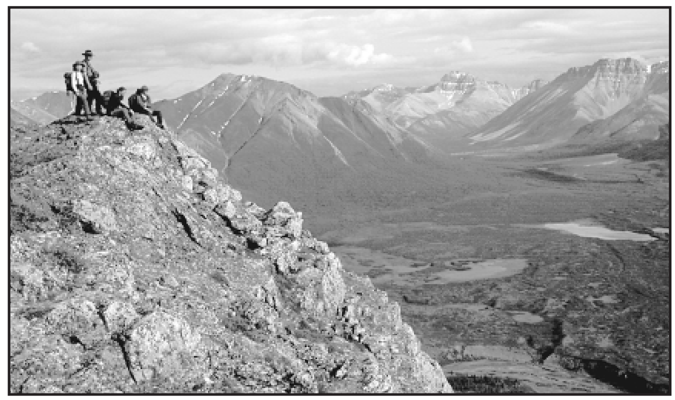
[2] Stephen Herrero, University of Calgary, Calgary, Alberta.

[3] Two of the more severe barriers in Y2Y are the large reservoirs located in the Rocky Mountain Trench: Williston Lake, 220 km (137 miles) long—the largest man-made lake in the world—and McNaughton Lake, 160 km (100 miles) long. Williston Lake not only isolates the Rockies from ranges to the west, an eastern branch cuts across the Rockies and divides the range.

Part of the 300-km2/116-square-mile Columbia Icefield of the Canadian Rockies, as seen from the summit of the Snow Dome (3460 m/11,350 ft.), hydrographic apex of North America. From this point the ice moves toward three oceans: Atlantic, Pacific and Arctic. Mt. Columbia (3747 m/12,293 ft., highest peak in Alberta), seen in the distance, marks the western edge of the icefield. Photo courtesy Jasper National Park.

Aerial view of the Rocky Mountain Trench, looking northwest from near Valemount, British Columbia. Columbia Mountains on the left, Canadian Rockies on the right. The trench marks a major fault, active over the last 55 million years, that runs from near the B.C./Montana boundary northwestward through British Columbia, connecting with the Yukon's Tintina Trench, which continues all the way to Alaska. Photo by Ben Gadd.

Mt. Edziza (2787 m/9143 ft.), at lower right in this aerial view, is the central volcano in a huge, long-lived, extremely violent eruption that has covered roughly 1000 km2/386 square miles of northwestern B.C. with lava and other kinds of volcanic rock over the last ten million years. Such eruptions have been typical of the western Y2Y area. Photo by George Wuerthner.



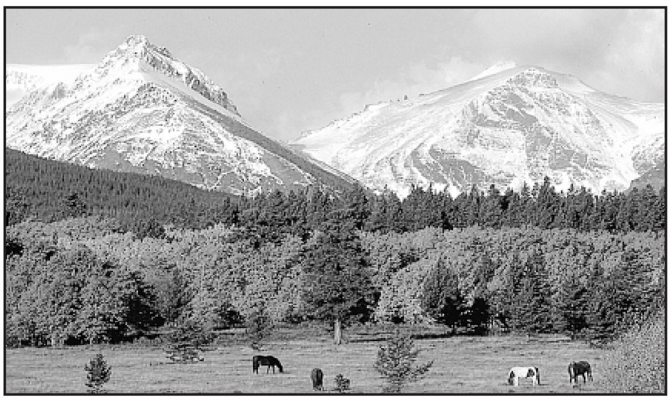
The sedimentary mountain ranges of the eastern Yukon have been glacially eroded to form a rugged landscape. The view here is of the Snake River Valley, near Y2Y's northern end, with Mt. Cameron (2037 m/6683 ft.) in the background. The hikers are perched at the western edge of the Mackenzie Mountains, looking across the valley toward the Wernecke Mountains, part of the Selwyn Mountains region. Photo by Baiba and Pat Morrow.

Grand Canyon of the Yellowstone River, with Yellowstone Falls visible at its head. The river has cut rapidly through geologically young lava flows of rhyolite that erupted 60,000—600,000 years ago. The rock has been softened and brightly colored by chemical alteration from the hot subterranean waters this park is famous for. The falls are 94 m high. Photo by Daniel J. Cox.

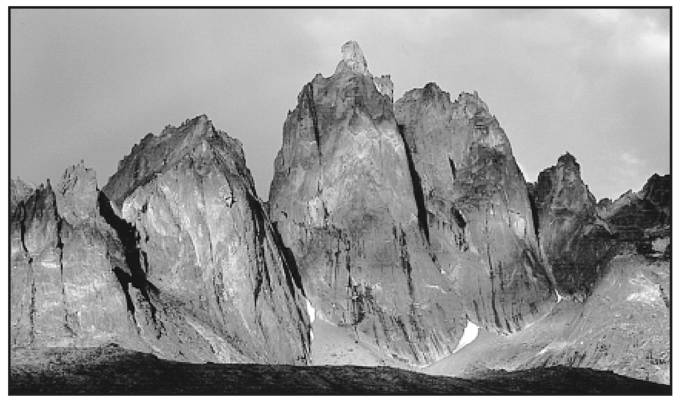
This gnarled, fire-scarred limber pine has weathered for perhaps 200 years the strong westerly winds that sweep the southern Alberta foothills, the easternmost—and geologically youngest—part of the Canadian Rockies. The photo was taken along Whaleback Ridge, north of Highway 3 in the Crowsnest Pass area. Photo by Harvey Locke.

Mt. Robson, as seen from Highway 16 in eastern British Columbia. At 3954 m/12,972 ft., this is the highest peak in the Canadian section of Y2Y (third-highest overall). Mt. Robson also has the greatest elevation gain of any Y2Y peak: 2969 m/9740 ft. The mountain is made of Cambrian sedimentary rock, raised above sea level in the great Columbian mountain-building episode that began to affect this area about 140 million years ago. Photo by Ben Gadd.

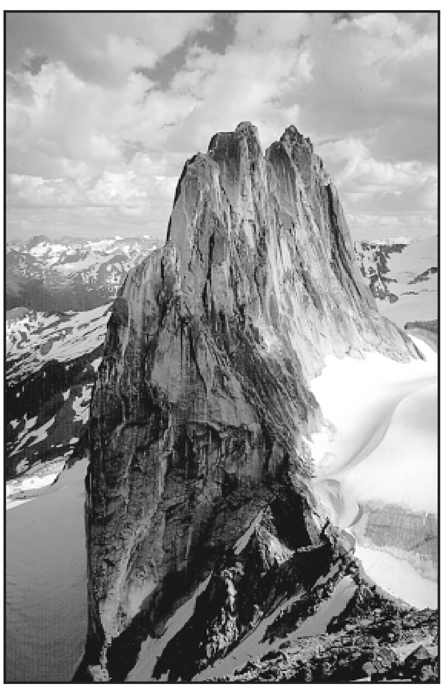
The Tetons, a block of uptilted basement rock, as seen from the east. The block has moved upward approximately 9 km/5.7 miles over a period of about nine million years, and the range is still growing. But the rate of erosion has been about 75 percent of the rate of uplift, leaving a base-to-summit topographic relief of 2.5 km/1.5 miles. The Grand Teton (4197 m/13,771 ft.), is the second-highest summit in Y2Y (Gannet Peak, not far to the south, is 10 m/33 ft. higher). Photo by Daniel J. Cox.



The mountains of Glacier National Park, Montana, hold the oldest sedimentary rock in the Y2Y area: the reddish/greenish argillite (lightly metamorphosed shale) and grey limestone of the Purcell/Belt Supergroup, sedimentary layers laid down 1.2—1.5 billion years ago. This photo was taken near East Glacier, not far from the park's eastern boundary. Photo by George Wuerthner.

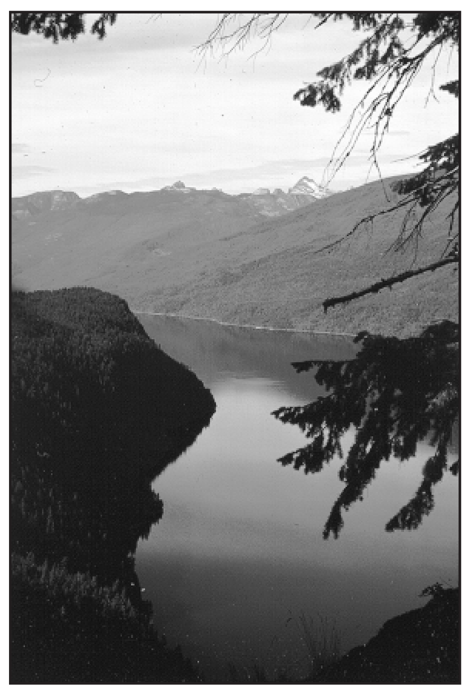


Mt. Monolith of Yukon's spectacular Tombstone Range, found in the Ogilvie Mountains about 50 km/30 miles northeast of Dawson along the Dempster Highway, is one of many Cretaceous granite intrusions that have punched their way up through the predominantly sedimentary rock of the northern Y2Y area. Photo by Baiba and Pat Morrow.



Snowpatch Spire (3063 m/ 10,050 ft.), part of the Bugaboo Group of the Purcell Mountains south of Golden, B.C., is a classic example of the heavily glaciated Mesozoic granite intrusions in the Columbia Mountains region. Photo by Pat Morrow.

Slocan Lake, BC. Y2Y valleys that drain toward the Pacific have been cut very deeply by the powerful rivers on this side of the divide, then deepened further, widened and straightened by glaciers. The result: many large, deep lakes, such as this one, Slocan Lake, found between the Selkirk and Purcell Mountains in southern British Columbia. Photo by Harvey Locke.



Literature Cited

Dawson, K. M., A. Panteleyev, A. Sutherland Brown, and G. J. Woodsworth. 1991. Regional metallogeny. Chapter 19 in Geology of the Cordilleran Orogen in Canada. Geological Society of America, Boulder, Colo., and the Geological Survey of Canada, Ottawa, Ont.

Gabrielse, H., and C. Yorath, eds. 1992. Geology of the Cordilleran Orogen in Canada. Geological Society of America, Boulder, Colorado, and the Geological Survey of Canada, Ottawa, Ont.

Hunt, C. B. 1974. Natural regions of the United States and Canada. W.H. Freeman, San Francisco.

Hutchinson, R., and J. Albers. 1992. Metallogenic evolution of the Cordilleran region of the western United States. Chapter 15 in The Cordilleran Orogen: conterminous United States. Geological Society of America, Boulder, Colo.

Johnston, S. T., P. J. Wynne, D. Francis, C. J. Hart, R. J. Enkin, and D. C. Engebretson. 1996. Yellowstone in the Yukon. Geology 24(11):997–1000

Lageson, D., and D. Spearing. 1988. Roadside geology of Wyoming. Mountain Press, Missoula, Mont.

Little, H. W., H. R. Belyea, D. F. Stott, B. A. Latour, and R. J. Douglas. 1991. Economic minerals of Western Canada. Chapter 9 and Map 1252A in Geology and economic minerals of Canada. Geological Survey of Canada, Ottawa, Ont.

Madole, R. F. et al. 1987. Regional geomorphology of North America. Chapter 1 in Geomorphic systems of North America, Geological Society of America, Boulder, Colo.

Mathews, W. H. 1986. Physiography of the Canadian Cordillera, Map 1701A. Geological Survey of Canada, Ottawa, Ont.

Noss, R. F., H. B. Quigley, M. G. Hornocker, T. Merrill, and P. C. Paquet. 1996. Conservation biology and carnivore conservation in the Rocky Mountains. Cons. Biol. 10(4):949–963.

Taylor, R. B., D. D. Rice, and H. J. Gluskoter. 1991. Oil and gas fields, Plate 5, and Coal map, Plate 9, in Economic geology, U.S. Geological Society of America, Boulder, Colo.

Yorath, C. J., P. L. Gordy, and G. K. Williams. 1991. Energy and ground water resources of the Canadian Cordillera. Chapter 20 in Geology of the Cordilleran Orogen in Canada. Geological Society of America, Boulder, Colo., and the Geological Survey of Canada, Ottawa, Ont.

Recommended technical references on Y2Y geology

Bally, A., and A. Palmer, eds. 1989. The geology of North America: an overview. Geological Society of America, Boulder, Colo.

Burchfiel, B., P. W. Lipman, and M. L. Zoback, eds. 1992. The Cordilleran Orogen: conterminous U. S. Geological Society of America, Boulder, Colo.

Gabrielse, H., and C. Yorath, eds. 1992. Geology of the Cordilleran Orogen in Canada. Geological Society of America, Boulder, Colorado, and the Geological Survey of Canada, Ottawa, Ont.

Graf, W., ed. 1987. Geomorphic systems of North America. Geological Society of America, Boulder, Colo.

Recommended non-technical references

Alt, D., and D. Hyndman. 1984. Roadside geology of Washington. Mountain Press, Missoula, Mont.

Alt, D., and D. Hyndman. 1986. Roadside geology of Montana. Mountain Press, Missoula, Mont.

Alt, D., and D. Hyndman. 1989. Roadside geology of Idaho. Mountain Press, Missoula, Mont.

Gadd, B. 1995. Handbook of the Canadian Rockies. Corax Press, Jasper, Alberta.

Lageson, D., and D. Spearing. 1988. Roadside geology of Wyoming. Mountain Press, Missoula, Mont.

Yorath, C. 1997. How old is that mountain? A visitor's guide to the geology of Banff and Yoho national parks. Orca Book Publishers, Victoria, B.C.

Yorath, C., and B. Gadd. 1995. Of rocks, mountains and Jasper: a visitor's guide to the geology of Jasper National Park. Dundurn Press, Toronto, Ontario, and the Geological Survey of Canada, Ottawa, Ont.

The Vegetation of Yellowstone to Yukon: A Preliminary Outline

Peter L. Achuff

This report develops a preliminary outline of 19 broad vegetation units in the Yellowstone to Yukon area based on existing vegetation and ecosystem classifications of Biogeoclimatic Zones in British Columbia, of Natural Sub-Regions and Ecoregions in Alberta, and of Habitat Types in Montana, Idaho and Wyoming. The 19 units are described in terms of their composition, geographical location and relationships to other units. Regional landscape cross-section diagrams further show their relationships and occurrence in parts of the Y2Y area. Six steps to develop further information on the vegetation of the Y2Y area are suggested: (1) more detailed analysis of the vegetation units, (2) more detailed descriptions of the vegetation units, (3) mapping of the units and entry in a GIS, (4) determining the conservation status of the units, (5) determining the conservation status of the component vegetation community types, (6) determining the conservation status of plant species of special concern. The latter two items should be done in conjunction with the provincial and state Conservation Data Centres and Natural Heritage Programs.

Introduction

This report is a first step in an account of the vegetation of the Yellowstone to Yukon area. A variety of concepts has been used to describe, classify and map the vegetation of the area, and no single approach covers the entire area. Some have described vegetation per se as community types or vegetation types (e.g. Achuff and Corns 1982; Achuff and Dudynsky 1984a, b; Achuff et al. 1993, 1997; Bourgeron and Engelking 1994; Cooper and Lesica 1992; Lea 1980, 1983, 1984; Mueggler 1988; Youngblood and Mueggler 1981) or in a hierarchical system with community types grouped into broader units (e.g. Brown et al. 1980). Others have described habitat types, which are based on potential climax vegetation (e.g. Cooper et al. 1991; Daubenmire and Daubenmire 1968; Mueggler and Stewart 1980; Pfister et al. 1977; Steele et al. 1981, 1983). Yet others have used more holistic units, combining climate, geology, and soils with vegetation, variously termed ecoregions, biogeoclimatic zones, or natural regions (e.g. Achuff 1992; Bailey 1978; Ecoregions Working Group 1989; Meidinger and Pojar 1991). Within this holistic approach, some have attempted to use all ecosystem elements (e.g. Achuff 1992), while others have emphasized the role of climate (e.g. Strong and Leggat 1981; Ecoregions Working Group 1989) or of vegetation (e.g. Meidinger and Pojar 1991).

These various approaches reflect differences in purpose, scope of the subject considered, and geographical scale. These differences in approach are legitimate and there is no right system for all purposes. However, in merging these various accounts into one, as I have attempted to do here, the concepts and units recognized inevitably clash and do not form a seamless web.

To gain the greatest geographical coverage and the best merging of concepts, the following were used mostly to develop this preliminary outline: for British Columbia (B.C.), Biogeoclimatic Zones (Meidinger and Pojar 1991); for Alberta, Natural Subregions (Achuff 1992); and for Montana, Idaho, and western Wyoming, the U.S. Forest Service Habitat Types (Cooper et al. 1991; Mueggler and Stewart 1980; Pfister et al. 1977; Steele et al. 1981, 1983).

Particular difficulties have occurred at political boundaries (B.C.–Alberta, U.S.–Canada), which define the geographical limits for most studies. Where vegetation units continue across these boundaries, they are often described with different conceptual limits and names. Conceptual limits, especially, vary with the information universe one works with. For example, the Montane–East Slope in Alberta probably includes units similar to those recognized as the Montane–Limber Pine in Montana or Montane–Interior Douglas Fir in B.C.

Also problematical are biologically transitional areas, such as the eastern Foothills of the Rocky Mountains, which are transitional between the Cordilleran Mountains and Boreal Forest, or the Aspen Parkland, transitional between the Great Plains grasslands and the Boreal Forest. In the former case, the Foothills are considered part of the Boreal Forest, while in the latter, an Aspen Parkland with three units was recognized. The consistency of this can be debated.

Thus, with apologies to all whose work has been misunderstood, twisted or bastardized, I have made decisions both about the units recognized (their level and characteristics) and about the names for them as described below. Comments and suggestions are most welcome.

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Vegetation units

Nineteen vegetation units are recognized in the following account (Table 1). These units are approximately the same level recognized by some other studies as biogeoclimatic zones (Meidinger and Pojar 1991), ecoregions (Achuff et al. 1993, 1997; Strong and Leggat 1981), forest sections (Rowe 1972), natural sub-regions (Achuff 1992), and habitat type series (Cooper et al. 1991; Daubenmire and Daubenmire 1968; Steele et al. 1981, 1983), although no formal name for these vegetation units is proposed at this time. The 19 units are grouped into six broader categories (Table 1): three (Alpine, Subalpine, Montane) occur in the mountains, and three (Great Plains, Aspen Parkland, Boreal Forest) are in the interior lowland plains, foothills and plateaus.

Table 1. Preliminary Vegetation Units of the Yellowstone to Yukon Area

ALPINE (AT)
- Alpine Tundra (AT)

SUBALPINE (SA)
- Engelmann Spruce–Subalpine Fir (SA–ESSF)
- Interior Cedar–Hemlock (SA–ICH)
- Spruce-Willow-Birch (SA–SWB)

MONTANE (MO)
- East Slope (MO–ES)
- Limber Pine (MO–LP)
- Ponderosa Pine (MO–PP)
- Interior Douglas Fir (MO–IDF)
- Sub-Boreal Spruce (MO–SBS)
- Sub-Boreal Pine–Spruce (MO–SBPS)
- Bunchgrass (MO–BG)

GREAT PLAINS (GP)
- Mixedgrass (GP–MG)
- Northern Fescue (GP–NF)
- Foothills Fescue (GP–FF)

ASPEN PARKLAND (AP)
- Foothills Parkland (AP–FP)
- Central Aspen Parkland (AP–CAP)
- Peace River Parkland (AP–PRP)

BOREAL FOREST (BF)
- Mixedwood (BF–M)
- Boreal White & Black Spruce (BF–BWBS)

Alpine (AT)

Alpine Tundra (AT). Alpine Tundra (AT), the highest unit elevationally, occurs above upper elevational timberline and is characterized by an absence of trees. Timberline itself, which is a transition between Subalpine forests with trees and treeless Alpine Tundra, often contains krummholz (dwarfed, twisted plants of tree species) as islands in favorable sites. Some workers include krummholz in Alpine Tundra, others in Subalpine.

AT occurs throughout the Y2Y area wherever the mountains extend above timberline. Timberline elevation decreases from south to north, being typically about 3050 m in the Yellowstone–Beartooth Plateau region (Despain 1990), about 2250–2300 m in the Banff-Jasper area (Achuff and Corns 1982), about 1400 m in northeastern British Columbia, and about 1000 m in northwestern B.C. and adjacent Yukon Territory (Meidinger and Pojar 1991). AT occurs above the Subalpine units Engelmann Spruce–Subalpine Fir (SA–ESSF) and Spruce-Willow-Birch (SA–SWB).

AT vegetation varies from north to south and along a moisture gradient from east to west. Systematic studies of AT vegetation, however, are lacking from much of the Y2Y area, and division into regional types cannot be done at present. Most regional vegetation studies have been sponsored by agencies interested in the forest and grassland vegetation below timberline.

Typical AT vegetation includes dwarf shrub communities dominated by Dryas octopetala, Phyllodoce spp., Cassiope spp., or dwarf willows (Salix arctica, S. nivalis), as well as graminoid meadows of sedges and grasses, and forb meadows with showy flower species. At the highest elevations, sparse cover of cushion plants and lichens is typical.

Subalpine (SA)

Engelmann Spruce–Subalpine Fir (SA–ESSF). Subalpine forests dominated by Engelmann spruce (Picea engelmannii) and subalpine fir (Abies lasiocarpa) occur through much of the Y2Y area in central and southern British Columbia, Alberta, Montana, western Wyoming and Idaho. Other characteristic tree species include whitebark pine (Pinus albicaulis), subalpine larch (Larix lyallii), mountain hemlock (Tsuga mertensiana) and, in the wake of fires, lodgepole pine (Pinus contorta). SA–ESSF occurs below the AT and above the Subalpine–Interior Cedar–Hemlock (SA–ICH), Montane–Interior Douglas Fir (MO–IDF), Montane–East Slope (MO–ES), Montane–Sub-Boreal Spruce (MO–SBS), Montane–Sub-Boreal Pine–Spruce (MO–SBPS), and Boreal Forest–Boreal White & Black Spruce (BF–BWBS) units.

Included in SA–ESSF are the Engelmann Spruce–Subalpine Fir (ESSF) and Montane Spruce (MS) Zones in British Columbia (Meidinger and Pojar 1992); the Abies lasiocarpa, Picea engelmannii, Pinus albicaulis, Pinus contorta and Tsuga mertensiana Series in Montana and Idaho (Cooper et al. 1991; Pfister et al. 1977; Steele et al. 1981, 1983); and the Subalpine Subregion and Ecoregion in Alberta and British Columbia (Achuff 1992; Achuff and Corns 1982; Achuff and Dudynsky 1984a; Achuff et al. 1993, 1997; Archibald et al. 1996; Beckingham et al. 1996).

Interior Cedar–Hemlock (SA–ICH). Forests of the Interior Cedar–Hemlock (SA–ICH) unit occur in western Montana, Idaho and southeastern British Columbia. Western red cedar (Thuja plicata) and western hemlock (Tsuga heterophylla) are characteristic. Other typical trees include grand fir (Abies grandis), western larch (Larix occidentalis) and western white pine (Pinus monticola). SA–ICH occurs below the Subalpine–Engelmann Spruce–Subalpine Fir (SA–ESSF) unit and, in limited areas, above the Montane–Interior Douglas Fir (MO–IDF).

Included in SA–ICH are the Interior Cedar-Hemlock (ICH) Zone in British Columbia (Meidinger and Pojar 1991), the ICH Ecoregion in central B.C. (Achuff and Dudynsky 1984b), and the Thuja plicata, Tsuga heterophylla, and Abies grandis Series in Montana and Idaho (Cooper et al. 1991; Pfister et al. 1977; Steele et al. 1981, 1983).

Spruce-Willow-Birch (SA–SWB). The Spruce-Willow-Birch (SA–SWB) unit occurs in northern B.C. and well into adjacent Yukon Territory and Northwest Territories, and is the most northerly Subalpine unit. Characteristic are white spruce (Picea glauca) and subalpine fir, along with dwarf birch (Betula glandulosa) and several willow species, including Salix glauca, S. barclayi, S. barrattiana and S. alaxensis. SA–SWB occurs above the Boreal White & Black Spruce (BF–BWBS) unit and occupies a position comparable to that of the SA–ESSF in central and southern B.C.

SA–SWB is the same as the Spruce-Willow-Birch Biogeoclimatic Zone (Meidinger and Pojar 1991).

Montane (MO)

East Slope (MO–ES). The Montane East Slopes (MO–ES) unit characteristically includes limber pine (Pinus flexilis), Douglas fir (Pseudotsuga menziesii), white spruce, and aspen (Populus tremuloides) forests in intermontane valleys and foothills of southern Alberta and perhaps north-central Montana. Lodgepole pine forests and grasslands occur in some areas. MO–ES occurs below the Subalpine–Engelmann Spruce–Subalpine Fir (SA–ESSF) and Boreal White & Black Spruce (BF–BWBS) units and above the Foothills Parkland (AP–FP), Central Aspen Parkland (AP–CAP), Foothills Fescue (GP–FF) and Northern Fescue (GP–NF) units.

MO–ES has a close relationship to the Montane–Interior Douglas Fir (MO–IDF) unit in British Columbia and the Montane–Limber Pine (MO–LP) unit in adjacent Montana. Further consideration may change the delineation of this unit. Included in MO–ES are the Montane Ecoregion and Natural Subregion in southwestern Alberta (Achuff 1992; Achuff and Corns 1982; Achuff et al. 1997; Archibald et al. 1996; Beckingham et al. 1996).

Limber Pine (MO–LP). The Montane–Limber Pine (MO–LP) unit is dominated by limber pine (Pinus flexilis) mostly along the Continental Divide and eastern slopes and foothills of the mountains in central Montana, central and eastern Idaho, and northwestern Wyoming. These are among the driest sites occupied by trees in the Y2Y area . MO–LP occurs below the Montane–Ponderosa Pine (MO–PP) and Montane–Interior Douglas Fir (MO–IDF) units and above the Montane-Bunchgrass (MO–BG) and Great Plains–Mixedgrass (GP–MG) units.

MO–LP includes the Pinus flexilis Series in Montana, Idaho and Wyoming (Pfister et al. 1977; Steele et al. 1981, 1983).

Ponderosa Pine (MO–PP). Ponderosa pine (Pinus ponderosa) is the characteristic dominant of forests in the Montane–Ponderosa Pine (MO–PP) unit. The forests are often open and grassy, although stands with shrubby understories occur in northern Idaho. MO–PP occurs in southeastern British Columbia, Idaho, and Montana. It occurs below the Montane–Interior Douglas Fir (MO–IDF) unit and above the Montane–Limber Pine (MO–LP), Montane–Bunchgrass (MO–BG) and Great Plains–Mixedgrass (GP–MG) units.

MO–PP includes the Pinus ponderosa Series in Montana and northern and central Idaho (Cooper et al. 1991; Pfister et al. 1977; Steele et al. 1981) and the Ponderosa Pine (PP) Biogeoclimatic Zone in southeastern British Columbia (Meidinger and Pojar 1991).

Interior Douglas Fir (MO–IDF). Forests dominated by Douglas fir (Pseudotsuga menziesii) are characteristic of the Montane–Interior Douglas Fir (MO–IDF) unit. MO–IDF is widespread in southern B.C., Idaho, Montana, and northwestern Wyoming. As noted above, its affinities to the MO–ES unit need to be clarified. MO–IDF occurs above the Montane–Limber Pine (MO–LP), Montane–Ponderosa Pine (MO–PP), Montane–Bunchgrass (MO–BG) and Great Plains–Mixedgrass (GP–MG) units, below the Subalpine–Engelmann Spruce–Subalpine Fir (SA–ESSF) unit, and adjacent to the Montane–Sub-Boreal Spruce (MO–SBS) and Montane–Sub-Boreal Pine–Spruce (MO–SBPS) units.

MO–IDF includes the Interior Douglas Fir (IDF) Biogeoclimatic Zone in southern B.C. (Meidinger and Pojar 1991) and the Pseudotsuga menziesii Series in Idaho, Montana and Wyoming (Cooper et al. 1991; Pfister et al. 1977; Steele et al. 1981, 1983).

Sub-Boreal Spruce (MO–SBS). The Montane–Sub-Boreal Spruce (MO–SBS) unit contains forests of hybrid white spruce (Picea engelmannii x P. glauca) and subalpine fir. Other common trees include lodgepole pine, aspen, paper birch (Betula papyrifera) and, in some areas, Douglas fir. MO–SBS occurs in central British Columbia on plateaus and lower mountain slopes below the Subalpine–Engelmann Spruce–Subalpine Fir (SA–ESSF) unit, and adjacent to the Subalpine–Interior Cedar–Hemlock (SA–ICH), Montane–Sub-Boreal Pine–Spruce (MO–SBPS), and Montane–Interior Douglas Fir (MO–IDF) units.

MO–SBS is the same as the Sub-Boreal Spruce Biogeoclimatic Zone (Meidinger and Pojar 1991).

Sub-Boreal Pine-Spruce (MO–SBPS). Forests of the Montane–Sub-Boreal Pine-Spruce (MO–SBPS) unit are characteristically dominated by lodgepole pine, occasionally by white spruce and aspen. MO–SBPS occurs on plateaus in the Chilcotin region of the west-central interior of British Columbia. It occurs above the Montane–Interior Douglas Fir (MO–IDF) unit, below the Subalpine–Engelmann Spruce–Subalpine Fir (SA–ESSF) unit, and adjacent to the Montane–Sub-Boreal Spruce (MO–SBS) unit.

MO–SBPS is the same as the Sub-Boreal Pine-Spruce Biogeoclimatic Zone (Meidinger and Pojar 1991).

Bunchgrass (MO–BG). Characteristic species of the Montane–Bunchgrass (MO–BG) unit are bluebunch wheatgrass (Agropyron spicatum), Sandberg's bluegrass (Poa sandbergii), and Idaho fescue (Festuca idahoensis), often with big sagebrush (Artemisia tridentata). MO–BG occurs in intermontane valleys in central British Columbia, Idaho, Montana and Wyoming, and to a limited degree along the east slope of the Rocky Mountains. It is often in the lowest parts of these valleys but, along the east slope of the Rocky Mountains, may be above the Great Plains–Mixedgrass (GP–MG) unit and adjacent to the Great Plains–Foothills Fescue (GP–FF) unit. It generally occurs below the Montane–Limber Pine (MO–LP), Montane–Ponderosa Pine (MO–PP) or Montane–Interior Douglas Fir (MO–IDF) units.

MO–BG includes the Bunchgrass Biogeoclimatic Zone in British Columbia (Meidinger and Pojar 1991), the Agropyron spicatum, Festuca idahoensis, Purshia tridentata, Artemisia tridentata and Artemisia tripartita habitat type Series in western Montana (Mueggler and Stewart 1980), and the bluebunch wheatgrass, Idaho fescue, big sagebrush and silver sage habitat types in Yellowstone National Park (Despain 1990).

Great Plains (GP)

Mixedgrass (GP–MG). Great Plains–Mixedgrass (GP–MG) typically contains a mixture of mid-height grasses, such as the spear grasses (Stipa comata, S. spartea, S. curtiseta), western wheatgrass (Agropyron smithii), June grass (Koeleria macrantha), and a short grass, blue grama (Bouteloua gracilis). It occurs at low elevations along the southeastern edge of the Y2Y area from southern Alberta to central Wyoming. It is usually below the Montane–Limber Pine (MO–LP), Montane–Interior Douglas Fir (MO–IDF), Montane–Ponderosa Pine (MO–PP), Great Plains–Foothills Fescue (GP–FF) or Great Plains–Northern Fescue (GP–NF) units.

GP–MG includes the Mixedgrass Natural Subregion in Alberta (Achuff 1992) as well as the Stipa comata Series and the Agropyron spicatum-Bouteloua gracilis habitat type in Montana (Mueggler and Stewart 1980).

Northern Fescue (GP–NF). Great Plains–Northern Fescue (GP–NF) characteristically is dominated by rough fescue (Festuca scabrella) with June grass (Koeleria macrantha), western porcupine grass (Stipa curtiseta), slender wheatgrass (Agropyron trachycaulum), and Hooker's oatgrass (Helictotrichon hookeri). It occurs in southern Alberta along the eastern boundary of the Y2Y area, north of the Great Plains–Mixedgrass (GP–MG), east of the Foothills Parkland (AP–FP), and south of the Central Aspen Parkland (AP–CAP).

GP–NF includes the Northern Fescue Natural Subregion in Alberta (Achuff 1992).

Foothills Fescue (GP–FF). Great Plains–Foothills Fescue (GP–FF) is dominated by rough fescue (Festuca scabrella), Idaho fescue, Parry's oatgrass (Danthonia parryi) and intermediate oatgrass (Danthonia californica). Associated grasses include June grass, northern wheatgrass (Agropyron dasystachyum), and Columbia needle grass (Stipa columbiana). GP–FF occurs in southern Alberta and Montana, usually above the Great Plains–Mixedgrass (GP–MG) and below the Foothills Parkland (AP–FP), Montane–Limber Pine (MO–LP), Montane–East Slope (MO–ES) or Montane–Interior Douglas Fir (MO–IDF) units .

GP–FF includes the Foothills Fescue Natural Subregion in Alberta (Achuff 1992) and the Festuca scabrella Series in Montana (Mueggler and Stewart 1980).

Aspen Parkland (AP)

Foothills Parkland (AP–FP). The Foothills Parkland (AP–FP) is characterized by a landscape pattern of rough fescue grassland and aspen grove forest. The grasslands are similar to those of the Foothills Fescue (GP–FF). AP–FP occurs in southern Alberta and south into Montana, east and southeast of Glacier National Park. It is typically above the Foothills Fescue (GP–FF) and below the Montane–Limber Pine (MO–LP), Montane–East Slope (MO–ES) or Montane–Interior Douglas Fir (MO–IDF) units .

AP–FP includes the Foothills Parkland Natural Subregion in Alberta (Achuff 1992) and part of the Populus tremuloides habitat type in Montana (Pfister et al. 1977).

Central Aspen Parkland (AP–CAP). The Central Aspen Parkland (AP–CAP) contains a landscape pattern of rough fescue grassland and aspen forest. The aspen forest varies from isolated groves in the south, to parkland, to nearly closed aspen forest in the north. The grasslands are similar to those of the Northern Fescue (GP–NF). AP–CAP occurs in southern Alberta, north of the Northern Fescue (GP–NF) unit and east of the Montane–East Slope (MO–ES) unit.

AP–CAP is the same as the Central Parkland Natural Subregion in Alberta (Achuff 1992).

Peace River Parkland (AP–PRP). The Peace River Parkland (AP–PRP) has a characteristic landscape pattern of grasslands, dominated by sedges (Carex spp.), intermediate oatgrass, June grass, western porcupine grass, and slender wheatgrass, and aspen forest with white spruce and balsam poplar (Populus balsamifera) often present. The grasslands occur mostly on saline soils, with some on steep, south-facing slopes. AP–PRP is surrounded by the Boreal Forest–Mixedwood (BF–M) and Boreal Forest–Boreal White & Black Spruce (BF–BWBS) units. It occurs along the Peace River in northwestern Alberta and adjacent B.C.

AP–PRP includes the Peace River Parkland Natural Subregion in Alberta (Achuff 1992) and was not recognized as a separate unit in B.C. within the Boreal White & Black Spruce Zone (Meidinger and Pojar 1991).

Boreal forest (BF)

Mixedwood (BF–M). The Boreal Forest–Mixedwood is characterized by a mosaic of coniferous trees—white spruce, black spruce (Picea mariana), balsam fir (Abies balsamea), jack pine (Pinus banksiana), tamarack (Larix laricina)—and deciduous trees—aspen, balsam poplar, and paper birch. It occurs in northwestern Alberta and northeastern British Columbia.

BF–M includes the Central Mixedwood Natural Subregion in Alberta (Achuff 1992) and the warm, moist Subzone of the Boreal White & Black Spruce biogeoclimatic Zone (BWBSmw) (Meidinger and Pojar 1991). It is not recognized currently as a separate zone in the British Columbia biogeoclimatic system (Meidinger and Pojar 1991) although others have recognized it (Rowe 1972; Ecoregions Working Group 1989).

Boreal White & Black Spruce (BF–BWBS). The Boreal White & Black Spruce (BF–BWBS) unit contains primarily coniferous forests of white spruce, black spruce, subalpine fir, and lodgepole pine with lesser amounts of aspen and paper birch. It occurs in the northern foothills of western Alberta and northeastern B.C. above the Mixedwood (BF–M) and below the Subalpine–Spruce-Willow-Birch (SA–SWB) and Subalpine–Engelmann Spruce–Subalpine Fir (SA–ESSF) units.

BF–BWBS includes the Foothills Natural Region in Alberta (Achuff 1992) and the dry, cool and wet, cool Subzones of the BWBS Biogeoclimatic Zone in British Columbia (Meidinger and Pojar 1991).

Regional landscape cross-sections

Although this preliminary outline does not include a map of the vegetation units across the Yellowstone to Yukon area, typical examples of the occurrence and positional relationships of the units are shown below as landscape cross-sections from high to low elevation.

Figure 1. Vegetation units in Yellowstone to Yukon.

Vegetation units in northwestern Wyoming (Despain 1990; Steele et al. 1983).

AT
|
SA–ESSF
|
MO–IDF
|
MO–LP
|
MO–BG
|
GP–MG

Vegetation units in east-central Idaho (Steele et al. 1981).

AT
|
SA–ESSF
|
MO–IDF
|
MO–LP
|
MO–BG

Vegetation units in west-central Idaho (Steele et al. 1981).

SA–ESSF
|
SA–ICH
|
MO–IDF
|
MO–PP
|
MO–BG

Vegetation units in northwestern Montana and northern Idaho (Cooper et al. 1991; Pfister et al. 1977).

AT
|
SA–ESSF
|
SA–ICH
|
MO–IDF
|
MO–PP
|
MO–BG

Vegetation units in southwestern Alberta (Achuff 1992; Achuff et al. 1997)

AT
|
SA–ESSF
|
MO–ES
|
AP–FP
|
GP–FF
|
GP–MG

Vegetation units in the central Alberta Rockies and to the east (Achuff 1992)

AT
|
SA–ESSF
|
MO–ES
|
AP–CAP
|
GP–NF
|
GP–MG

Vegetation units of the northern Alberta Rockies and to the northeast (Achuff 1992).

AT
|
SA–ESSF
|
MO–ES
|
BF–BWBS
|
BF–M
|
AP–PRP

Vegetation units in southern British Columbia (Meidinger and Pojar 1991).

AT
|
SA–ESSF
|
MO–IDF
|
MO–PP
|
MO–BG

Vegetation units in south-central British Columbia (Meidinger and Pojar 1991).

AT
|
SA–ESSF
|
SA–ICH

Vegetation units in east-central British Columbia (Meidinger and Pojar 1991).

AT
|
SA–ESSF
|
MO–SBS

Vegetation units in west-central British Columbia (Meidinger and Pojar 1991).

SA–ESSF
|
MO–SBPS
|
MO–IDF

Vegetation units in northeastern British Columbia (Meidinger and Pojar 1991).

AT
|
SA–ESSF
|
BF–BWBS
|
BF–M

Vegetation units of northwestern British Columbia and southeastern Yukon Territory (Meidinger and Pojar 1991; Rowe 1972)

AT
|
SA–SWB
|
BF–BWBS

Further steps

Several steps can be taken to develop further this account of the vegetation of the Yellowstone to Yukon area.

1. More detailed analysis and comparison of the vegetation units could be done based on existing literature, consultation with knowledgeable people, and further field work. This would help resolve questions about the relationships of some units and their geographical extent.
2. More detailed descriptions of the units could be prepared including, for example, more information on elevational and geographical ranges, and component community types (habitat types, vegetation types, associations, etc.).
3. The vegetation units could be mapped at an appropriate scale for entry into a GIS.
4. Information on the conservation status of the vegetation units could be determined (for example, the amount of each unit in protected areas or receiving special management; the amount disturbed by human activities (past, present, and planned) including road densities, forest harvesting, flooding, and agricultural activities; and the status of natural disturbance regimes).
5. The conservation status of the component community types could be developed through the various provincial and state Conservation Data Centres (CDCs) and Natural Heritage Programs (NHPs) which exist in Alberta, British Columbia, Idaho, Montana, and Wyoming. Efforts are underway to develop a coordinated classification of vegetation community types and determine their conservation status.
6. The occurrence and conservation status of plant species of special concern could also be developed through the CDCs and NHPs.

Literature cited

Achuff, P. L. 1992. Natural regions and subregions of Alberta: a revised classification for protected areas management. Report to Alberta Parks Service, Alberta Tourism, Parks and Recreation and Natural and Protected Areas, Alberta Forestry, Lands and Wildlife. 85pp. + map.

Achuff, P. L. and I. G. W. Corns. 1982. Vegetation. In W. D. Holland and G. M. Coen, eds. Ecological (biophysical) land classification of Banff and Jasper national parks. Volume II: Soil and vegetation resources. Alberta Institute of Pedology Publication SS-82-44:71–156.

Achuff, P. L. and H. A. Dudynsky. 1984a. Vegetation. Pages 43–131 in P. L. Achuff, W. D. Holland, G. M. Coen and K. Van Tighem, eds. Ecological land classification of Kootenay National Park, British Columbia. Volume I: Integrated resource description. Alberta Institute of Pedology Publication M-84-10.

Achuff, P. L. and H. A. Dudynsky. 1984b. Vegetation. Pages 33–83 in P. L. Achuff, W. D. Holland, G. M. Coen and K. Van Tighem, eds. Ecological land classification of Mount Revelstoke and Glacier national parks, British Columbia. Volume I: Integrated resource description. Alberta Institute of Pedology Publication M-84-11.

Achuff, P. L., W. S. Taylor and L. J. Knapik. 1993. Ecological land classification of Yoho National Park, British Columbia. Report to Yoho National Park, Field, B.C. 283pp. + maps.

Achuff, P. L., R. L. McNeill, and M. L. Coleman. 1997. Ecological land classification of Waterton Lakes National Park, Alberta. Parks Canada, Waterton Lakes National Park, Alberta. 220pp. + maps.

Archibald, J. H., G. D. Klappstein, and I. G. W. Corns. 1996. Field guide to ecosites of southwestern Alberta. Canadian Forest Service Special Report 8.

Bailey, R. G. 1978. Description of the ecoregions of the United States. USDA Forest Service, Intermountain Region, Ogden, Utah. 77pp.

Beckingham, J. D., and J. H. Archibald. 1996. Field guide to ecosites of northern Alberta. Canadian Forest Service Special Report 5.

Beckingham, J. D., I. G. W. Corns, and J. H. Archibald. 1996. Field guide to ecosites of west-central Alberta. Canadian Forest Service Special Report 9.

Bourgeron, P. S., and L. D. Engelking, eds. 1994. A preliminary vegetation classification of the western United States. The Nature Conservancy, Western Heritage Task Force, Boulder, Colorado.

Brown, D. E., C. H. Lowe, and C. P. Pase. 1980. A digitized systematic classification of ecosystems with an illustrated summary of the natural vegetation of North America. USDA Forest Service Gen. Tech. Rep. RM-73. 93pp.

Cooper, S. V., and P. Lesica. 1992. Plant community classification for alpine vegetation on Beaverhead National Forest, Montana. Conservation biology research report to Montana Natural Heritage Program, Helena, Montana. 80 pp .

Cooper, S. V., and R. D. Pfister. 1981. Forest habitat types of the Blackfeet Indian Reservation. Bureau of Indian Affairs, Wind River Agency, Ft. Washakie, Wyoming. Review draft.

Cooper, S. V., K. E. Neiman, R. Steele, and D. W. Roberts. 1991. Forest habitats of northern Idaho: a second approximation (revised edition). USDA Forest Service Gen. Tech. Rep. INT-236. 135pp.

Daubenmire, R. F. 1970. Steppe vegetation of Washington. Washington State University Agricultural Experiment Station Technical Bulletin 62. 131pp.

Daubenmire, R. F., and J. B. Daubenmire. 1968. Forest vegetation of eastern Washington and northern Idaho. Washington Agricultural Experiment Station Technical Bulletin 60. 104pp.

Despain, D. G. 1990. Yellowstone vegetation: consequences of environment and history in a natural setting. Roberts Rinehart Inc., Boulder, Colorado. 239pp.

Ecoregions Working Group. 1989. Ecoclimatic Regions of Canada, First Approximation. Environment Canada, Canadian Wildlife Service, Ottawa, Ecological Land Classification Series 23. 118pp. + map.

Lea, E. C. 1980. Explanatory legend for vegetation maps of the East Kootenay area. British Columbia Ministry of Environment, Kelowna, British Columbia. 36pp.

Lea, E. C. 1983. Explanatory maps for the Purcell study area. British Columbia Ministry of Environment, Kelowna, British Columbia. 45pp.

Lea, E. C. 1984. Biophysical resources of the East Kootenay area: Vegetation. Vol. 1. Regional vegetation. British Columbia Ministry of Environment, Kelowna, British Columbia.

Meidinger, D., and J. Pojar, eds. 1991. Ecosystems of British Columbia. British Columbia Ministry of Forests, Special Report Series 6. 330pp.

Mueggler, W. F. 1988. Aspen community types of the Intermountain Region. USDA Forest Service Gen. Tech. Rep. INT-250. 135pp.

Mueggler, W. F., and W. L. Stewart. 1980. Grassland and shrubland habitat types of western Montana. USDA Forest Service Gen. Tech. Rep. INT-66. 154pp.

Pfister, R. D., B. L. Kovalchik, S. F. Arno, and R. C. Presby. 1977. Forest habitat types of Montana. USDA Forest Service Gen. Tech. Rep. INT-34. 174pp.

Rowe, J. S. 1972. Forest regions of Canada. Canadian Forestry Service Publication 1300. 172pp.

Steele, R., R. D. Pfister, R. A. Ryker, and J. A. Kittams. 1981. Forest habitat types of central Idaho. USDA Forest Service Gen. Tech. Rep. INT-114. 138pp.

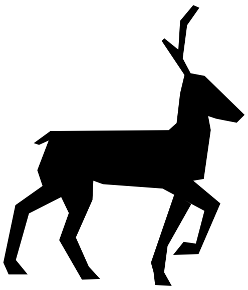
Steele, R., S. V. Cooper, D. M. Ondov, D. W. Roberts, and R. D. Pfister. 1983. Forest habitat types of eastern Idaho-western Wyoming. USDA Forest Service Gen. Tech. Rep. INT-144. 122pp.

Strong, W. L., and K. R. Leggat. 1981. Ecoregions of Alberta. Alberta Energy and Natural Resources Technical Report T/4. 64pp. + map.

Youngblood, A. P., and W. F. Mueggler. 1981. Aspen community types on the Bridger-Teton National Forest in western Wyoming. USDA Forest Service Research Paper INT-272. 34pp.

Youngblood, A. P., W. G. Padgett, and A. H. Winward. 1985. Riparian community type classification of eastern Idaho–western Wyoming. USDA Forest Service, Intermountain Region, R4-Ecol-85-01. 78pp.

Land Cover Structure of Yellowstone to Yukon



Troy Merrill and
David J. Mattson

Land cover maps provide information on the environment and the ecology of an area. Knowing the types of vegetation present in a region gives us a good idea of other variables such as moisture, temperature, and soil. Vegetation is also an indicator of the types of wildlife that may be present in an area. This information is necessary for designing a system of reserves that will preserve regional biodiversity.

We created a map of 11 general land cover types (Fig. 1) based on a map of vegetation of North America created by the United States Geological Survey. The 11 land cover types are based more on the structure of the vegetation than on the species making up the structure. Vegetation structure contains valuable information on regional scale processes such as fire regime and climatic patterns that have influenced the ecology of the region.

The cover types displayed on the map are:

- Wet Shrublands: primarily willow and alder; most common in the northern portion of the Y2Y region
- Grasslands: primarily grasslands mixed with croplands; most common in the southern portion of Y2Y
- Dry Range/Shrublands: arid grasses and shrubs such as big sage and rabbitbrush; most common in the southern portion of Y2Y
- Tundra: found primarily in the north of Y2Y but present at high altitudes throughout the region
- Mixed Forests: primarily deciduous species such as maple, birch and aspen; distributed throughout the region but most common in the northeast portion of Y2Y
- Open Needleleaf Forests: primarily ponderosa pine and juniper, and open woodlands; most common in the southern Y2Y
- Pine Forests: ponderosa, lodgepole and other pines; widely distributed but dominant in southern Y2Y
- Spruce/Fir Forests: primarily black and white spruce; most common in the North but found throughout the Y2Y region at higher altitudes
- Cedar/Hemlock Forests: western red cedar, western hemlock and Douglas fir; found throughout Y2Y but most common in areas with a maritime influence
- Agriculture: has replaced most grasslands in the region
- Bare Rock: generally high altitude

Although general, these land cover types provide a sense of the region. Fifty-nine percent of the region is forested, primarily with mixed deciduous forests (16%). Only 2.6% of Y2Y is classified as Agriculture, although an additional 7.5% (3% Dry Range and 4.5% Grasslands) is probably grazed but not cultivated. The area of each cover type, the percentage of the region occupied by each cover type, the percentage of each cover type in national parks or wilderness areas, and the percentage of national parks and wilderness areas occupied by each cover type is shown in Table 1.

By combining the land cover map with a map of national and provincial parks and wilderness areas, we can get an idea of what land cover types are not well represented in the current system of protected areas. There are no rules about how much of a land cover type needs to be protected to ensure long term viability, but estimates range from 10% to 50% (Merrill et al. 1995). Currently 10.2% of the region is reserved in some type of protected area. Looking at representation by land cover type we see that several types—Grasslands, Mixed Forests, and Cedar/Hemlock Forests—do not appear in protected areas in the same proportion as they do in the region as a whole. This indicates that species or ecological processes that occur primarily in association with those cover types may be lacking adequate protection.

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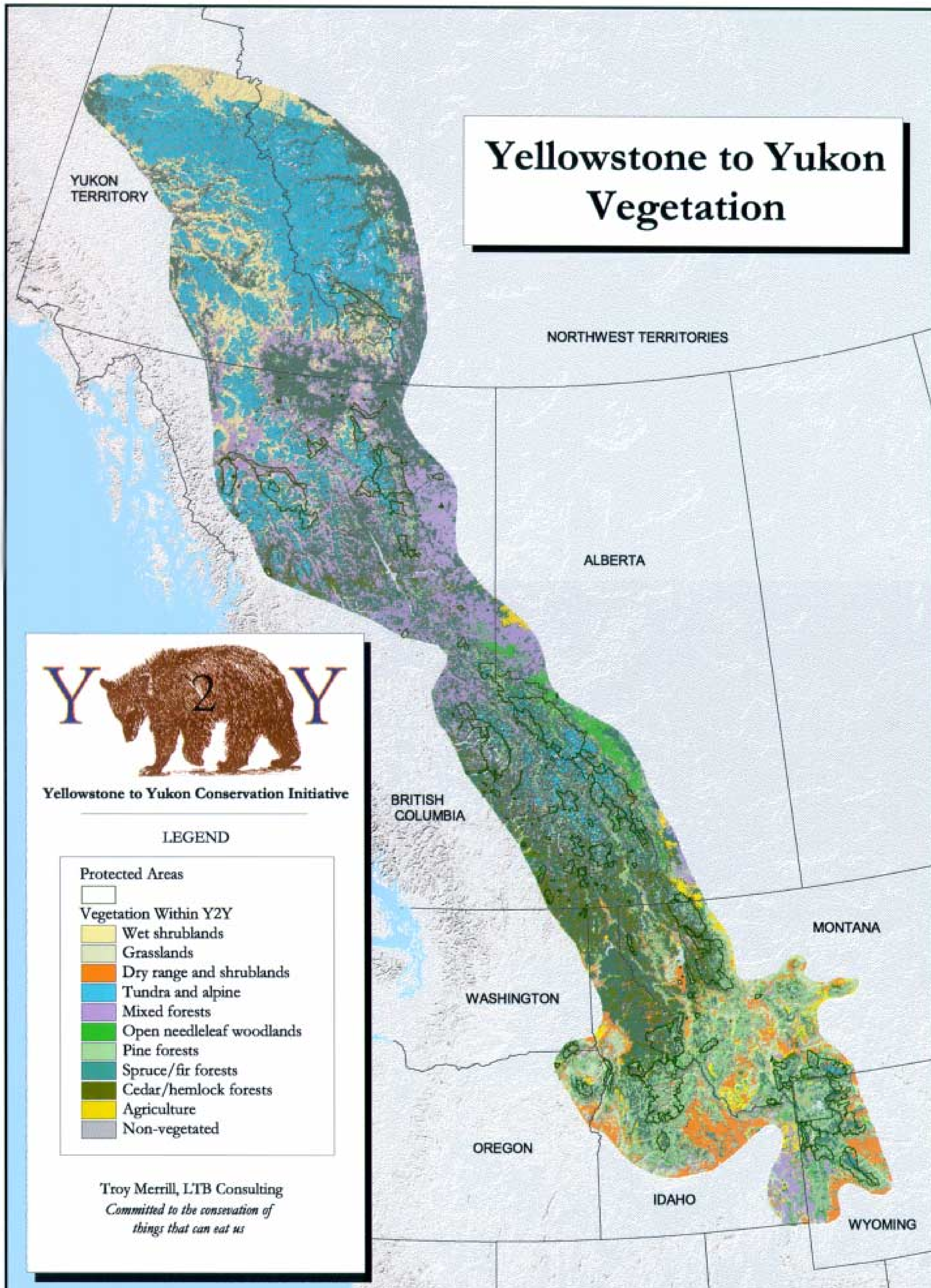
Table 1. Area and proportion of land cover types of Yellowstone to Yukon

Structure Type	Total Area (km2)	Protected Area (km2)	% of Total Area	% Protected	% of Protected Area System
Wet Shrubland	168,383	9,365	12.6	5.6	6.9
Grasslands	59,816	1,682	4.5	2.8	1.2
Dry Range and Shrublands	39,764	722	3.0	1.8	0.5
Tundra	253,713	18,701	18.9	7.4	13.7
Mixed Forest	213,475	12,777	15.9	6.0	9.4
Needleleaf Woodlands	96,689	18,504	7.1	19.3	13.6
Pine Forests	103,970	30,072	7.8	28.9	22.1
Spruce/Fir Forests	149,980	21,669	11.2	14.4	15.9
Cedar/Hemlock	200,440	18,178	14.9	9.1	13.4
Agriculture	35,308	696	2.6	2.0	0.5
Bare Rock	20,483	3,766	1.5	18.4	2.8
Total	1,341,021			10.2	

Literature cited

Merrill, T., R. G. Wright, and J. M. Scott. 1995. Using ecological criteria to evaluate wilderness planning in Idaho. Environmental Management 19 (6):815–825.



Yellowstone to Yukon
Vegetation
YUKON TERRITORY
NORTHWEST TERRITORIES
ALBERTA
BRITISH COLUMBIA
MONTANA
WASHINGTON
OREGON
IDAHO
WYOMING
Y 2 Y
Yellowstone to Yukon Conservation Initiative
LEGEND
Protected Areas
Vegetation Within Y2Y
Wet shrublands
Grasslands
Dry range and shrublands
Tundra and alpine
Mixed forests
Open needleleaf woodlands
Pine forests
Spruce/fir forests
Cedar/hemlock forests
Agriculture
Non-vegetated
Troy Merrill, LTB Consulting
Committed to the consevation of
things that can eat us

HUMAN INFLUENCES AND TRENDS

Sacred Geography: First Nations of the Yellowstone to Yukon

Brian O.K. Reeves

The Re–Creation Of The World[1]

In the beginning the world was all covered with water. Napi (Old Man-Creator) and the animals were sitting on the highest mountain—Ninastakis (The Chief Mountain).[2] Napi sent Otter deep down to get some earth. For a long time he waited. Otter came up dead. Nothing was on his feet. Next Beaver went down, but after a long time he also came up drowned and with empty feet. Muskrat went next. He drowned too. Finally, Creator sent Duck. Duck drowned but in his paw he held some earth. Napi took the earth and feigned putting it on the water three times. The fourth time he dropped it. Then the Up-Above-People sent rain and everything grew on the earth.

Napi began to walk north making the mountains, lakes, rivers, prairies and forests, the fish, the birds, and the animals. Napi put sacred red paint in the ground here and there. He arranged the world as we see it today. Napi covered the plains with grass for the animals to feed on and made all kinds of roots and berries to grow. He planted trees and put all kinds of animals on the ground. Napi created the bighorn with its big head and horns out on the prairie, but it didn't travel easily so Napi took all the rocks lying about and made the Backbone (Rocky Mountains). There he put the bighorns. They were happy, and so were the antelope and the buffalo because now they could run a lot faster without bumping into the rocks and hurting themselves.

One day Napi decided to make a woman and child out of clay. He moulded the clay and said, "You must be people," and after four days the clay shapes became people. They walked down to the river with their Maker. While they were standing there, Old Woman asked Napi if they would live forever. Napi hadn't thought about that. He threw a buffalo chip into the river, saying, "If it floats, people will die for four days and then live again. If it sinks, it will be forever." The buffalo chip floated. Old Woman picked up a stone and said, "If this floats we will always live. If it sinks people will die forever." The rock sank to the bottom of the river. Old Woman was pleased, saying, "It is better that people die or there would be no sympathy in the world." Old Man said, "Well, let it be that way."

At first humans were poor and naked and didn't know how to feed themselves. Napi taught them which roots and berries to eat. He taught them which animals to eat, and how to gather and hunt them, particularly the buffalo. He showed them how to drive the buffalo over cliffs. He showed them which herbs were good for sickness. He taught them to make weapons and pots. Napi gave the people culture.

Most importantly, Napi taught the people how to get spirit power. Napi told the people:

> Go away by yourself and go to sleep. Something will come to you in your dream that will help you. It may

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[1] This account of the Piikani Recreation is drawn from Wissler and Duvall 1908, Grinnell 1892, and Clark 1966. Specific details vary between these and other recorded Piikani accounts, particularly with regard to the water, the animals, their dive sequence, and which animal brings back the dirt. Napi may be on a mountain or a raft or log, but never in a canoe, as in northern forest accounts, as the Piikani did not make or use canoes. The Piikani share with many other First Nations of the Northern Hemisphere a common mythic motif known as the "Earth Diver Motif" in explaining how the world came to be. In some cases the Creator is in a human form; in others, in animal form—Raven for example. See Nelson 1983 for a Koyukon account involving Raven, and Riddington (1988:116 fol.) for a Beaver People account involving a personified Creator. The common mythic elements link them to the great floods which occurred throughout the Northern Hemisphere at the end of the last Ice Age.

[2] See Reeves 1994 for a detailed discussion of the sacred nature of Ninastakis.

> be some animal. Whatever this animal tells you in your sleep, you must do. Obey it. Be guided by it. If later you want help, if you are traveling alone and cry aloud for help, your prayer will be answered. It may be by an eagle, perhaps by a buffalo, perhaps by a bear. Whatever animal hears your prayer, you must listen to it (Clark 1966:237–38).[3]

Napi told the people that they must respect all the animals and other beings and always give them thanks for helping the people.

Napi kept on traveling north, creating the forests and the big rivers and lakes where the Cree live. Many of the animals came with him and stayed in the forest. Napi created the Cree and other Indian people along the way and fixed up their country for them. Eventually he left the world and went away toward the west, disappearing in the mountains. Before he started, he said to the people, "I will always take care of you, and some day I will return."

This is the Piikani accounting of how their world came to be recreated. Their story shares with other First Nations the belief that the world already existed but in another state. It was a time when the people and the animals could still talk to each other, not just in their dreams. The Australian Aborigines call this the "Dream Time," when giant kangaroos roamed their lands, and big inland lakes with fish and fowl existed in the great interior deserts. The Old Testament calls it the Garden of Eden, when the deserts of the Middle East were lush places to live. Geologists call this time when things changed the end of the last Ice Age. The Piikani mythic account of the Creator walking northwards is a deep time memory of the ice and lakes receding, and the plants, animals, and people coming back to these lands we know as the Eastern Slopes of the Rocky Mountains and the Western Plains of the headwaters of the Missouri and Saskatchewan, their part of the lands of the Y2Y.

The Last 10,000 Years

To understand the First Nations' relationship to the land, it is necessary to understand the history of the land itself, and how the events of millennia have shaped the beliefs, practices, technologies, cultures, and distribution of the peoples of Y2Y. The First Nations' associations with their traditional territories have evolved out of the thousands of years their ancestors have lived with, not on, these lands. Catastrophic volcanic eruptions and giant floods that occurred at the end of the last Ice Age are remembered in geographically distinct tribal recreation myths and stories. Climatic shifts had profound effects on the plant and animal communities with which the First Nations lived, and in turn on the people's cultures and technologies. The religions of the First Nations too are grounded in the sacred geography of the landscapes in which they have lived for thousands of years.

The First Nations' associations with their traditional territories have evolved out of the thousands of years their ancestors have lived with, not on, these lands. Catastrophic volcanic eruptions and giant floods that occurred at the end of the last Ice Age are remembered in geographically distinct tribal recreation myths and stories.

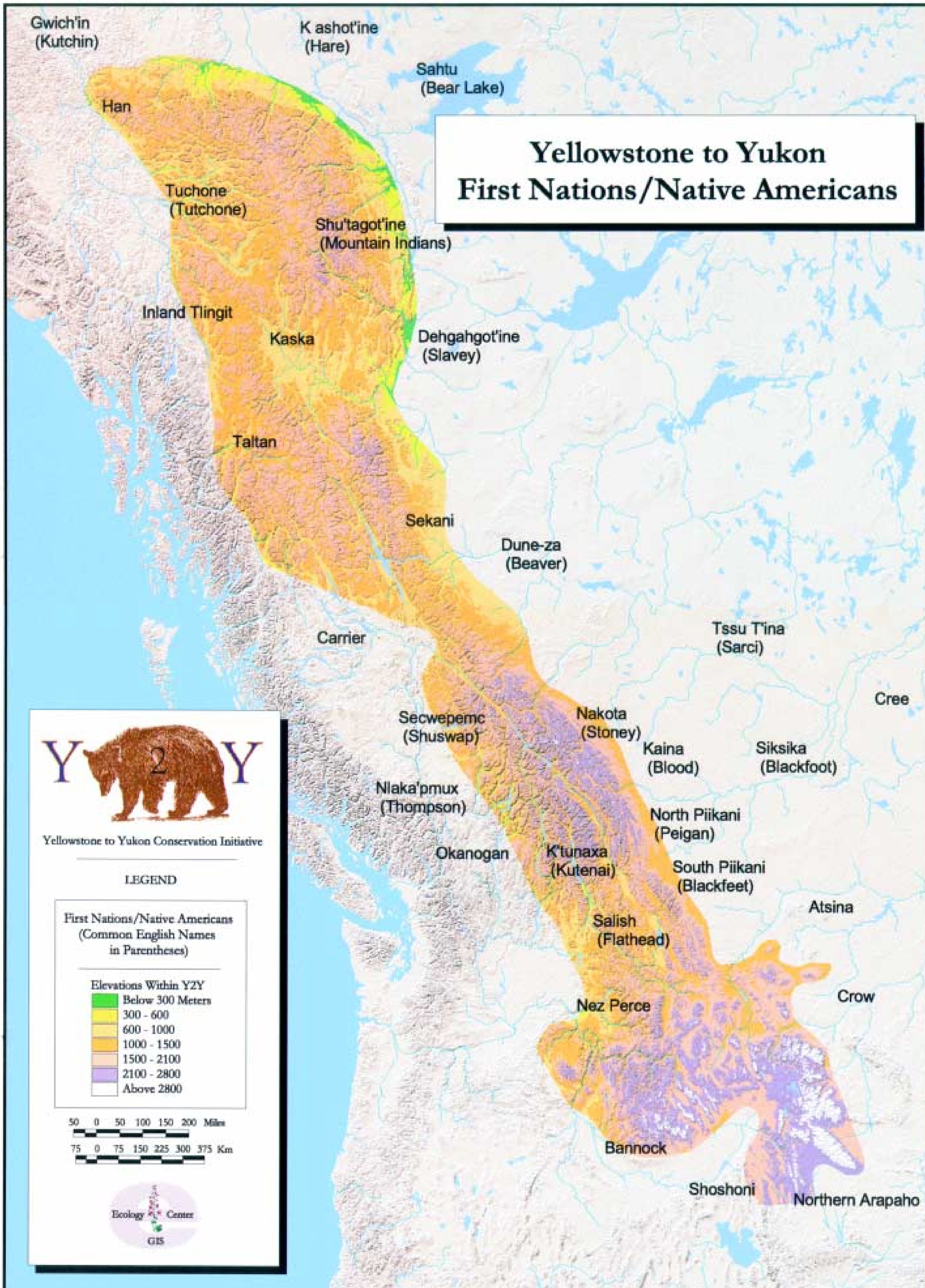
22,000 years ago, at the height of the last Ice Age, the central core of Y2Y was covered by ice, as were outlying areas such as the Yellowstone Plateau. Valley and piedmont glaciers extended out onto the surrounding plains and plateaus. In the north, the Continental Glacier abutted against the Mackenzies, reversing the river drainages westward across the unglaciated plateaus and valleys of the Yukon. At that time the Yukon was part of Eastern Beringia, a vast sparsely treed Arctic grassland akin to the African savannahs in biological productivity. Vast herds of bison, horse and mammoth roamed the plains and were hunted by small bands of ancestral Dene.

As the climate changed some 14,000 years ago, the land bridge submerged, grasslands turned to tundra, muskeg spread, and the boreal forests readvanced from their refugia in the Gulf of Alaska. As the Continental and Cordilleran Ice Caps retreated, Native people who had lived to the south began to move slowly north along the Rocky Mountain Front and the interior valleys and plateaus of the Cordillera to repopulate Y2Y. The early post-glacial climate prior to 5000 years ago was dryer and warmer than today and these early people expanded far to the north, eventually meeting the Dene as they expanded south and east out of Beringia. By 10,500–11,000 years ago Y2Y had been recolonized.

Catastrophic floods and volcanic eruptions

Although the Ice Age had ended, later catastrophic and climatic events continued to have an impact on the evolving post-glacial ecosystems of which the First Nations were an integral part. Vast catastrophic floods occurred at the end of the Ice Age. In the south, Glacial Lake Missoula, which occupied all of the Flathead Valley below the Cordilleran Ice, broke through its morainal dam some 11,000 years ago. It caused a vast flood across large parts of the Columbia Plateau, forming channelled scablands and sweeping plants, animals and people before it. This event was seared in the peoples' collective memory. As recalled down through the

[3] This same accounting was given to Grinnell.


Yellowstone to Yukon
First Nations/Native Americans
Gwich'in (Kutchin)
K ashot'ine (Hare)
Sahtu (Bear Lake)
Han
Tuchone (Tutchone)
Shu'tagot'ine (Mountain Indians)
Inland Tlingit
Kaska
Dehgahgot'ine (Slavey)
Taltan
Sekani
Dune-za (Beaver)
Carrier
Tssu T'ina (Sarci)
Cree
Secwepemc (Shuswap)
Nakota (Stoney)
Kaina (Blood)
Siksika (Blackfoot)
Nlaka'pmux (Thompson)
North Piikani (Peigan)
Okanogan
K'tunaxa (Kutenai)
South Piikani (Blackfeet)
Atsina
Salish (Flathead)
Crow
Nez Perce
Bannock
Shoshoni
Northern Arapaho
Y 2 Y
Yellowstone to Yukon Conservation Initiative
LEGEND
First Nations/Native Americans (Common English Names in Parentheses)
Elevations Within Y2Y
Below 300 Meters
300 - 600
600 - 1000
1000 - 1500
1500 - 2100
2100 - 2800
Above 2800
50 0 50 100 150 200 Miles
75 0 75 150 225 300 375 Km
Ecology Center
GIS

ages by the ancestors of today's Sahaptin, Salish, Kutenai, and Algonkian speakers, whose homelands during the last Ice Age were in the western basins, ranges, and plateaus, it became a geographically differentiated explanatory myth accounting for the divisioning of the tribes/linguistic groups in the far distant past.

Around 9900 years ago a catastrophic flood occurred in the Mackenzie Valley when Glacial Lake Aggasiz, which covered most of the Saskatchewan and Manitoba prairies (today's remnants are Lake Winnipeg and Winnipegosis), breached a drainage divide at the headwaters of the Clearwater River in Northwestern Saskatchewan and reversed its drainage from the Mississippi (Smith and Fisher 1993; Fisher and Smith 1994). The lake lowered 46 metres in a matter of weeks, sending 21,000 cubic kilometres of water down the Athabasca, into the Mackenzie, and into the Beaufort Sea, raising world sea levels 6 cm and affecting the climate of the entire Northern Hemisphere. This catastrophic event ended the last Ice Age within four to five years. Dene flood and recreation stories recall this event.

Great volcanic eruptions also played a role in altering landscapes, plants, and animal and human communities. Stories among the southern Sahaptin and Salish-speaking tribes clearly recall the more recent eruptions of the Cascade volcanoes in the last thousand years. They also speak of much more ancient eruptions, perhaps the great eruption 6800 years ago when a volcano (Mount Mazama) in today's southern Oregon—known today as Crater Lake—erupted. This eruption, which was 48 times the power of the recent Mount St. Helens event, sent a plume of ash far to the northeast, beyond the valley of the North Saskatchewan. The ash that fell in Y2Y resulted in a long-term increase in plant and wildlife productivity and an increase in regional Native populations.

Further north in the Interior Cordillera of British Columbia, Salish and Dene First Nations such as the Gitskan recall the eruptions of the coastal volcanoes and other catastrophic events (Harris 1997). The eruptions of Mt. Edziza, the sacred mountain of the Tahltan, are remembered in their oral histories.

1200 years ago a huge volcanic explosion—known as the White River Ash Fall—occurred in the St. Elias Range in the Southwest Yukon, resulting in a vast plume of ash dispersing eastward across the Yukon. This event had catastrophic effects on local plant, animal, and human communities. Traditional lands were abandoned. Some Dene left their ancestral lands never to return. Dene oral histories throughout the region speak of these catastrophic times as a recreation of the world.

Dehgahgot'ine (Slavey) Elder Madeline Mouse recalls:

> At the begining of the world it was winter all the time. Always cold. Ashes falling like snow. The burning all over it. People made caves in the ground and by lakes and lived there and cut as many young willows as they could and threw them into the water. Then when the fire passed, green trees. For everything burned....It started to snow again and the trees disapeared beneath the snow. They wondered if ever they would have summer again, for even the highest trees were covered (Hanks 1994: 23).

Regional climate change

The regional climate of Y2Y also changed in response to global trends and shifts. The climate for the first 4–5 millennia following the Lake Agassiz Flood was generally warmer and dryer than that of the last 5000 years. Palynological records from the Athabasca and Columbia south to the Yellowstone indicate that valley grasslands were more expansive and the forests more open than they are today. 5000 years ago, the climate became cooler and wetter, forests closed, grasslands diminished, alpine tundra communities expanded, muskegs formed, and the western boreal forest communities expanded southward along the foothills to and beyond the Bow Valley.

Pollen records of the last 5000 years record a significant increase in charcoals which, along with indicator plant species and frequencies, suggest that southern Y2Y First Nations began to fire the valley grasslands and montane forests to maintain grassland productivity and the game animals on which they depended—mountain bison on the East Slopes, deer and elk to the west. Recently completed fire return studies in the mountain parks indicate a change in fire return frequency coincident in time with the removal of the Native peoples from these ecosystems. Fires in the montane forests were much less frequent in the last 100 years than they were before.[4]

The climatic shift of 4000–5000 years ago had a significant impact on Native cultures throughout the Y2Y. Forest-adapted Dene speaking people spread south and east from their northwestern homeland across the northern boreal forest. Cultures changed and populations numbers decreased as carrying capacities and plant and animal communities changed. Some alpine and valley areas isolated by vast tracts of unproductive forest from preferred hunting, camping,

[4] See Barrett (1996), Despain (1990). As a result of fire suppression in the last 100 years throughout the southern Y2Y, particularly in the montane/valley grassland life zones, these critical ecosystems, maintained by Native peoples for the last 5000–4000 years through the consistent and repeated application of controlled firing in spring, are moving in a direction which has not existed since the southern Y2Y was recreated at the end of the last Ice Age.

and fishing areas were abandoned or rarely visited in the following millennia.

New food collecting, processing, cooking, and storage technologies developed in the south, partly in response to the changed ecology. These technologies resulted in increasing cultural complexity over the next two millennia, including the development of the "classic" nomadic bison hunters of the Eastern Slopes and Northern Plains and the salmon fishing/root digging village tribes of the Columbia and Fraser Plateaus. Stone boiling and hot rock pit roasting/steaming food preparation technologies appear in the archaeological records around 5000 years ago. Adapted from tribes resident in the Great Basin and California, these technologies had a profound effect on the peoples' subsistence, settlement and cultural complexity. The big game hunters found that combining grease boiled out of the broken ends of limb bones with dried pounded meat and berries produced an easily carried and highly concentrated food—pemmican—which, if kept dry, lasted a very long time. The development of new and more complex bison hunting technologies, new religious forms (sweat lodges, medicine pipes, etc.), and the skin-covered tipi led to the emergence of the bison hunting cultures by 1500 years ago (Reeves 1990).

West of the mountains, the Interior Salish and Sahaptin tribes discovered that by cooking roots such as camas, bitterroot and balsam root in earth ovens heated by hot rocks and earth, they could transform these formerly indigestible foods into highly concentrated carbohydrate sources, which could then be dried or pounded into meal and stored for the coming winter. By digging only older plants (the common practice in digging medicinal roots), weeding and firing the root patches, and transplanting the plants, they further enhanced productivity. Along with new and improved methods of taking, processing, and storing salmon first developed by the Northwest Coast people, this provided the accumulated and stored food surplus which allowed the development of large semi-permanent villages along the salmon-rich rivers. These technologies resulted in elaborating cultural complexity and the emergence of the plateau cultures some 3000 years ago. Similar complexity developed inland along the great salmon rivers of the Yukon and Pacific Northwest associated with new technologies of catching, processing, and winter storage of large numbers of salmon.

The cultural record of the last 5000 years is one of increasing cultural complexity and stability. It shows change as well, in response not only to climate changes but also to new ideologies and technologies. Extensive trade networks existed throughout the region, which hint at the extent of contact between neighboring groups and an awareness of the larger geographic/cultural setting within which the Native cultures of the Y2Y lived. Obsidian from the Yellowstone Plateau was traded as far north as the Peace River country and as far east as Illinois and Ohio, where it is found in 2000-year-old burial mounds associated with the Hopewell Culture—the first of the village farming cultures of the Eastern Woodlands. Other exotic flints from quarries in the Wyoming and Montana Rockies occur both in Hopewell and in the later very culturally complex Mississippian Culture burials. Occasionally a distinctive Hopewell or Mississippian artifact is found in a site in the southern Y2Y. These finds hint at extensive trade/interaction between the bison-hunting tribes of the western plains/eastern slopes and the village farmers and complex societies of the East. Some major religious complexes, such as the "Sun Dance" characteristic of the bison-hunting tribes, are thought to have their origins in the Mississippian culture of 1000 years ago.

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Southeastern Oregon obsidians have been found in sites in the Rockies and Fraser Plateau; Anaheim Lake obisdians from central B.C. have been found in the Peace River and Athabasca; and Mt. Edziza obsidian (the farthest north of major obsidian sources) occurs throughout the Yukon, on the Mackenzie, in the Peace, and as far east as the Birch Mountains of northeastern Alberta. Trade and contact with the coastal peoples through the interior plateau is also evident in the occasional recovery of dentalium and other marine shells, as well as jadite axes/adzes from sites on the east slopes of the Rockies. The archaeological record can only hint at the cultural complexity and the nature of contact/trade between the First Nations of the Y2Y before the coming of the white man.[5]

Y2Y First Nations: Traditional Territories, White Contact, And Relocations

Y2Y straddles the traditional territories of some 31 different Native American tribes. Many of these First Nations differ markedly in their language, culture and history, reflecting the diverse mountain, plateau, basin, forest and plains environments which their traditional territories encompass, as well as their individual tribal histories and relationships with neighboring tribes.

The nature and timing of white cultural contact and acculturation also had a differential impact among the tribes. In the settled southern areas of Y2Y, First Nations were displaced partly or wholly from their traditional territories and placed on reserves (reservations). Many of their traditional ways and associations with the land were lost. In contrast, many of the Dene of the northern Y2Y have, until recent years, maintained the traditional way of life and association with the land developed during the fur trade of the last century.

Tribes of the southern Y2Y (Missouri, Saskatchewan, Snake, Columbia, and Kootenai drainages)[6]

Traditional cultures and their resource harvesting and occupancy patterns within the southern Y2Y are very diverse. East of the divide in the broad open valleys around the Yellowstone Plateau and in the Upper Missouri, as well as northward along the Rocky Mountain Front in today's Montana and Southern Alberta, plains buffalo hunters, such as the Crow, Northern Arapaho, Atsina and Piikani[7] hunted both the plains and mountain bison in their wintering ranges along the foothills. The people camped in the sheltered and wooded river and stream valleys along the Front. While most bands followed the buffalo east into the shortgrass country, some bands and families would remain along the eastern slopes during the summer, traveling into the high country to hunt buffalo, sheep, fish, and fowl, gather food and medicinal plants, vision quest, and carry out other religious ceremonies. Focal areas such as the Greater Yellowstone and Crown of the Continent ecosystems continue to be of special sacred significance to the First Nations today.

Arapaho, Atsina, and Piikani. The Arapaho, Atsina and Piikani, whose languages are among the oldest and most ancient of the Algonkian language family, have resided in these lands and followed the way of their ancestors for thousands of years since the ancestors of the Algonkian-speaking peoples came into these lands from west of the mountains 8000 or more years ago. Over the millennia that followed, these people, particularly the Piikani and their fellow Saskatchewan Plains tribesmen—the Kaina and Siksika (who with the Piikani collectively refer to themselves as the Nitsitapii)—developed the most complex communal big game hunting culture the world has every known (see Reeves 1990). At contact the Nitsitapii probably numbered between 15,000 and 20,000 people. The Crow came into these lands only 500 years ago, migrating up the Missouri River from the Hidatsa villages on the Big Bend of the Missouri.

Cree. The Cree people, whose language is one of most ancient Algonkian languages, apparently came originally from north-central Manitoba. Oral tradition, as well as archaeology, indicates that both the Saskatchewan Cree and the Nakota people (who at the time of the fur trade lived in the parklands along the North Saskatchewan as well as in the forests to the north) had begun their westward expansion some centuries before the fur trade reached Hudson Bay (not after it, as most histories have it). The Cree began expanding outward around a thousand years ago, reaching the Forks of the Saskatchewan 500 years ago and the western parklands/foothills of Alberta 200 years later. They often wintered with the Piikani, Siksika and Kaina.

Nakota. The Nakota (Stoney) also arrived in the eastern slopes before the fur trade had left Hudson Bay. The Nakota are linguistically and culturally related to the Dakota and Lakota people of the northeastern plains. They began to expand northwestwards from their homeland around 800

[5] Archaeological sites are a very significant non-renewable cultural resource of the Y2Y. Large numbers of significant sites have been lost or impaired in the southern Y2Y over the last 100 years, both within and outside protected areas, as white settlement/land use focused on the same areas—the valley floors—as Native settlement had. These sites contain significant records not only of past Native peoples but also of the environment in which they lived and are invaluable to understanding the past and predicting the future. Legislation and management programs vary markedly between Canada and the United States and between the individual states and provinces. Regionally oriented, culturally based research/management plans exist only within the National Parks.

[6] This section is drawn from a wide variety of primary and secondary sources on the native peoples and their ethnohistory. Much of the material dealing with the Northern Plains and Rocky Mountains was brought together in the yet-to-be-published report for the U.S. National Park Service, "An Ethnographic Overview of Glacier National Park," authored by Reeves and Peacock (1995a). There are many books dealing with the Native American cultures in the southern Y2Y. They range from the individual tribal ethnographies of the early part of this century to tribal histories and summaries by state, province, region or country. Unfortunately, the Smithsonian Institution's *Handbook of North American Indians* volumes dealing with the Plains and the Plateau, which have been in the works for close to 20 years, remain yet to be published. Vol. 11, *The Great Basin*, edited by Azevedo (1986) is an excellent source for the Shoshonian-speaking peoples and their recent history within the Y2Y. A useful guide for tribes of the Columbia Plateau in the United States is the well referenced Ruby and Brown 1992. An excellent overall, well referenced introduction to the First Nations of North America is Kehoe 1992.

[7] Whenever possible in this paper I use the traditional names by which the tribes prefer to refer to themselves today. Many First Nations in Canada are taking back their own names in their languages as their official names. The three "Blackfoot" First Nations resident in Canada prefer to be known by their own tribal names—the Piikani (Peigan Reserve), Siksika (Blackfoot Reserves) and Kainaa (Blood Reserve)—rather than Blackfoot. Today the Canadian tribes use the term Blackfoot or Blackfoot Confederacy when referring to themselves as a collectivity. In America, the Blackfeet of the Blackfeet Reservation in northern Montana are a southern division of the Piikani; Blackfeet traditionalists prefer to refer to themselves as Piikani.

years ago, reaching the plains of central Saskatchewan 200–300 years later and the Rocky Mountain foothills perhaps a hundred years after that.

Shoshoni, Kiowa, Apache, and Bannock. Other tribes, some ancient occupants, others more recent newcomers, occupied the western and eastern slopes of the Rocky Mountains and the upper reaches of the Snake, Columbia and Kootenai Rivers. In the arid basins and adjacent mountains of southeastern Idaho, Wyoming, Utah, and Colorado lived various bands of the Shoshoni. They arrived in this region from the southwestern Great Basin area between 800 and 500 years ago. The Shoshoni occupied lands once occupied by the ancestors of the Kiowa before their migration eastward onto the High Plains some 500 years ago. A thousand years earlier, the Kiowa's ancestors, who were related to the Pueblo people of the Southwest, had established successful farming villages in northern Utah, which lasted until the droughts of the twelfth century brought about their collapse and abandonment. The Kiowa hunted for a time, finally abandoning the territory to the Shoshonian-speaking immigrants.

Y2Y straddles the traditional territories of some 31 different Native American tribes. Many of these First Nations differ markedly in their language, culture and history, reflecting the diverse mountain, plateau, basin, forest and plains environments which their traditional territories encompass, as well as their individual tribal histories and relationships with neighboring tribes.

During their migration eastward around 500 years ago, the Kiowa met the Apache at the Great Stinking Lake (Yellowstone Lake). The ancestral Apache are closely related linguistically to the Dene people of Northern Alberta—the Beaver and Tssu T'ina (Sarsi). The Apache's ancestors probably left the northern forests and foothills around 500–600 years ago and drifted southward along the Front.

Most of the Shoshoni lived in a very limiting environment. They consisted of a number of small subsistence groups who tended to associate with particular resource-harvesting areas. Individuals and families moved freely between the groups. Social organization was very simple. The Tukadea (Sheep Eaters), who were associated with the Greater Yellowstone Ecosystem, lived as small families in this high country until the mid-late 1800s, when disease, Crow and Arapaho bands, fur traders, miners, ranchers, and the U.S. Army exterminated them. The Bannock, a closely related Shoshonian-speaking tribe, moved into the Idaho area from further south in the Great Basin in the early 1800s.

Nez Perce. Northwest of the Shoshoni and Bannock, along the Snake and its salmon-rich tributaries in today's central Idaho, are the Nez Perce. The Nez Perce had canoes, built large grass mat semi-subterranean lodges, and lived in large semi-permanent villages along the major salmon streams. They fished the salmon runs, dried salmon for the winter, hunted deer, and harvested the rich variety of food plants found in the region. Their staples were dried salmon and camas root, which they dug, cooked, and dried in late spring. The Nez Perce belong to the Sahaptin language family. Their ancestors have been resident in these lands for 8000 or more years. Their village way of life developed in the last 3000 years as a result of new food preparation and storage technologies.

Spokane, Couer d'Alene, Kalispell, and Salish. On the Clark's Fork of the Columbia and its tributaries lived Interior Salish-speaking First Nations: the Spokane, Couer d'Alene, Kalispell (Pend Oreille) and Salish (Flathead). They fished, hunted deer, and dug camas and other roots. The down-river tribes had access to salmon runs and lived in large semi-permanent villages, while those above the falls (which blocked the runs) were more nomadic. Camas processing was probably first developed by the Kalispell (People of the Camas) some 5000 years ago. The technology and the plants spread outwards to neighboring tribes, eventually reaching across the Rocky Mountains to the Piikani some 2000 years later. The Salish of the Flathead Valley in western Montana, according to their oral traditions and their linguistics, arrived in the southern part of the valley around a thousand years ago. Some Kalispell people moved into the Flathead Valley in the 1800s.

K'tunaxa (Kutenai). The K'tunaxa (Kutenai) are the people of the Rocky Mountains. They are linguistically and genetically distinct from all other peoples of the region. They consist of two divisions: the Lower or Lake K'tunaxa, whose traditional territory encompassed the lower Kootenai River and the Kootenai Lake in British Columbia, and the Upper K'tunaxa of the upper Kootenai/uppermost Columbia Rivers and the Rocky Mountains. There were at least seven bands of Upper K'tunaxa. Their population probably numbered around 1000 people in the early 1700s. Their traditions say the first K'tunaxa were created at the Tobacco Plains. The Upper K'tunaxa bands' traditional territory along the eastern slopes extended from the Kootenai Plains on the North Saskatchewan to Waterton-Glacier. On the west it ran from the Big Bend of the Columbia southwards to above Bonnington Falls on the Kootenai River. It also included the northern part of the Flathead Valley.

Most Upper K'tunaxa bands wintered west of the mountains, traveling eastward over the passes on spring, fall, and winter buffalo hunts. Fishing was important on both the west and east slopes, as was hunting for sheep and deer, digging roots, and collecting other food and medicinal plants. Archaeology traces their way of life back at least 5000 years. The ancestral K'tunaxa were probably the first people to repopulate this region when the glaciers retreated some 10,000 years ago.

Secwepemc, Okanogan, and Nlaka'pmux. North of the K'tunaxa, on the Columbia and Shuswap Lakes as well as on the Upper Thompson, are the Interior Salish-speaking Secwepemc (Shuswap). South of them are the Okanagan. To the west are the Nlaka'pmux (Thompson). These people lived in large permanent pit house villages. Salmon fishing supplemented by plant gathering, root digging (particularly balsam root), and deer hunting provided the foundations for a stable and culturally complex village way of life traceable back over 3000 years. Salish-speaking peoples appear to have once occupied the Columbia Lakes at the headwaters of the Columbia around 1000–3000 years ago, and then abandoned this area, which was also occupied by K'tunaxa bands. These Salish people also briefly visited the eastern slopes of today's Upper Bow and Red Deer valleys, where they constructed pit houses and cache pits dating to about 1000–3000 years ago. In the 1800s, a band of Secwepemc returned to and settled on the Columbia Lakes.

Contact with Whites

The arrival of the horse, repeated epidemics of smallpox and other diseases, the development and westward spread of the fur trade on the Saskatchewan and Missouri, increasingly easy access to manufactured goods, and other "benefits" of white civilization—notably alcohol—resulted in many changes in both the territories and the cultures of the southern Y2Y tribes. The eventual settlement of the west by whites led to further changes.

Horses stolen from the Spanish in New Mexico by the Comanche and other southwestern tribes filtered northwards along the plains east of the Rockies and through the valleys of the Intermountain West, arriving in the southern Y2Y around 300 years ago. Horses thrived on the grasslands of the Snake, Columbia and Flathead valleys, and Shoshoni and Salish groups began to hunt buffalo and reside east of the divide both in the Missouri headwaters and east of the Rocky Mountain Front, occupying lands temporarily vacated by Arapaho, Atsina and Piikani in the early 1700s. These smallpox-decimated tribes were engaged in ongoing warfare with the Siouan-speaking Snake People—Crow, Nakota (Plains Assiniboine), and Lakota, who had been penetrating their traditional territories from the southeast since the 1500s.

At the same time that horses arrived in the Y2Y, the first smallpox epidemic, spread from French traders in the Upper Mississippi and the Red River country to the Assiniboine and Cree, decimated the tribes of the Upper Missouri/Saskatchewan and Rocky Mountain West. Eighty percent or more of the people died. Some tribes and bands disappeared forever. Two tribes of the Arapaho-speaking people whose traditional territory was in the Upper Yellowstone and Wyoming area, between the Northern Arapaho and the Atsina (the northernmost of the original five tribes of the Arapaho) were lost, as was a band of the Upper K'tunaxa who traditionally associated with the Crowsnest Pass region of southwestern Alberta.

The fur trade

As the fur forts advanced westward up the Saskatchewan, the Nitsitapii and Atsina and their neighbors, the Cree and the Assiniboine of the Saskatchewan, became increasingly involved in the fur trade. The smallpox-ravaged tribes focused their activities on the northern part of their traditional territories. As they recovered from the smallpox, the Nitsitapii and their allies the Atsina, accompanied by the Tssu T'ina who had left their northern kinsmen the Beaver People to camp with the Siksika and take up a plains way of life, began to expand and re-occupy their old territories. They continued raiding Shoshoni and Salish camps for horses and slaves (many of whom were traded to the whites).

In the early 1800s, when all the beaver had been trapped out of the Saskatchewan by the Indians and Freemen, these tribes travelled far southward into the Rocky Mountain West to trap beaver, raid Shoshoni, Bannock, and Utes, and kill eastern American white and Indian trappers. The easterners were directly trapping for beaver rather than trading for trapped beaver on lands the tribes considered to be their exclusive trapping territory. The Nitsitapii, Atsina and Tssu T'ina became known to the whites as the "Blackfeet." The "Blackfeet" were stereotyped by the eastern American press as white-haters and savage murderers. They were considered fair game by the American trappers.

The extension of the fur trade on the Upper Missouri in the 1840s to Fort Benton, the appearance of steamboats, and the growth in the bison hide trade for eastern industrial consumption, followed by the discovery of gold in the Rocky Mountain West and an influx of settlers along the Oregon and Bozeman trails, led to the signing of treaties, the Indian wars, and the removal of many of the tribes from all or part of their traditional lands within the American section of the Y2Y.

Although historical events took a different course among the "Canadian" tribes of the Upper Saskatchewan during the last century, the outcome was much the same. As the trade with the Hudson Bay Company depleted both the furs and bison herds in the parklands in the 1830s and 1840s, the Nitsitapii began to winter southwards in the Missouri.

The Cree moved southwards as well, wintering more frequently in the foothills and parklands of today's central Alberta and hunting in traditional Nakota and Nitsitapii lands to the south. Conflicts over fur and bison escalated in the next three decades between these tribes as well as with the Plains Assiniboine, Atsina, Salish, Kalispell, and some K'tunaxa bands. Former allies and friends became foes, as the massive Metis buffalo slaughter for the Hudson Bay Company encroached ever westward on the diminishing herds.

Relocation and confinement to reserves

Missionaries and priests began their work among the tribes west of the Rockies in the 1840s, 30 years before they had any significant influence on the Blackfeet east of the divide in Montana Territory. The miners, settlers, and economic development that soon followed in the Intermountain West resulted in a more rapid and extensive loss of language and culture among the tribes west of the mountains than among those on the east. The American and Canadian Indian experiences also varied.

In the settled southern areas of Y2Y, First Nations were displaced partly or wholly from their traditional territories and placed on reserves (reservations). Many of their traditional ways and associations with the land were lost. In contrast, many of the Dene of the northern Y2Y have, until recent years, maintained the traditional way of life and association with the land developed during the fur trade of the last century.

Many tribes were placed on reservations during the second half of the nineteenth century. Shoshoni bands, who had moved into the Big Horn Basin/Powder River country in the 1800s and adopted a bison economy, were forcibly placed, along with the remaining Northern Arapaho, on a common reserve on the Wind River in 1868. Other Shoshoni and Bannocks were forced onto the Fort Hall Reservation in Southeastern Idaho in 1869. Under the Hell Gate Treaty of 1855, the Salish, Kalispell and K'tunaxa resident in the Flathead Valley of Montana were placed on a large reserve which encompassed half of the lake and much of the valley to the south (today, 80% of the Flathead Reserve in Montana is owned by whites). Salish bands who preferred to remain in the Bitterroot Valley were forced off their lands. Some Lower K'tunaxa living at Bonner's Ferry in Idaho were forceably removed to the Flathead. Fortunately, there was no gold in the Flathead Valley. In contrast, the lands the Nez Perce had initially received under the Walla Walla Treaty of 1855 were reduced in size and occupied by white gold miners and settlers after gold was found in 1860. The end result was the Nez Perce War of 1877 and the removal of many Nez Perce from their allotted lands.

The Crow and Blackfeet (South Piikani) were among the very few plains tribes who were not involved in the Indian Wars with the U.S. Army. As a result, unlike many other tribes, they were not removed from their traditional lands. While their reservations have diminished considerably in size since the signing of treaties in 1855, and are in part owned by whites as a result of the Indian Allotment Act of 1887 (the Blackfeet Reservation is less than a quarter of its original size, and 40% is owned by whites), oral traditions and associations with Y2Y among these tribes remain strong for the Greater Yellowstone and the Crown of the Continent ecosystems.

American whiskey and hide traders operating out of Fort Benton moved into today's southern Alberta after the Civil War. These traders extended the impact of white culture on the First Nations who resided in the Upper Saskatchewan. The tribes' lands, part of Ruperts Land, belonged to the Hudson's Bay Company, whose southernmost post was at Rocky Mountain House. The Company had been in a losing battle with the Americans for the trade since before the Civil War.

Rupert's Land was sold to the Government of Canada in 1869, two years after Confederation. Increasing concern in Ottawa about loss of customs revenue from the bison hides being taken out from the now "Canadian" west by Americans, as well as public concern among eastern liberals for the debauched Indians in the west, resulted in the formation of the Northwest Mounted Police and their march westward in 1874. Treaty 7 was signed three years later, and the signatory tribes—Kaina, Piikani, Siksika, Tssu T'ina and Nakota—were soon confined to their reserves. Tradition among those tribes with close ties to the foothills and mountains has remained strong.

In British Territory, the relict populations of the small K'tunaxa bands, who collectively numbered less than 200, were placed on small reserves within the Kootenai and Columbia valleys and near the foot of Kootenai Lake. The Secwepemc people resident in the Columbia Valley received a small parcel of land. Small reserves were also allotted for other Secwepemc, Nlaka'pmux and Okanagan tribes within their traditional lands to the west. None of these tribes, however, signed treaties with the Queen's representatives. They have not "surrendered" their traditional lands. Retention of traditional knowledge has varied from band to band and tribe to tribe in British Columbia, depending on the extent and timing of priest and missionary activities, mining, settlement and economic development.

Tribes of the northern Y2Y [8]

Many of the First Nations of the Northern Rockies, interior B.C., and the Mackenzie, while differing significantly in details, share a common cultural-linguistic heritage as members of the Dene-speaking people adapted to life in the western subarctic boreal forest. During the last Ice Age, their ancestors lived west and north of the Continental and Cordilleran Ice Sheets in Eastern Beringia. Sites dating back to the height of the last Ice Age have been found, such as Blue Fish Cave in the Richardson Range.

As the valley and alpine glaciers and ice sheets receded, the glacial lakes lowered and drained, and the great rivers reversed and assumed their present courses, the ancestral Dene people spread south out of the refugia into the Mackenzies, the Cordillera and the Northern Rockies. They reached the upper reaches of the Peace, Athabasca, and Fraser drainages around 4000–5000 years ago, when "modern" northern boreal forest conditions became established in these southern regions. Their subsequent cultural development differed east and west of the Continental Divide. Those Dene west of the divide had access to salmon and were in contact with the Northwest Coast cultures, with whom they traded, resulting in more complex and settled traditional Dene cultures developing in the Fraser, Skeena, Yukon, and other Pacific drainages than east of the divide.

Dunne-za (Beaver) and Sekani. The southern Dene groups in the Rocky Mountains and adjacent eastern slopes/ boreal forest underwent both a depopulation and a territorial shift early in the nineteenth century as the Woodlands Cree expanded westward into the Peace River country. The Cree displaced the Dunne-za (Beaver) from their original territory in today's northeastern Alberta westward into the Peace, where their close relatives the Sekani lived. The Sekani had gradually split from the Beaver in the eighteenth century, moving westward and northward. Sekani traditional territory became more focused on the foothills and mountains of the Upper Peace. Sekani range may have extended southward into the headwaters of the Upper Athabasca and its southern tributaries. That area was uninhabited when first visited by the fur traders in the early 1800s. Local bands had probably succumbed to the smallpox epidemics of the 1730s or 1780s.

Kaska, Dehgahgot'ine, Shu'tagot'ine, Sahtu, and Kashot'ine. North of the Sekani are the Kaska, whose traditional territory centers on the Cassiar region. One band of Kaska may have lived in the Fort Liard area and were displaced by a movement of a Dehgahgot'ine (Slavey) band upriver from the Mackenzie. Slavey territory today extends downstream along the Mackenzie to Fort Norman. West of the Slavey are the Shu'tagot'ine (Mountain Dene) whose traditional territory encompasses the Mackenzie Mountains east of the Continental Divide. Most bands traditionally traded with Fort Norman. The Sahtu (Bear Lake) Dene live to the east. North of the Slavey along the lower Mackenzie are the Kashot'ine (Hare), whose traditional territory extended into the northeastern flanks of the Mackenzie.

For the Dene groups associated with those portions of the Peace and Mackenzie drainages which lie within the Y2Y, traditional life since the coming of the fur trade focused on hunting, fishing, and trapping. Fish lakes have always been important places for winter settlement. Places such as Fisherman's Lake north of Fort Liard, for example, have a record of Native occupation extending back over 8000 years. Until the Second World War, the only contact with whites that many of the bands/families north of the Peace River agricultural region had was limited to fur traders, missionaries and bureaucrats. The development of the Alaska Highway in the south, the CANOL pipeline through the Mackenzies, the Norman Wells oil field, and the Mackenzie River transportation system increased contact with whites. More isolated Dene still maintain a partially traditional way of life, relying on subsistence hunting, fishing, and trapping and trade in furs. Many groups within the settlements along the rivers and highways are undergoing rapid and irreversible acculturation.

Northern Carrier. West of the Sekani is the Northern Carrier's traditional territory, which lies north of the Chilcotin in the upper Fraser and southern tributaries of the upper Skeena. The Carrier, estimated to number 8500 before contact, fished for salmon, hunted deer, moose, mountain goat, and caribou, and collected plants. Most resided in semi-permanent villages along the major salmon streams and lakes. In pre-contact times the Carrier were part of a well established trade network with the coastal Gitskan and Tsimishian. While socially considerably more complex than the neighboring Sekani or Kaska, the Northern Carrier were not socially stratified like the coastal people. Archaeology indicates they have been resident here for at least 5000 years.

Tahltan. Northwest of the Northern Carrier and Sekani and west of the Kaska in the Stikine drainage are the Tahltan, who are linguistically related to the Kaska. The Tahltan are centered today around Telegraph Creek. Like the Carrier to the south, the Tahltan lived in large semi-permanent villages, harvested the salmon runs, traded with the Coastal Tlingit, and were more socially complex than their Kaska neighbors.

Eastern Interior Tlingit. Eastern Interior Tlingit territory lies on the western edge of Y2Y north of the Tahltan

[8] The principle source which I have used for this review of the Dene people of the Subarctic is the Smithsonian Institution *Handbook of North American Indians*, Vol. 6, *Subarctic*, edited by June Helm (1981). A very useful recent book on Mackenzie Valley Dene history is Abel 1993.

and west of the Kaska. It encompasses Teslin Lake and the Nesutlin River, and the upper reaches of the Big Salmon River. The Interior Tlingit, like their coastal relatives, were socially complex with a clan structure, potlatching, and extensive trading with the coast.

Northern Tutchone. Y2Y also includes part of the territory of the Northern Tutchone bands in the Upper Yukon and its eastern tributaries, the Stewart, MacMillan, Pelly and Big Salmon rivers. The Northern Tutchone were caribou and moose hunters and salmon fishers living in semi-permanent villages. They were involved in trade through Southern Tutchone bands in the Southwest Yukon with the coastal Chilkat. The Tahltan, Interior Tlingit and Tutchone were all heavily impacted by the Gold Rush.

Han. Between the Northern Tutchone and the Gwich'in lie the Han, whose traditional territory centered on the Yukon from the Klondike River and Dawson City downstream to above Circle, Alaska. The Han were a relatively small group of hunters and fishers, whose settlements focused on the Yukon River and the salmon runs. Winter caribou hunting was important. The Gold Rush, epidemics and missionary activity had a major impact on their traditional culture and way of life at the turn of the century. Few Han traditions survived this intense period of white contact. The population dropped from around 1000 at contact to 300 people by mid-century.

Gwich'in. Y2Y ends in the Gwich'in's traditional territory, which extends eastward from the Yukon Flats and Fort Yukon across the Porcupine River drainage and Old Crow Flats to the Peel and Arctic Red River on the Mackenzie. The Gwich'in are comprised of nine regional bands living in various communities throughout their territory. They consider themselves to be "people of the deer (caribou)." Seasonal caribou hunting is of major significance to their life, as is river and lake fishing for salmon and other species. In pre-contact times they lived in semi-permanent villages. They and other nearby groups, such as the Koyukon, have until very recently retained a great deal of their traditional culture, values, ecological knowledge and oneness with the land (see Nelson 1983; Gwich'in Renewable Resources Board 1997). Interaction with whites until after the Second World War was limited and confined primarily to fur trading. Trapping still remains a mainstay for most Gwich'in families and communities today.

Archaeological sites are a very significant non-renewable cultural resource of the Y2Y. Large numbers of significant sites have been lost or impaired in the southern Y2Y over the last 100 years, both within and outside protected areas, as white settlement/land use focused on the same areas-the valley floors-as Native settlement had. These sites contain significant records not only of past Native peoples but also of the environment in which they lived and are invaluable to understanding the past and predicting the future.

Traditional Religious Belief And Sacred Geography [9]

Traditional religious belief and sacred geography encompasses the plants and animals, the landscape and its particular features, and the aspects of the climate within which a particular First Nation has lived for hundreds and thousands of years. "Sacred places," such as mountains, hills, rivers, springs, and rocks, play significant roles, both as the place where mythic/legendary events associated with the Creator occurred in mythic time and as wellsprings of visionary experience which resulted in sacred songs, objects and rituals—fundamental aspects of traditional religious belief and practice.

Traditional belief and sacred power

Native religious folk taxonomies generally partition the universe into human and "other than human" beings. The "others" reside or can be reached at certain places which play a focal role in traditional religious practice. These places are a source of inspiration, a place to access the sacred, and a source of sacred materials. Individual, group, and community religious activities may be carried out at these places. For example, among the Piikani, the word Matiapi, Piikani for person, is used as a transcendental term to refer not only to human beings but also spirits. "These may appear as people, animals, birds, plants, rocks, or places, or may change form back and forth. Thus a Matiapi may appear in human form giving power, assistance, or power objects to an individual, and then change into another form to show the receiver his true identity" (Raczka and Bastein 1986:19).

The traditional Native world view is cosmotheistic, holistic and transcendent. The secular is not separated from the sacred. Hence, place and the "other than human beings" who reside there—plants, animals, rocks, minerals, water, and other transcendent beings—are viewed as part of, and interrelated with, each other. All are one, and all are interdependent on each other for the continued well being of each, as well as the whole. They are sources/conduits of sa-

[9] For those readers interested in the comparative religious/anthropological approach to the subject of Native American religion, I would recommend Brown 1988, Hultkrantz 1981, and Vecsey 1990. Other excellent works of a regional nature are Harrod 1987 and 1996. For sacred sites and sacred geography see Carmichael et al. 1994 and the articles and references cited therein. On vision questing see Irwin 1994.

cred power for traditional believers, who individually and collectively may access these sources to help themselves, their families, or the larger community through religious ritual. Respect for "Nature" is fundamental to their traditional belief, for the Elders recognize that human beings are dependent upon "Nature" as is "Nature" on humans—all are part of one great interdependent community of beings.

Sacred power pervades the Universe and all the "beings" that inhabit it. The theological essence of cosmotheism, which extends to include the whole local ecosystem, is a moral principle. It is the fundamental article of faith:

> People, animals, plants, and other forces of nature—sun, earth, wind, and rock—are animated by spirit. As such they share with humankind intelligence and will, and thus have moral rights and obligations as PERSONS (Hunn 1990:230).

Sacred power reveals itself to humans through speech. "The being who speaks may be an object, such as a rock, or an animal form; or the being who speaks may take first the form of an animal and then become transmuted into a person; or the process may begin with a person who is transmuted into an animal." Speech also includes song. It is when the being speaks or sings that it becomes a source of sacred power (Harrod 1987:23-24).

Visionary experience is fundamental to traditional religious belief and practice. Sacred beings are experienced in both dream visions and waking visions. Dream visions are more common than waking visions. The most important and powerful form of dream vision is that received during a vision quest. Waking visions, while rare, are very powerful. Sometimes they are experienced simultaneously by more than one person. Humans share in the power which the transcendent beings possess through the transfer of power during the immediate visionary experience. Transfer is a matter of establishing a particular kinship relationship between humans and the sacred sources of power. Relationships and obligations are established between the human and the transcendent being who is often referred to as "father" or "mother" while the human's self-understanding is as "son" or "daughter."

The ability to transfer sacred power is a fundamental and characteristic feature of religions. In many traditional religions, like those of many Dene groups in the northern forest, it is a "one-on-one" relationship between the sacred being and the human and is not further transferable. In other religions, sacred power acquired by one person can be transferred to contemporaries as well as down through time to future generations. Among the Piikani, who have one of the most complex systems in the Y2Y, power which has initially been received by one person can be transferred to another person through a process of mediation in which the original relationship and obligations established in the original vision experience are transferred to another person. When the ritual and songs are transferred along with the sacred object(s) (which are generally enclosed within a bundle), the power inherent in the original vision becomes active in the experience of the receiving person.

Sacred geography

Sacred geographies relate to the visioning and origins of many focal aspects of traditional religion. These focal areas are places where traditional Native people experience the sacred through fasting and prayer. Sacred geographies are established gradually over many hundreds of years of people associating with a particular landscape/ecosystem. In North America there are hundreds of Native American sacred places, which is indicative of the long association of the peoples with their traditional lands. In contrast there are very few associated with Christian religion in North America.[10]

Native American religions are geographically/ecosystemically based. Sacred geographies are abstractions of much larger and complex all-encompassing holistic sacred ecosystems associated with specific tribal groups and their traditional territories. The symbolic boundaries established through religious tradition, originating in time-transgressive and perpetually renewing personal visionary experiences, provide a means that particular groups distinguish themselves from other societies in like environments. Through shared religious practice this sense of separate cultural/personal identity is maintained down through the generations.

Traditional religious practice within the First Nations' sacred geography give them a deep sense of place, identity, and continuity with past generations. Their social identity emerged, and continues to be reinforced, as a result of intentional acts of interpretation and reinterpretation within the shared religious tradition.

The traditional ritual year was seasonally and spatially structured, based in part on the movement of the game, fish runs, and plant harvests, so that group members had a shared and repeated experience of their surrounding territory. Sacred activities interpenetrate with and are viewed as one with secular activities. The success of these secular activities was preconditioned through carrying out the appropriate individual and group religious activities.

Transcendent beings resident/associated with a sacred geography and its particular sacred focal places are brought into contact with human beings through religious tradition and practice. These beings gave rise both to humans and to their particularly experienced world, including some (but usually not all) of its life forms. Productive relationships are established with these transcendent beings through rituals which produce results in the everyday world, in such activities as hunting, gathering, trapping, warfare, and other matters. Without this relationship, results would not be forthcoming.

Traditional Associations With The Y2Y

The First Nations' associations with their traditional territories are sacred and holistic and are based on thousands of years of association with the land. These traditional associations have been severed or severely diminished for many First Nations over the last 150 years, particularly in the south. In the north, traditional life styles developed during the fur trade survived among many Dene until the last 20 or so years. Today they are rapidly disappearing as younger generations no longer participate in the traditional subsistence economy. Despite an increasing number of community- and/or government-initiated programs to record traditional ecological knowledge and other aspects of traditional culture, traditional Elders are passing on, and the acculturative and destructive forces of white society on the young are such that, for most if not all First Nations of Y2Y, little of the old ways will survive the first century of the coming millennium.

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There is a common misperception that much of North America was unused or "practically unknown" prior to the arrival of Europeans. This belief is echoed in the famous 1963 "Leopold Report" to the U.S. National Park Service, which declared that each large national park should maintain or recreate a "vignette of primitive America," seeking to restore "conditions that prevailed when the area was first visited by the white man."

Unfortunately, the "vignette" envisioned by the Leopold Report captures only a portion of the picture. It excludes Native peoples who used these "wilderness" areas for generations and denies their role in creating and maintaining the diverse habitats originally observed by Europeans. As Anderson (1993:9) notes, "By dismissing the Indians, their plight and their knowledge, Muir and other early conservationists set the foundation for an environmental movement that has systematically disregarded the role of Indians as environmental managers and has perpetuated a myth of native North America as a virgin, untouched wilderness." [11]

Today, the myth of a "pristine wilderness" is waning with the growing realization that many habitats are not "natural," but resulted from, and are dependent upon, human interaction. Concomitant with this is an increasing appreciation for the depth and breadth of the traditional ecological knowledge retained by Native peoples throughout North America. Perhaps more importantly, western science is beginning to understand that the oral traditions of Native peoples contain much of value to the management of natural resources and the conservation of biodiversity, particularly in national parks and other "wilderness" areas. Gadgil et al. (1993:151) note:

> Indigenous peoples with a historical continuity of resource-use practices often possess a broad knowledge base of the behaviour of complex ecological systems in their own localities. This knowledge has accumulated through a long series of observations transmitted from generation to generation. Such "diachronic" observations can be of great value and complement the "synchronic" observations on which western science is based.

The great federal national parks of the southern Y2Y were and still are perceived as essentially "wilderness" in which the Native Americans played little or no role. It has only been within the last 10 years that co-management has been talked about in the southern parks. In the case of the U.S. National Park Service, and to a lesser extend the Bureau of Land Management and the U.S. Forest Service, this has come about primarily as a result of the passage by Con-

[10] See Carmichael et al. 1994; Swan 1990. Native sacred sites are a management concern in Y2Y. There is no overall understanding on a regional basis of the nature, extent, and complexity of sacred and traditional sites. Many sacred sites do not have an archaeological dimension (e.g. a vision quest site without a stone structure; or a traditional medicine or paint collecting place) and, as such, are not necessarily included within the legislation which protects archaeological sites, particularly within Alberta and British Columbia. Conflicts between resource development and sacred sites are occurring. Proposed energy development in the Badger-Two Medicine area of the Lewis and Clark National Forest, which was once part of the Blackfeet Reserve, conflicts with the traditional use of this area for vision questing (Historical Research Associates 1993; USDI Bureau of Land Management 1990). A similar conflict between energy development and traditional vision questing occurred in the Twin Peaks area south of the Peace in Northeastern British Columbia.

[11] See also Anderson and Nabhan 1991; Hunn 1993; Turner 1991; Lewis 1973, 1989.

gress of the Native American Graves Protection and Repatriation Act in the early 1990s, which mandated ethnographic, ethnobotanical and other studies involving First Nations of the national parks and other reserve areas as well as the inclusion of First Nations in the environmental impact review and assessment process.

In Canada, southern Y2Y First Nation knowledge is now only beginning to be recorded and taken into consideration in the national parks.[12] In the northern Y2Y, because the territories are federal lands, Parks Canada has worked more closely with Native groups both within and outside the national parks, involving them in some cases in the development of co-management strategies and active management of the parks. On a provincial level, British Columbia parks and land management agencies are much more involved with First Nations than are those in Alberta. Studies of traditional land use of forest lands in B.C. are being carried out and funded by the government of British Columbia. In north-central Alberta studies are being funded by the federal government and industry.[13] The government of Alberta appears to be particularly reticent in participating in or undertaking traditional studies.

How did/do First Nations traditionally relate to Y2Y lands and resources? To answer this question for each of some 30 First Nations whose traditional lands fall within Y2Y is beyond the scope of this paper. Indeed, for some First Nations far removed in time and space from their traditional lands, the question is beyond answering. Instead of attempting to generalize, I present two examples of First Nation traditional associations which exist in the Y2Y: the Piikani in the south and their association with the Crown of the Continent (specifically Waterton-Glacier National Peace Park); and the Mountain Dene and their association with the Mackenzie Mountains. Both Nations' associations extend back thousands of years, providing us with insights of what it was once like for all of Y2Y before the coming of the white man and his "gifts."

The Piikani and Waterton-Glacier International Peace Park [14]

Waterton-Glacier International Peace Park, with its spectacular landscapes, abundant wildlife, and diverse plant life, is in many Americans' minds one of the last remnants of "primeval wilderness" in the U.S. Rocky Mountains. Despite the strong image of Native Americans (specifically the Blackfeet) associated with the initial promotion and interpretation of Glacier, the park is often depicted as a relict of this once-great American wilderness in which Native Americans played little or no role, or as an area not occupied by Indians until very recently and then, at best, only peripherally. This image prevails today, despite the fact that for over 30 years, archaeologists and anthropologists have known that Native Americans have seasonally frequented this region of the Northern Rockies for the last 10,000 years.

The Piikani are long-time residents of these lands. Their oral traditions, sacred geography, archaeology, linguistics, and genetics indicate they have been here thousands of years. The eastern slopes of Glacier National Park and the Lewis and Clark National Forest to the south were part of the revised and smaller Blackfeet Reservation established by Congress in 1874. The mountains were ceded to the U.S. Government in 1897, becoming a national forest the following year. Glacier National Park was created in 1910. The South Piikani (Blackfeet) maintained traditional hunting, fishing, and logging rights while the land was national forest. They lost these once it became a national park. Their claims were later denied. Waterton Lakes National Park was part of the lands which the North Piikani (Peigan) had expected to receive when they signed Treaty 7 in 1877. These lands are part of their traditional land claim.

Piikani tradition says it was here in the Backbone (Mistakis—the Piikani name for the Rocky Mountains) that the three tribes—Kaina, Piikani, and Siksika—were created in the long ago time. Prior to becoming the Nitsitapii, tradition has it that they lived somewhere southwest of the mountains. The Piikani's relationship with these lands is a fundamental part of their traditional religion and way of life. Mistakis is most sacred to the Piikani Elders. Mistakis is a place of great power, where many sacred "doings" happened in the past and continue today. Mistakis is the place to vision quest,[15] the place where many sacred rituals and objects come from, the place with which many traditional accounts associate, and the place from which comes sacred materials: paints, animals, and plants.

Many fundamental aspects of Piikani traditional religion originated in and continue to be sustained by Mistakis. Medicine pipes come from the mountains. They are gifts to the Nitsitapii from Thunder. The first of the eight pipes—the Long Time Pipe—came from Ninastakis (Chief Mountain), where the most powerful of the Up-Above-People, including Thunder Bird, live.

The Beaver Bundle, the great tribal bundle of the Piikani and other Nitsitapii, was given to the First Piikani by the Beaver People at the Big North Inside Lake (Waterton Lake). Later, at the foot of the Big South Inside Lake (St. Mary), the Beaver People gave the tobacco seeds for this bundle.

[12] See Reeves and Peacock 1995a and 1995b for examples of national park-related ethnographic overviews.

[13] See Robinson and Ross 1977, Dene'Tha'Nation 1997, and Gwich'in Renewable Resources Board 1997 for discussion and examples of community-based studies; see also Brody 1988 for one of the first studies done in northeastern British Columbia.

[14] This section is summarized from Reeves and Peacock 1995a and 1995b.

These events happened thousands of years ago. These and other bundles have a wide variety of plants, animals, and other sacred materials within them which have specific associations with the bundle's origin and power. In most cases, these plants and animals are intimately linked with Mistakis in origin and ongoing ritual. Those materials used in the ceremonies must be collected from specific places in the mountains. Other sacred objects and ceremonies envisioned in the mountains include a number of sacred lodges and drums. The three sacred red paint collecting locales are in Mistakis: one is underwater in a Bureau of Reclamation Reservoir in the Lewis and Clark Forest, another is in Glacier National Park, and the third is on crown land in the Castle River area—known as Red Paint Place River to the Piikani—in Southwestern Alberta. Eagle trapping for sacred parts was an important activity along the golden eagle flyway adjacent to the Rocky Mountain Front.

An uncommonly rich body (oral accounts and written transcriptions) exists of Piikani stories of the mountains and the sacred animals: real bears (grizzlies), wolves, eagles, ravens, and others. Bear stories involving both real and spirit bears are most common, reflecting the importance of the bear and bear power in traditional Piikani religion. Piikani bear lore is the richest of any Native group in the southern Y2Y.

Vision quests occur at a number of locales, some of which are still used today. The mountain tops are the focus. In the older days, however, lakes, rivers, streams, and waterfalls were also important places. These places are the abode of the Under-Water-People who, like real bears, can be a source of great power and help to the Piikani. Certain peaks, particularly Ninastakis (Chief Mountain) are the favored places for vision questing. Many traditional Nitsitapii as well as traditionalists from other First Nations visit Ninastakis every year for both individual and collective religious observances. Archaeological evidence indicates that vision questing goes back over 8000 years.

The Piikani's ethnotophonmy (place names) focuses on the rivers, streams, and large valley lakes of the region, particular camping places, trails, and passes. Rivers often have multiple names referring to different places—fords, battles, buffalo jumps, etc. For example, names for today's St. Mary River included South Big Inside Lake River, Green Banks, Blue Banks, Many Chiefs Died Here, Banks Roped Together, and Bull Pound. Only specific mountains received individual names, reflecting their shape (Bear, Heart), color (Yellow, Red), secular (Sheep), or sacred significance (Ninastakis, "The Chief").

Winds and weather are critical elements to those who reside in this most windy place in all of Y2Y. The Piikani have specific names for many seasonal wind/weather patterns. English has adopted the Salish name "Chinook" for the warm and often violent winter winds. The Piikani have individual names for different kinds of chinooks. They also say the chinook winds originate at the head of the Big Inside Lakes and are result of Napi or Under Water Buffalo breaking wind.

The Piikani's traditional ecological knowledge is extensive. They have a rich vocabulary for birds, naming many different species. They named all the major mammals, separating some by age, gender and race; for example, plains and mountain bison. Their ethnobotanical knowledge is the most extensive of any First Nation in the region, reflecting in part the unique nature of the plant communities of Mistakis, which include a number of western species not found elsewhere on the eastern slopes. Over 80 plants were or still are collected in and adjacent to the national parks. Of these, 41 have uses as foods, 66 as medicinals, 25 as spirituals, and 48 for a variety of purposes.

The Piikani are of the opinion that the plants in the parks are bigger and have more power than do those outside. This is in fact the case, as the soils are richer and precipitation higher in the mountains than in the foothills to the east. The Piikani have a well developed set of plant management techniques that, in traditional times, ensured a continued supply of plants for food and medicinal and spiritual purposes. While the Elders appreciate the role the parks have played in protecting the plants from overgrazing by cattle and horses, many are frustrated and concerned about having to "sneak in" to obtain the plants. They also express the opinion that the plant collecting places are not doing as well as they used to—other species are crowding in and competition is increasing. The Elders say this is happening because there is no one there to look after these places in a traditional manner through selective harvesting of older plants, "weeding," and burning. Elders recall stories of their grandparents camping in the valleys of Mistakis over a hundred years ago before the confinement of the people to the reserves. Interestingly enough, it is at this same time that the fire-return interval changed in the montane forests along the east slope valley of Waterton-Glacier.

Shu'tagot'ine (Mountain Dene) [16]

The ancestors of today's Dene peoples of the Northwest Territory, Yukon, Alaska, and British Columbia were residents of these unglaciated lands during the last Ice Age. Many of the contemporary Dene groups have a rich oral history with stories of reversing rivers, giant lakes, floods, giant animals, and even the ice barrier itself. Mountain Dene Elder Gabe Echinelle tells of a time:

[15] Over 70 vision quest sites have now been recorded in the Crown of the Continent area. See Dormaar and Reeves 1993 for a discussion of the types and locations of vision quest sites within the area.

> Long ago, the north had all of the dangerous animals. Down south there was nothing. If it went like before "down south" would have winter and there would still be places to live here in the north. The animals (from those times) still dream and travel. [17]

After the end of the Ice Age these people began to spread southward out of Beringia, arriving east of the Mackenzies around 6000 years ago (Hanks 1997:179, citing Clark 1991 and Morrison 1987). Later migrations, some related to the White River volcanic explosion(s), also occurred. The settling of the migrants, together with earlier Dene residents, resulted in the evolution of the present Dene groups in the Mackenzie.

"Two brother tales" are central to the oral traditions of the Dene groups of the Mackenzie. These stories account for the origin of the Dene. The good brother, the law giver, known as Yamoria to the Mountain and Bear Lake Dene, is responsible for ordering the landscape throughout Denehdeh. Yamoria stories recall events and creatures relating back to the end of the last Ice Age.

Bear Rock, a small peak at the end of the Norman Range of the Franklin Mountains, is a very prominent landmark on the east bank of the Mackenzie River. It was here during the most ancient time when the giant people lived that Yamoria slew the giant beavers after chasing them down the Nahani or the Great Bear River. The impression of the three beavers' bodies can be seen today on the side of the rock. A medicine spring on the west face attests to the sacred nature of this place. These narratives provide an explanation for the origin of the landscape in the deeds of Yamoria. Today Bear Rock is used by the Dene Nation to symbolically express their unity, appearing as a central device in their logo.

These and other stories reflect the fundamental Dene view that the old world dominated by giant animals was changed to the new world safe for people by the actions of the culture heroes. Death and rebirth of the Dene world appears at least once more in the narratives, associated with the events surrounding the eruption of the White River Volcano 1250 years ago. Death and rebirth is also central to Dene religious belief concerning the acquisition of individual medicine powers.

The traditional lands of the Mountain Dene straddle the Mackenzie Mountains. An ancient trail system dating back to the beginning weaves across the land, linking a maze of resources, including Mackenzie River whitefish and inconnu fisheries, stone quarries at a variety of places, salt licks with associated Dall sheep snare fences, mountain lake fisheries, caribou drift fences in the mountain passes, caribou winter yards, calving grounds, moose "nests," and beaver ponds on the Yukon side, and the salmon fishery in the Ross and Stewart rivers (Hanks 1994:51, citing Hanks and Pokotylo in press and Ebutt 1931).

The trails provide not only a physical but a metaphorical and sacred link between the people and their land. The campsites, resource harvesting areas, sacred places, and stone quarries along the trails are named and related in the Dene travel narratives. Red Dog Mountain and Sheep Mountain are very important sacred sites along the major trail system over the mountains.

Red Dog Mountain on the Keele River separates the Mackenzie Mountain foothills from the Mackenzie Valley. The Keele hugs its vertical south face as it enters the valley. Waters from a sacred spring on this face drop down into the Keee. The Dene say these waters are the last trace of the time when the Keele flowed under Red Dog. Red Dog's cave is on the face of the mountain.

The Red Dog Mountain story addresses the problems the Mountain Dene had in descending the Keele River. Set in mythical times when animals and people could speak, the story tells of a medicine man who struck a deal with the giant Red Dog to free the Keele from the cliffs and let people pass out of the Mackenzie Mountains without portaging. As a result the people agreed to pay homage to the Red Dog. His spring became a source of medicine and prophesy. This is the second of the three most important Mountain Dene medicine springs (the third is near Twitya Lake). The Red Dog story is part of the cycle of stories involving legendary medicine people rather than mythical giants such as Yamoria making the landscape safe for the people.

The most significant stone quarry for the Mountain Dene is located along the trail in the Tertiary Hills in the Mackenzie Mountain foothills southwest of Fort Norman. It is the source of a high quality fine-grained fused siliceous clinker. Used for some 10,000 years by the people of the Mackenzie, there is a Yamoria story associated with it, in which Yamoria slays some giant grasshoppers at this place, making the stone safe for the Mountain Dene to use. In the Slavey version he not only made it safe but also spread the stone in streams about the country. To remember his deeds, offerings are made when the stone is collected. Not to exchange gifts could lead to the stone being taken away by the spirits

[16] This discussion is taken largely from Chris Hanks's 1994 and 1997 studies on Mountain Dene (with thanks for his permission). Hanks's 1997 publication deals with the Bear Rock and is taken from his 1994 study for the National Historic Sites Directorate of Parks Canada. Other important published works on the Dene and their traditional knowledge and spirituality include George Blondin's stories of the Dene (1990, 1997), Robin Riddington's work with the Dunne-za (Beaver People) of the Fort Nelson Area (1988, 1990), and Richard Nelson's classic study of Koyukon traditional ecological knowledge and spirituality (1983).

[17] Hanks (1994:44-45). This story was given to Chris Hanks by Elder Gabe Echinelle in 1992.

who live in it. Thus the Dene insure against natural events such as landslides, floods, and other natural occurrences which might take away their stone. Knowledge of the quarry and the stories were passed on to young people by their parents through narratives associated with the trail. This quarry remained an essential place to collect strikes-a-lights well into this century, even after metal implements had replaced the uses of the fused clinker during the fur trade.

Drum Lake, the largest alpine lake in the Mackenzie Mountains, located between the Keele and Moose Horn rivers, was a focal settlement and resource harvesting locale for the Mountain Dene. Sheep Mountain is located in the center of Drum Lake. It is the home of the giant Dall sheep's spirit. He lives in a cave. The sheep protects a place of great natural wealth. (Spirit animal guardians are common among the Dene and other Native peoples). Drum Lake has a rich fishery which is used from spring to fall. Sheep are hunted in the summer and fall in the high country. The old dried up lake bed adjacent to today's lake is rich moose habitat. In the winter, the Moose Horn caribou herd yards in the region. Despite its richness, the Drum Lake camp was not used every year as it was necessary to rest the land.

Despite an increasing number of community- and/or government-initiated programs to record traditional ecological knowledge and other aspects of traditional culture, traditional Elders are passing on, and the acculturative and destructive forces of white society on the young are such that, for most if not all First Nations of Y2Y, little of the old ways will survive the first century of the coming millennium.

Drum Lake was where Yats'sule, the last of the traditional Mountain Dene chiefs and prophets, and his people lived. Born in the 1870s, Yats'sule perceived by the mid-twentieth century the changes which again threatened his people (they had sucessfully adapted to the fur trade). To prepare his people for the challenges to come he dreamed a song cycle of 52 drum songs, seeking in his last years to establish a moral basis for his people to cope with an uncertain future. He died after finishing his last song.

Today some young people among the Mountain Dene continue to seek visions in their traditional mountain homeland and follow the traditional ways and values taught in Yats'sule's drum songs. Talk continues among traditional people of spirit mountains which appear and disappear, the healing power of the springs, the medicines, the prophets of the past, and those today who have medicine power. Medicine power, Elder George Blondin (1997:51-52) says,

> ...is a spirit, with a mind of its own...we borrow it. A person can't control this spirit. It comes with its own rules or policy, so the owners have to follow those orders and live carefully by them, or they could be killed by their own medicine powers....Strong medicine people know how the earth and the heavens operate and how to tap their forces. It seems that their powers come from energy or natural forces on the earth and in the universe, powers placed there by the Creator.

Dreaming Y2Y

To the First Nations of Y2Y, many of whom have resided here since the Creator recreated/reordered the world 10,000 years ago, time is not linear. Time cycled forward—yet successive generations remained connected with the lands and their beginnings through the retelling of the oral traditions and the medicine powers received through visionary experience. By maintaining the proper order of the world through proper respect and attention to the other beings, they ensured that what the Creator had put upon this earth would continue for the benefit of all of Creation.

Knowledge and power are one. The First Nations lived by knowing how to integrate their lives with those of the sentient beings around them, whether they be animals, plants, springs, lakes, rivers, rocks, or the mountains. The truths of life for these peoples are essential and unchanging from generation to generation. Mythic events are the essential truths. They are not contingent events like history which happen once and are forever gone; rather, mythic events return again and again like the birds in spring. They are shared across time/space by succeeding generations and give the fundamental meaning to life (Riddington 1990:11-12). First Nations view human life as in and fundamentally inseparable from nature.

In speaking of the future of the Dene—but equally applicable to the white man—Elder George Blondin says, "I think we will need some spiritual help to make it into the future....I believe nothing is ever completely lost, it is just forgotten" (Blondin 1997:233). He is hopeful, as some of the young people have begun to dream again. So must our society begin to dream again and recreate our relationships with all beings if Y2Y is to survive until the end of this interglacial cycle, when it will once more be recreated by the Creator.

Literature cited

Abel, K. 1993. Drum songs: glimpses of Dene history. McGill-Queen's University Press, Montreal.

Anderson, M. K. 1993. The experimental approach to the assessment of the potential ecological effects of horticultural practices by indigenous peoples on California wildlands. Ph.D. Diss., Department of Wildland Resource Science, University of California, Berkeley.

Anderson, K., and G. P. Nabhan. 1991. Gardeners in Eden. Wilderness, Fall 1991.

Azevedo, W. L., ed. 1986. The Great Basin. Handbook of North American Indians, Vol. 11. Smithsonian Institution, Washington, D.C.

Barrett, S. W. 1996. The historic role of fire in Waterton Lakes National Park, Alberta. Final report on file, Waterton Lakes National Park.

Blondin, G. 1990. When the world was new: stories of the Sahtu' Dene. Outcrop, Yellowknife.

Blondin, G. 1997. Yamoria the lawmaker. NeWest Publishers Limited, Edmonton, Alberta.

Brody, H. 1988. Maps and dreams. Indians and the British Columbia frontier. Douglas and McIntyre, Vancouver, B.C.

Brown, J. E. 1988. The spiritual legacy of the American Indian. Crossroad Publishing, New York.

Carmichael, D. L., J. Hubert, B. O. K. Reeves, and A. Sanche, eds. 1994. Sacred sites, sacred places. Routledge, London.

Clark, D. 1991. Western subarctic prehistory. Canadian Prehistory Series. Canadian Museum of Civilization, Ottawa, Ont.

Clark, E. E. 1966. Indian legends from the northern Rockies. Vol. 82 in The Civiliation of the American Indian Series. University of Oklahoma Press, Norman, Okla. and London.

Despain, D. G. 1990. Yellowstone vegetation: consequences of environment and history in a natural setting. Roberts Rinehart, Boulder, Colo.

Dene Tha' Nation. 1997. Dene Tha' traditional land-use and occupancy study. Arctic Institute of North America, Calgary

Dormaar, J. F., and B. O. K. Reeves. 1993. Vision quest sites in the southern Canadian and northern Montana Rockies. Pages 162–178 *in* Kunaitupii: coming together on native sacred sites. B. O. K. Reeves and M. A. Kennedy, eds. Archaeological Society of Alberta, Calgary.

Ebbut, F. 1931. The Gravel River Indians. Canadian Geographic 2(4):310–321.

Fischer, T. G., and D. G. Smith. 1994. Glacial Lake Agassiz: Its northwest maximum extent and outlet in Saskatchewan (Emerson Phase). Quat. Sci. Rev. 13:845–858.

Gadgil, M., F. Berkes, and C. Folke. 1993. Indigenous knowledge for biodiversity conservation. Ambio 22(2–3):151–156.

Greiser, S. T., and T. W. Greiser. 1993. Blackfoot culture, religion, and traditional practises in the Badger-Two Medicine Area and surrounding mountains. Final Report for Lewis and Clark National Forest, Great Falls, Mont.

Grinnell, G. B. 1892. Blackfoot lodge tales. Charles Scribner and Sons, New York.

Gwich'in Renewable Resources Board. 1997. Nanh' kak geenjit Gwich'in ginjik. Gwich'in words about the land. Gwich'in Renewable Resources Board, Inuvik.

Hanks, C. C. 1994. Bear Rock, Red Dog Mountain, and the Windy Island to Sheldon Lake trail: proposals for the commemoration of the cultural heritage of Denendeh, and the history of the Shu'tagot'tine. National Historic Sites Directorate, Parks Canada Contract #1632-929220, Ottawa, Ont.

Hanks, C. C. 1997. Ancient knowledge of ancient sites: tracing Dene identity from the late Pleistocene and Holocene. Pages 178–189 *in* G. P. Nicholas and T. D. Andrews, eds. At a cross roads: archaeology and First Peoples in Canada. Archaeology Press. Simon Fraser University, Burnaby.

Hanks, C. C., and D. Pokotylo. In press. Mountain Dene in situ and the impact of European contact on Mackenzie Drainage Athapaskan land use patterns. Pages 000–000 *in* J. Van Stone, B. Shaw, and R. Harritt, eds. Culture contact in Arctic and Subarctic areas of Asia and North America. University of Alaska Press, Fairbanks.

Harris, H. 1997. Remembering 10,000 years of history: the origins and migrations of the Gitskan. Pages 190–196 *in* G. P. Nicholas and T. D. Andrews, eds. At a cross roads: archaeology and First Peoples in Canada. Archaeology Press. Simon Fraser University, Burnaby.

Harrod, H. L. 1987. Renewing the world. University of Arizona Press, Tucson.

Harrod, H. L. 1996. Becoming and remaining a people. University of Arizona Press, Tucson.

Helm, J. 1981. The Great Basin. Vol. 11, Handbook of North American Indians. Smithsonian Institution, Washington, D.C.

Historical Research Associates. 1993. Blackfoot culture, religion, and traditional practices in the Badger-Two Medicine area and surrounding mountains. Report on file, Lewis and Clark National Forest, Great Falls, Mont.

Hultkrantz, A. 1981. Belief and worship in Native North America. Syracuse University Press, Syracuse, N.Y.

Hunn, E. S. 1990. Nch'i-Wana "The Big River." Mid-Columbian Indians and their land. University of Washington Press, Seattle.

Hunn, E. S. 1993. What is traditional ecological knowledge? Pages 13–15 *in* N. M. Williams and G. Baines, eds. Traditional ecological knowledge: wisdom for sustainable development. Centre for Resource and Environmental Studies, Australian National University, Canberra.

Irwin, L. 1994. The dream seekers. Native American visionary traditions of the Great Plains. University of Oklahoma Press, Norman.

Kehoe, A. B. 1992. North American Indians: a comprehensive account, 2nd ed. Prentice-Hall, Englewood Cliffs, N.J.

Lewis, H. T. 1973. Patterns of Indian burning in California: ecology and ethnohistory. Ballena Press Anthropological Paper No. 1, Ballena Press, California.

Lewis, H. T. 1989. Ecological and technological knowledge of fire: Aborigines versus park rangers in Northern Australia. American Anthropologist 91:940–961.

Morrison, D. 1987. The middle prehistoric period and the archaic concept in the Middle Mackenzie Valley. Can. J. Archaeology 11:49–74

Nelson, R. K. 1983. Make prayers to the raven: a Koyukon view of the northern forest. University of Chicago Press, Chicago.

Raczka, P. M., and L. Bastein. 1986. Cultural impact survey of the Peigan Indian Reserve. Manuscript submitted to the Peigan Band Administration, Brocket, Alberta.

Reeves, B. O. K. 1990. Communal bison hunters of the northern plains. Pages 168–194 *in* L. B. Davis and B. O. K. Reeves, eds. Hunters of the Recent Past. Unwin and Hyman, London.

Reeves, B. O. K. 1994. Ninastakis (Chief Mountain): the Nitsitapii's sacred mountain. Pages 265–295 *in* D. Carmichael, J. Hubert, B. Reeves, and A. Sanche, eds. Sacred spaces, sacred places. Routledge, London.

Reeves, B. O. K., and S. Peacock. 1995a. "Our mountains are our pillows": an ethnographic overview of Glacier National Park. Final Report, U.S.D.I. National Park Service, Rocky Mountain Regional Office, Denver.

Reeves, B. O. K., and S. Peacock. 1995b. Waterton Lakes National Park ethnoarchaeological study. Preliminary Report 1994. Report on file, Waterton Lakes National Park.

Riddington, R. 1988. Trail to heaven. Douglas and McIntyre, Vancouver, B.C.

Riddington, R. 1990. Little Bit Know Something. Douglas and McIntyre, Vancouver, B.C.

Robinson, M. P., and M. .M. Ross. 1997. Traditional land use and occupancy studies and their impact on forest planning and management in Alberta. The Forestry Chronicle 73(5):596–602.

Ruby, R. H., and J. A. Brown. 1992. A guide to the Indian tribes of the Pacific Northwest. University of Oklahoma Press, Norman.

Smith, D. G., and T. C. Fisher. 1993. Glacial Lake Agassiz: the northwestern outlet and paleoflood. Geology 21:99–12.

Swan, J. A. 1990. Sacred places: how the living earth seeks our friendship. Bear and Company, Santa Fe.

Turner, N. J. 1991. Burning mountainsides for better crops: Aboriginal landscape burning in British Columbia. Archaeology in Montana 32(2):57–73.

U.S., Dept. of Interior, Bureau of Land Management. 1990. Proposed oil and gas drilling near Badger Creek and Hall Creek. Final Environmental Impact Statement, Lewis and Clark National Forest, Great Falls, Mont.

Vecsey, C., ed. 1990. Religion in Native North America. University of Idaho Press, Moscow.

Wissler, C., and D. C. Duvall. 1908. Mythology of the Blackfoot Indians. Anthropology Papers, Vol. 2, Part II. American Museum of Natural History, New York.

Economic Trends in the Yellowstone to Yukon Region: A Synopsis

Ray Rasker and Ben Alexander

Background

This chapter is a summary of the findings of a larger report entitled *The New Challenge: People, Commerce and the Environment in the Yellowstone to Yukon Region*. It is a summary of the economic and demographic conditions in the United States and Canadian portions of the Yellowstone to Yukon (Y2Y) region. In *The New Challenge* we rely on published statistics on employment, income and demographic trends made available through federal, state and provincial agencies. We have supplemented this data with stories about communities and individuals in order to lend a human face to the statistics, and to help explain the implications of certain trends. We have also searched relevant literature in economics, geography, demographics, ecological economics, and rural development to compare the trends in the Y2Y region to other areas around the world, and to compare our interpretation of the data with that of other specialists.

In addition to highlighting important economic and demographic trends, the report also asks some tough questions of environmentalists. For example, in aggregate the Y2Y region has grown beyond a sole dependence on resource extraction, and much of the growth is stimulated by business owners, retirees and entrepreneurs who have decided that living in the Rockies—close to recreation, spectacular scenery and wildlife—is important to their quality of life. The beauty of places like Bozeman, Montana or Canmore, Alberta is an economic asset that stimulates growth. On the surface this shows that conservation and development are complementary, but a deeper look at this trend in "amenity-based growth" begs several questions: Who wins and who loses when an economy makes a transition away from resource dependency? What type of political opposition is created when not all people benefit from growth? And, from an environmental perspective, is growth the same as sustainable development? Is the growth we are seeing today, with its associated urban sprawl and high levels of resource consumption, any less threatening to wildlife conservation and our quality of life than clearcuts or mines?

The beauty of places like Bozeman, Montana or Canmore, Alberta is an economic asset that stimulates growth. On the surface this shows that conservation and development are complementary, but a deeper look at this trend in "amenity-based growth" begs several questions: Who wins and who loses when an economy makes a transition away from resource dependency?

The purpose of *The New Challenge* is therefore to highlight recent changes in the economy, refute common myths about the economic "base," and wake us up to new challenges.

Findings

In *The New Challenge* we document in geographic detail the long-term trends in population, and income and employment by industry. We do this at a scale that includes individual counties (U.S.), clusters of counties, census divisions (Canada) and clusters of census divisions that follow the boundaries of the Y2Y region. In the space allowed for this chapter of *A Sense of Place*, a few typical examples illustrate the transition that has taken place. As examples we have chosen the U.S. portion of Y2Y, in aggregate, and the Alberta and British Columbia portions of Y2Y, also in aggregate. Those looking for details on the Yukon or Northwest Territories, or for a finer geographic scale, should refer to *The New Challenge*. That report also includes references used in this synopsis.

Figure 1 shows where the growth has been in the U.S. portion of Y2Y (an aggregate of all counties). The most significant trend in the last 25 years has been that 46% of the growth in personal income came from non-labor income sources, commonly referred to as money earned from past investments and retirement income. In 1995, $13.8 billion in personal income in the U.S. portion of Y2Y was from non-labor sources, representing 36% of all income. To put this in perspective, this is more than 20 times the income earned in farming and ranching ($691 million) and more than 11 times the income earned in mining, oil and gas, and lumber and wood products combined ($1.1 billion). The only major industry grouping that comes close in size is services and professional industries ($14 billion and a growth of $7.8 billion since 1970).

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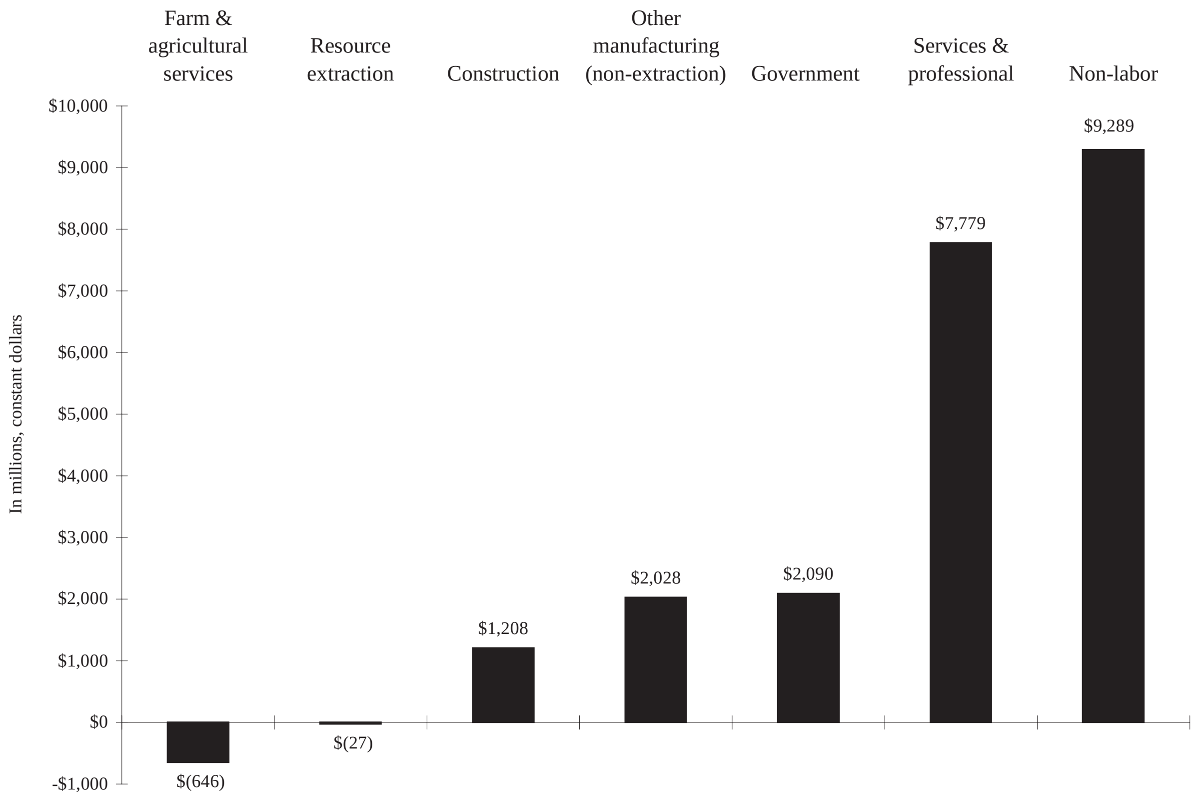
Figure 1. New personal income by category, U.S. counties of Y2Y, 1970 to 1995.

Source: Bureau of Economic Analysis. 1997. Regional Economic Information System (REIS CD-ROM), U.S. Department of Commerce, Washington, DC.

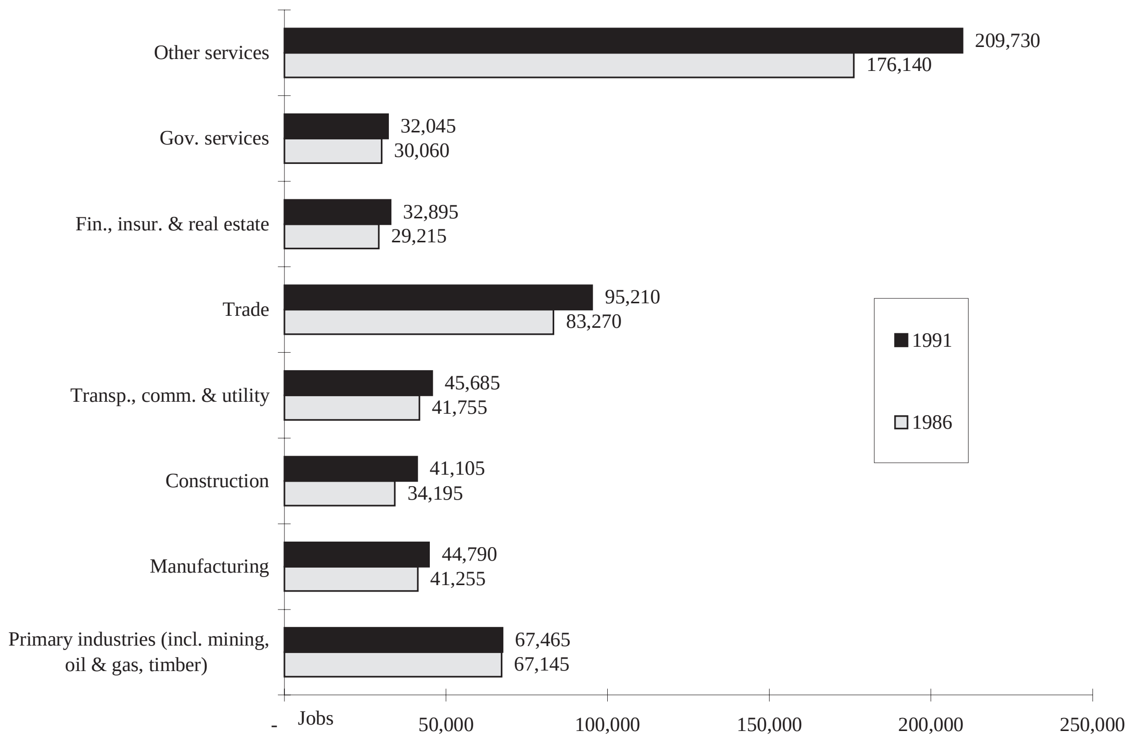


The population of the U.S. portion of Y2Y has grown from 1.6 million in 1980 to 1.7 million in 1990 and more than 1.9 million in 1995. This represents a 7% growth during the 1980s and a 14% growth in the first half of the 1990s (an average annual rate of 2.8% from 1990 to 1995). These figures show a remarkable turnaround, especially in some of the rural counties where resource industries have been in decline. During the 1980s, 27 of the 69 counties (39%) lost population. From 1990 to 1995 only 3 counties (4%) lost population, while many others had phenomenal growth rates.

Figure 2 shows that for the census divisions corresponding to the Alberta portion of the Yellowstone to Yukon region the fastest growing employment category is in service-related occupations. From 1986 to 1991, over 65,000 new jobs were created in this sub-region of Y2Y. Over 33,000 new jobs were created in other services, which includes business, education, health and social services, as well as accommodation, food and beverage services. Other fast growing sectors in the same time period include wholesale and retail trade (trade), with 11,940 new jobs, and construction, with 6,910 new jobs. Other areas of employment growth include manufacturing, transportation, communications, and utilities, finance, insurance, real estate, and government services. The only sectors that were relatively stagnant are the so-called primary industries: logging and forestry, mining, oil and gas, agriculture and agricultural services, fishing and trapping. Collectively these industries grew by ½ of a percent from 1986 to 1991, adding only 320 new jobs. This means that over 99% of new jobs were in industries not

Figure 2. Changes in employment by industry, 1986 and 1991 (latest figures), combined census divisions for the Alberta portion of the Yellowstone to Yukon region.

Source: Statistics Canada. 1986 & 1991 Census. Industry Canada, Ottawa, Ontario.



related to resource extraction or agriculture. These findings are the same as those for the U.S. portion of Y2Y. While these industries contribute little to employment growth, the rest of the economy is growing and diversifying. The economy of the Y2Y region of Alberta is clearly driven by something other than resource industries alone.

In 1991, 19% of total personal income in the Y2Y portion of Alberta was from non-labor sources, up from 17% in 1986. During that time the unemployment rate dropped and the average income, in real terms, increased from C$23,372 to C$23,692. Similar to the U.S., the population growth in the 1990s was faster than in the 1980s. From 1981 to 1991 the census divisions of the Alberta portion of Y2Y added over 148,000 new people, at an average annual rate of 1.7% per year. From 1991 to 1996 the region added another 90,916 people, at an average rate of 1.8% per year, faster than the province as a whole (1.2% per year).

Figure 3 shows the change in jobs by industry from 1986 to 1991 for the British Columbia census divisions that most closely fit within the Y2Y boundaries. Note that during that time only the resource extractive "primary industries" lost employment. While logging, oil and gas, mining and agriculture collectively lost 470 jobs, the rest of the sectors collectively added over 19,000 jobs. The fastest growth sectors were in service-related sectors (10,350 new jobs), trade (3,505 new jobs) and construction (3,055 new jobs). 22% of the personal income in 1991 was from non-labor sources, the same as it was a decade ago.

The relative decline in resource extractive industries does not mean average income has declined. To the contrary:

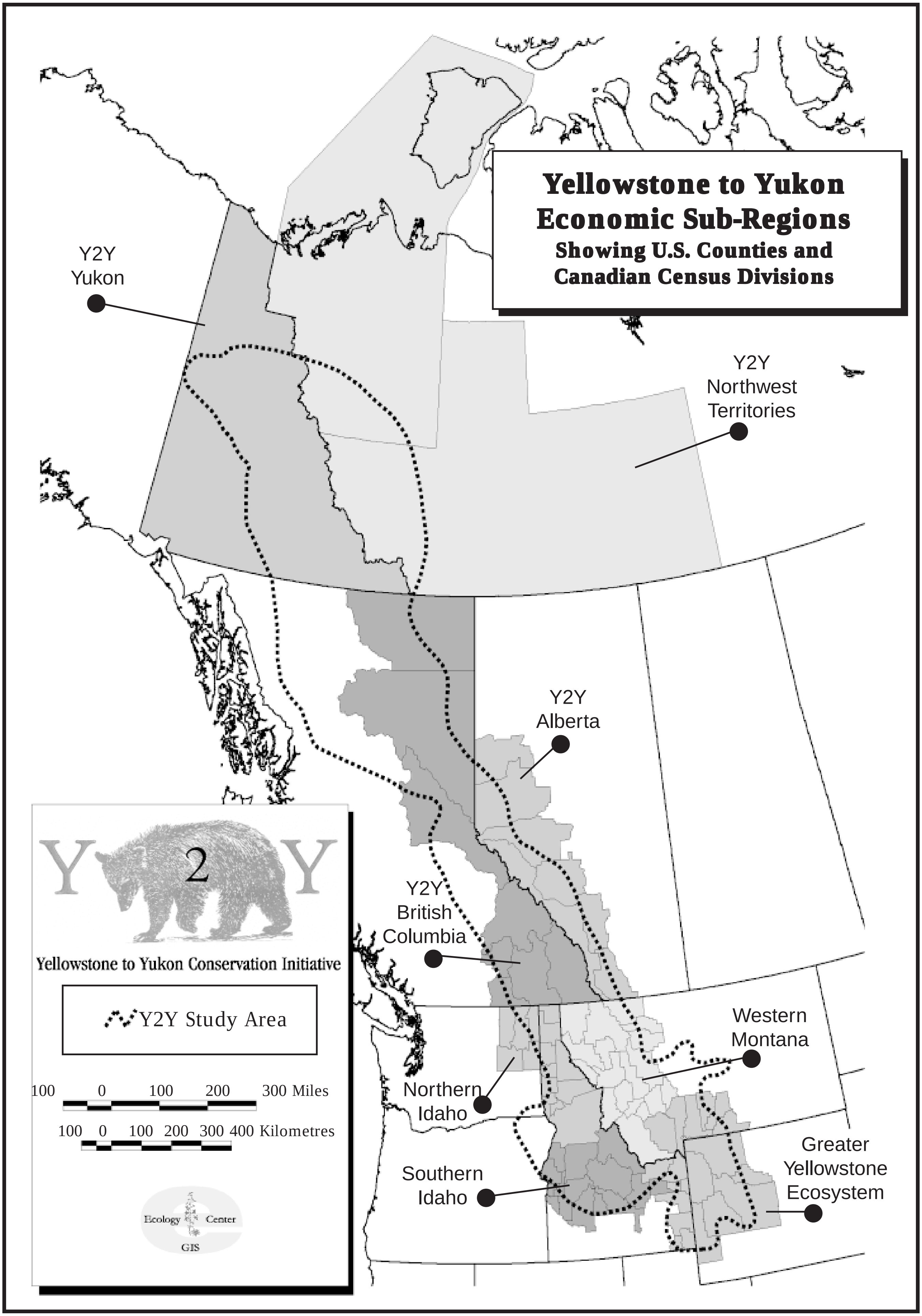
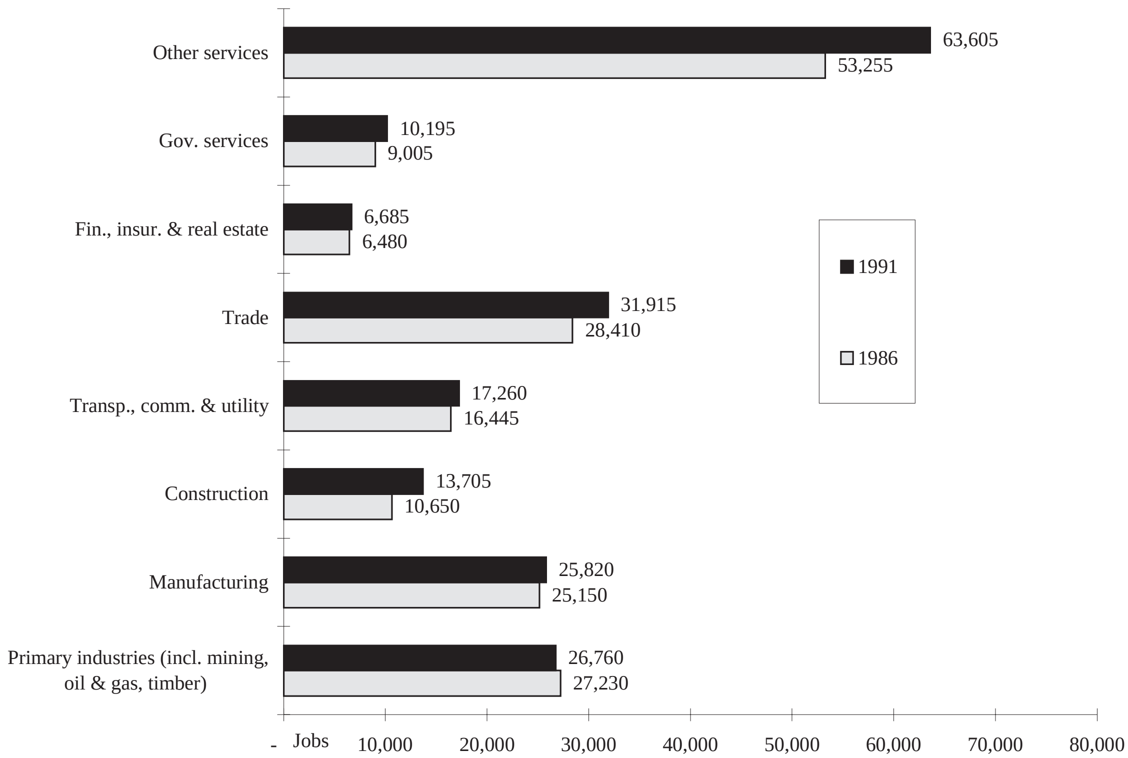

Yellowstone to Yukon
Economic Sub-Regions
Showing U.S. Counties and
Canadian Census Divisions
Y2Y
Yukon
Y2Y
Northwest
Territories
Y2Y
Alberta
Y2Y
British
Columbia
Western
Montana
Northern
Idaho
Greater
Yellowstone
Ecosystem
Southern
Idaho
Y 2 Y
Yellowstone to Yukon Conservation Initiative
Y2Y Study Area
100 0 100 200 300 Miles
100 0 100 200 300 400 Kilometres
Ecology Center
GIS

Figure 3. Changes in employment by industry, 1986 and 1991 (latest figures), combined census divisions for the British Columbia portion of the Yellowstone to Yukon region.

Source: Statistics Canada. 1986 & 1991 Census. Industry Canada, Ottawa, Ontario.



adjusted for inflation, average income increased by 7.6%, from C$23,173 in 1986 to C$24,926 in 1991. During that time unemployment rates dropped from 15.8% to 11.9%. Similar to U.S. trends, the population also grew much faster in the late 1990s than in the 1980s. In the 1980s, four of the census divisions in the B.C. portion of Y2Y lost population. In aggregate, the population of the B.C. Y2Y region was stagnant. From 1990 to 1995, in contrast, all of the census divisions added population, for an average annual growth rate of 2.1%. This is slightly slower than the province as a whole (2.7% per year), but faster than the nation (1.1% per year).

Implications for conservation

It is important to note that although the data presented in The New Challenge are the most recent available, they are somewhat dated, and U.S. and Canadian sources are not directly comparable. They are most useful, therefore, to analyze trends to see if they shed some light on the degree of resource dependency in the region. Specifically, when employment in the resource extractive industries declines, do other sectors also decline in size? Do the unemployment rates go up? Do wages decline? And what happens to the population? If industries like mining, oil and gas, and forestry are defined as the wealth-producing "basic" or "primary" industries, then the implication is that other (secondary) industries, such as finance, real estate, trade, banking, etc. will rise and fall, being pulled along by the primary sectors. The data clearly show that this is not the case.

In the U.S. and Canadian portions of the Y2Y region several important trends are evident: (1) a rapid population turnaround in the 1990s, (2) high growth in industries other than those that historically supported the region, such as mining, oil and gas development and logging, (3) a rapid growth in service-related sectors, and (4) high growth in non-labor income sources like retirement and investment income. Even in so-called resource-dependent communities, the growth in the economy has occurred in the face of declining employment in historically important sectors like mining, forestry and agriculture. This means that no longer are the traditional resource-dependent sectors the horse pulling the cart. The economic base has broadened considerably.

Many factors influence why an economy grows. An aging population contributes to a higher demand for health and other local services. An influx of urban refugees and a decline in out-migration results in a tighter housing market, a rapid rise in construction, and new vitality in sectors like real estate, banking, finance, and retail trade. This growth also pushes up the demand for government services, which in turn pushes up government-related employment and the development of infrastructure like roads and schools. A rise in the stock market and the accumulated wealth of the World War II generation results in a higher measure of non-labor income. Some of these people choose to retire or run their business in a rural setting in the Rockies. Add to this the development of telecommunications and delivery services like UPS and FedEx, and it seems plausible that much of what a country makes can be done in the form of a scattered assembly line, with the engineer living in Boise, Idaho, the architect in Bozeman, Montana, and the freelance graphic artist in Canmore, Alberta, while the clients may live in New York or Toronto. On top of all of this, many places like Banff, Alberta and Jackson, Wyoming have booming tourism industries. In short, the causes of economic growth are varied.

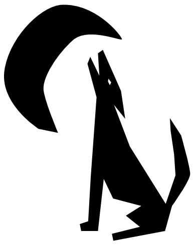
The key challenge is to manage growth in a way that protects both the values of the community and the integrity of the ecosystem, to think of development as an increase in quality. Instead of recruiting outside businesses to open shop in town, for example, a sustainable development approach would focus on making existing businesses more successful and long-lasting. In this view, a community would not promote itself unless it first has in place strategies for protecting social and natural amenities. The health of the environment and quality of life in a community are one and the same.

Surveys, as well as a large body of literature on development, are making it clear that among the varied reasons for economic growth, one of the significant determinants of people's decisions to live in a particular place is the quality of life, which includes a healthy environment. This means that environmental protection is good for business. It keeps existing businesses from leaving and attracts newcomers, including retirees and entrepreneurs. The environment is an asset that helps diversify the economy and insulate it from the boom-and-bust cycles of the past. Saying that the environment plays a significant role in development, however, should not imply that there is no role for resource extraction. All it means is that land uses that damage the environment, whether mining or urban sprawl, actually weaken the economy in the long run.

The economic expansion of most of the Y2Y region can mean increased economic opportunities and a wider choice of jobs than in the days when the mines and lumber mills were the only game in town. Growth means more choices, and a move away from the boom-and-bust cycles of resource extraction. Many in the emerging field of ecological economics and proponents of sustainable development, however, have pointed out that economic growth is not the same as sustainable development, and the results of this report validate this view. The faster communities grow, the more they seem to destroy the very qualities that stimulated the growth in the first place. The process has amounted to trading quality for quantity. Bozeman, Montana and Canmore, Alberta are good examples of what can happen when a community grows beyond its base of agriculture or resource extraction. The price of success is too much growth, resulting in the loss of open space and valuable wildlife habitat to make room for new migrants and people who want a home next to the river or in the mountains. What sets a successful, sustainable community apart, more than anything else, is the pace and scale of development.

The lesson for conservationists in the Yellowstone to Yukon area is that if the argument is made that wild land protection is good for the economy, then we must explicitly acknowledge that by "good for the economy" we mean growth. This is not the same as sustainable development. The key challenge is to manage growth in a way that protects both the values of the community and the integrity of the ecosystem, to think of development as an increase in quality. Instead of recruiting outside businesses to open shop in town, for example, a sustainable development approach would focus on making existing businesses more successful and long-lasting. In this view, a community would not promote itself unless it first has in place strategies for protecting social and natural amenities. The health of the environment and quality of life in a community are one and the same.

Human Threats in the Yellowstone to Yukon



Michael Sawyer

An assessment of current and future threats to the ecological integrity of the Y2Y bioregion requires an understanding of the character, extent and intensity of human activity within the region. The Y2Y bioregion has had a relatively short occupation by non-indigenous settlers, but during that brief period human use of the area has increased significantly. Within the Y2Y, industrial extractive activities known to have landscape-level environmental effects include coal, placer and hard rock mining, oil and gas exploration and development, industrial forestry, and agriculture, primarily domestic livestock grazing. The bioregion is intensively used for many forms of recreational activities. These human activities all warrant consideration when conducting an assessment of the threats to the ecological integrity of the Y2Y. The following sections provide brief overviews of the extent and intensity of human activities in the Y2Y.

Forestry

Forest harvesting has occurred in the Y2Y bioregion since at least the 1870s. Early logging was concentrated in the southern portions of the bioregion, primarily in response to demand for lumber for the mining and railway industries. Large scale commercial forest harvesting did not begin in the bioregion until the 1930s; since then, particularly since the 1960s, logging became increasingly extensive and intensive. The 1996 combined annual allowable cut (AAC) from public lands within the Y2Y bioregion was 17.8 million cubic meters (4.4 MMBF) (USDA Forest Service 1997a; B.C. Ministry of Forests 1992, 1993a-b, 1994a-b, 1995a-f; Alberta Environmental Protection 1997). No accurate estimates are available for volumes harvested from private lands within the bioregion. British Columbia and Alberta respectively account for approximately 49% and 43% of the region's AAC. Extrapolating from the AAC, it is estimated that more than 590 km^2 of forest are harvested annually in the Y2Y bioregion. As only half of the entire Y2Y bioregion supports productive forests, and little harvesting currently occurs in the Yukon and Northwest Territories, this disturbance is concentrated onto a land base of approximately 400,000 km^2.

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Oil and gas

Oil and gas have been produced in the Y2Y bioregion since 1890 when oil production began in western Wyoming (USDI Geological Survey 1996). Since that time most areas with suitable geology have been explored, and where petroleum resources have been discovered in economic quantities, production has occurred. The eastern fringe of the Y2Y bioregion has demonstrated the greatest potential for economic discoveries (USDI Geological Survey 1996; Alberta Energy and Utility Board 1997). This area includes those portions of the Overthrust Belt and the Western Canadian Sedimentary, Williston, and Bighorn Basins immediately adjacent to the eastern fringe of the main ranges of the Rocky Mountains. Exploratory activity is occurring in other areas as well.

Limited amounts of oil have been discovered or produced within the Y2Y. To date, a total of 4.98 billion barrels of oil (BBO) have been produced in the Y2Y, 3.48 BBO from the oil-producing basins east of Yellowstone National Park (Beeman et al. 1996; Charpentier et al. 1996) and 1.5 BBO from Alberta and northeast British Columbia (Alberta Energy and Utility Board 1997; B.C. Ministry of Employment and Investment 1996). Geologists currently estimate that an additional 2.5 BBO remain to be discovered in the U.S. portion of the Y2Y (Beeman et al. 1996; Charpentier et al. 1996), while an additional 1.1 BBO may be found in Alberta and northeast British Columbia (National Energy Board 1994).

Significant quantities of natural gas have been discovered in the Y2Y bioregion. To date, a total of 28.6 trillion cubic feet (Tcf) of natural gas has been produced in the Y2Y: 7.5 Tcf from Montana and Wyoming (USDI.Geological Survey 1996), 9.9 from British Columbia (B.C. Ministry of Employment and Investment 1996), and 11.2 Tcf from Alberta (Alberta Energy and Utility Board 1997). Total remaining proven reserves of natural gas are 17.1 Tcf, of which 13.5 Tcf are in the eastern slopes of Alberta and British Columbia. Geologists speculate that 94.6 Tcf of marketable natural gas remains undiscovered in the Y2Y bioregion: 29.3 Tcf in Montana and Wyoming (USDI Geological Survey 1996; Beeman et al. 1996; Charpentier et al. 1996), 33.2 Tcf in Alberta (Alberta Energy and Utility Board 1997), and 31.9 Tcf in northeast British Columbia (B.C. Ministry of Employment and Investment 1997).

To put these numbers into perspective, consider that to date, an estimated 51,000 oil or natural gas wells have been drilled in the Y2Y (B.C. Ministry of Employment and Investment 1996; Alberta Energy and Utility Board 1996; USDA Forest Service 1997d, USDI Bureau of Land Management 1997). Eighty percent of those have been drilled along Alberta's eastern slopes. Each well requires construction of an average of 6.7 m of seismic line and 3.2 km of road (Mayhood 1997). These estimates are for developed oil and gas fields; remote exploratory wells can require considerably more linear disturbance. If the well is successful, pipelines, powerlines and gas processing plants must be constructed. A minimum of 163,200 km of roads and 341,700 km of seismic lines have been constructed in the Y2Y as a result of historical oil and gas activities.

Production and consumption of natural gas, within both the U.S. and Canada, has increased dramatically in the past decade (National Energy Board 1994, Energy Information Administration 1996). This has resulted in increased industry activity to replenish reserves that are being rapidly depleted through ongoing production. Industry and government studies have predicted that approximately 2.7 times the number of existing wells will have to be drilled before the year 2015 just to maintain current rates of natural gas consumption in North America (Sproule Associates Limited 1997). This translates into an additional 137,000 wells being drilled within the Y2Y within the next 20 years. That predicted level of drilling will result in an additional 918,000 km of seismic line and 438,000 km of road being constructed within the Y2Y, mostly within the eastern slopes of Wyoming, Montana, Alberta, and British Columbia. In light of the current levels of habitat fragmentation within the natural gas-bearing regions of the Y2Y, this anticipated future activity constitutes a very significant threat to the ecological integrity of the affected areas of the Y2Y.

Industry and government studies have predicted that approximately 2.7 times the number of existing wells will have to be drilled before the year 2015 just to maintain current rates of natural gas consumption in North America.

Agriculture

The Y2Y bioregion has a long history of agricultural activity, particularly livestock grazing. In 1996 a minimum of 1.5 million animals were grazed in the Y2Y bioregion, including 1.2 million cattle, 41,000 horses, and 174,000 sheep (Alberta Agriculture 1992; B.C. Ministry of Forests 1995g; USDA Forest Service 1997b). These numbers do not, with the exception of data for Alberta, include livestock grazed on private lands, and so are a conservative estimate of grazing intensity. These numbers represent approximately 7.5 million animal unit months (AUMs) of grazing. Alberta (including private lands) has the largest portion of the livestock found within the Y2Y, with 961,000 cattle, 30,000 horses and 114 ,000 sheep, for a total of 1.1 million animals or 77% of the livestock found in the Y2Y (Alberta Agriculture 1992). British Columbia has a considerably smaller livestock herd with 85,000 cattle, 4,000 horses, and 10,000 sheep, for a total of 108,000 animals or 8% of the livestock found in the Y2Y (B.C. Ministry of Forests 1995g). On national forests in the U.S. portion of the Y2Y, roughly 186,000 cattle, 4,000 horses, and 25,000 sheep are grazed, for a total of 215,000 animals or 15% of the livestock found in the Y2Y (USDA Forest Service 1997b).

Recreation and tourism

The Y2Y bioregion has long been renowned for its outstanding recreational opportunities. The bioregion has been and continues to be intensively used for recreational activities including hunting, fishing, camping, horseback riding, and off-highway vehicle driving. Unbridled recreational use can be a threat to the ecological integrity of the bioregion.

In 1996, a total of 77.5 million visitor days of recreational activity occurred on the national and provincial forests within the Y2Y bioregion: 41.5 million visitor days of recreational activity in the Montana, Idaho, and Wyoming national forests (USDA Forest Service 1997c), 15 million visitor days in Alberta's provincial forests, and 21 million visitor days in British Columbia's provincial forests (B.C. Ministry of Forests 1995g). Of the total visitor use on these public lands, 5.3 million (6.8%) visitor days were spent hunting, 17.3 million (22.3%) visitor days were spent fishing, 14.6 million (18.8%) visitor days were spent using motorized vehicles for recreation, and 4.9 million (6.3%) visitor days were spent participating in wilderness-dependent recreational activities (B.C. Ministry of Forests 1995g; USDA Forest Service 1997c).

These statistics do not include visitor days associated with the 10 national parks found in the bioregion. In 1996, recreational use in these national parks totaled 36.9 million visitor days. The seven Canadian national parks accounted for 20.4 million visitor days (Canadian Heritage 1997a) and the three U.S. national parks accounted for 16.5 million visitor days (USDI National Park Service 1997). The total estimated recreational use of both national parks and national or provincial forests in 1996 in the Y2Y bioregion was 114.4 million visitor days.

To determine if a trend exists in recreational use, 1996 visitor statistics from the national parks were compared to 1988 data from the same parks (Canadian Heritage 1997b; USDI National Park Service 1997). The comparison showed that, with the exception of Glacier National Park, all national parks had experienced an increase in visitation between 1988 and 1996. In the Canadian national parks visitation increased a staggering 96% over the past decade, while in the U.S. national parks the increase was a more modest 12% over the same period. The results from the Canadian national parks are somewhat skewed by the growth in visitation to Banff National Park, from 0.7 million visitor days in 1988 to 11.3 million visitor days in 1996. Growth in demand for all forms of recreation can be expected in the future in the Y2Y bioregion.

Effects of human activities

Environmental effects associated with human use of the Y2Y have been widely documented (Alberta Environmental Protection 1996; Noss and Cooperrider 1994). They include widespread habitat fragmentation and destruction; creation of edge; increased sedimentation in streams due to higher run-off and erosion along linear disturbances; net loss of nutrients; watershed erosion; microclimatic changes; soil damage, especially via compaction and erosion; changes in water table levels; contamination of surface and groundwater and soil; alteration of natural processes (e.g., changes in normal succession pattern, suppression of fire, altered species composition, skewed age class distributions, and simplified structural diversity of the original forested landscape); increased risk of wildlife mortality, both direct and indirect; displacement of wildlife through disturbance; changes in vegetation diversity and age structure; degradation of local and regional air quality; and green house gas emissions and the potential ecological consequences of global climate change.

Literature cited

Alberta Agriculture. 1992. Alberta 1991 farm census. Alberta Agriculture Statistics Branch, Edmonton, Alberta. 34pp.

Alberta Energy and Utility Board. 1996. Alberta well list. Alberta Energy and Utility Board, Calgary, Alberta. 324pp.

Alberta Energy and Utility Board. 1997. AEUB statistical series 97-18: Alberta's hydrocarbon reserves. Alberta Energy and Utility Board, Calgary, Alberta. 324pp.

Alberta Environmental Protection. 1996. Prospects for protection: the Foothills Natural Region of Alberta. Alberta Environmental Protection, Natural Resources Service, Recreation and Protected Areas Division, Edmonton, Alberta. 192pp.

Alberta Environmental Protection. 1997. Approved "net" conifer and deciduous annual allowable cut by forest management unit. Unpublished agency data. Alberta Environmental Protection, Land and Forest Service, Edmonton, Alberta. 4pp.

B.C. Ministry of Employment and Investment. 1996. Oil and gas in British Columbia statistics 1986-1996. B.C. Ministry of Employment and Investment, Victoria, B.C. 4pp.

B.C. Ministry of Employment and Investment. 1997. Hydrocarbon and by-product reserves in British Columbia. B.C. Ministry of Employment and Investment, Victoria, B.C. 183pp.

B.C. Ministry of Forests. 1992. Fort Nelson TSA timber supply analysis. B.C. Ministry of Forests, Victoria, B.C. 62pp.

B.C. Ministry of Forests. 1993a. Kootenay Lake TSA timber supply analysis. B.C. Ministry of Forests, Victoria, B.C. 74pp.

B.C. Ministry of Forests. 1993b. Revelstoke TSA timber supply analysis. B.C. Ministry of Forests, Victoria, B.C. 77pp.

B.C. Ministry of Forests. 1994a. Dawson TSA timber supply analysis. B.C. Ministry of Forests, Victoria, B.C. 64pp.

B.C. Ministry of Forests. 1994b. Robson Valley TSA timber supply analysis. B.C. Ministry of Forests, Victoria, B.C. 72pp.

B.C. Ministry of Forests. 1995a. Mackenzie TSA timber supply analysis. B.C. Ministry of Forests, Victoria, B.C. 67pp.

B.C. Ministry of Forests. 1995b. Fort St. John TSA timber supply analysis. B.C. Ministry of Forests, Victoria, B.C. 79pp.

B.C. Ministry of Forests. 1995c. Golden TSA timber supply analysis. B.C. Ministry of Forests, Victoria, B.C. 50pp.

B.C. Ministry of Forests. 1995d. Prince George TSA timber supply analysis. B.C. Ministry of Forests, Victoria, B.C. 59pp.

B.C. Ministry of Forests. 1995e. Cranbrook TSA timber supply analysis. B.C. Ministry of Forests, Victoria, B.C. 73pp.

B.C. Ministry of Forests. 1995f. Invermere TSA timber supply analysis. B.C. Ministry of Forests, Victoria, B.C. 84pp.

B.C. Ministry of Forests. 1995g. Forest, range & recreation resource analysis 1994. B.C. Ministry of Forests, Victoria, B.C. 308pp.

Beeman, W. R., R. C. Obuch, and J. D. Brewton. 1996. Digital map data, text and graphical images in support of the 1995 national assessment of United States oil and gas resources—results, methodology, and supporting data. U.S. Geological Survey Digital Data Series DDS-35. U.S. Dept. of the Interior, Geological Survey, Washington. D.C. CD-ROM.

Canadian Heritage 1997a. Western region attendance stats—1996. Unpublished agency data. Canadian Heritage, Alberta Region, Business Services Group, Calgary, Alberta. 2pp.

Canadian Heritage 1997b. Western region attendance stats—1988. Unpublished agency data. Canadian Heritage, Alberta Region, Business Services Group, Calgary, Alberta. 2pp.

Charpentier, R. R., T. R. Klett, R. C. Obuch, and J. D. Brewton. 1996. Tabular data, text and graphical images in support of the 1995 national assessment of United States oil and gas resources—results, methodology, and supporting data. U.S. Geological Survey Digital Data Series DDS-36. U.S. Dept. of the Interior, Geological Survey, Washington, D.C. CD-ROM.

Energy Information Administration. 1996. Natural gas 1996—issues and trends. Energy Information Administration, Office of Oil and Gas, U.S. Dept. of Energy, Washington, D.C. 174pp.

Mayhood, D. W. 1997. Roads for oil and gas exploration and development in the Western Canada Sedimentary Basin: the magnitude of the problem. Rocky Mountain Ecosystem Coalition Research Report 97-1, Calgary, Alberta. 10pp.

National Energy Board. 1994. Canadian energy: supply and demand 1993 - 2010. National Energy Board, Calgary, Alberta. 276pp.

Noss. R. F., and A. Y. Cooperrider. 1994. Saving nature's legacy: protecting and restoring biodiversity. Defenders of Wildlife and Island Press, Washington, D.C. 416pp.

Sproule Associates Limited. 1997. The future natural gas supply capability of the Western Canada Sedimentary Basin. Prepared for TransCanada Pipelines Limited, Calgary, Alberta. 100pp.

U.S., Dept. of Agriculture, Forest Service. 1997a. Timber cut and sold—Region 1, fiscal year 1996. Unpublished agency data. USDA Forest Service, Missoula, Mont. 4pp.

U.S., Dept. of Agriculture, Forest Service. 1997b. Annual range management information summary—Region 1, fiscal year 1996. Unpublished agency data. USDA Forest Service, Missoula, Mont. 15pp.

U.S., Dept. of Agriculture, Forest Service. 1997c. State summary of total recreation use on national forest system lands by activity—Region 1, fiscal year 1996. Unpublished agency data. USDA Forest Service, Missoula, Mont. 42pp.

U.S., Dept. of Agriculture, Forest Service. 1997d. Mineral and geology program summary. Region 1, fiscal year 1996. USDA Forest Service, Missoula, Mont. 12pp.

U.S., Dept. of the Interior, Bureau of Land Management. 1997. Annual report, fiscal year 1996 Montana/Dakotas BLM. U.S. Dept. of the Interior, Bureau of Land Management. Billings Mont. 28pp.

U.S., Dept. of the Interior, Geological Survey, 1996. 1995 National assessment of United States oil and gas resources—results, methodology, and supporting data. U.S. Geological Survey Digital Data Series DDS-30 Release 2. U.S. Dept. of the Interior, Geological Survey, Washington D.C. CD-ROM.

U.S., Dept. of the Interior, National Park Service. 1997. Summary of use statistics for Glacier, Yellowstone and Grand Teton national parks—FY 1996. Unpublished agency data. U.S. Dept. of the Interior, U.S. National Park Service, Washington, D.C. 3pp.

Cumulative Effects of Human Activity in the Yellowstone to Yukon

By Michael Sawyer
and Dave Mayhood[1]

An environmental impact is the negative effect on a resource of some change in the environment. A cumulative impact is the total accumulated effect on the resource of all environmental changes. The concept is an important one. It holds that, while individual impacts may be small in themselves, the overall impact of all environmental changes affecting the resource taken together can be significant. Moreover, successive environmental changes may damage an ecosystem not only in an additive way, but in complex ways that are difficult to predict beforehand and difficult to measure after the fact. This is because biological processes are rarely linear over wide ranges of conditions, but typically have thresholds beyond which they fail to operate or break down entirely. When a resource is near a threshold, a small change can drive it over the edge.

An example of a threshold phenomenon important in conservation biology is the minimum viable population, the smallest population of a given species that has a high probability of persisting indefinitely despite the foreseeable effects of chance events and natural catastrophes. Should a population be near its minimum viable size, even a small impact could extirpate it. It has been postulated that whole ecosystems may have a critical viable size as well. It is the threshold phenomenon, coupled with the smallness of the individual impacts, that makes the problem of cumulative impacts so insidious. Each small bit of damage in itself might well be insignificant, but the cumulative damage is just as real as if it had occurred suddenly from some dramatic and obvious change.

There are three important implications of a commitment to prevent cumulative environmental impacts. First, there are no minor environmental impacts. Even if an environmental effect is judged acceptable or unavoidable for some reason, at some point the cumulative damage from repeated acceptable/unavoidable changes will be unacceptable. Second, because it is the natural condition of the ecosystem that must be used as the baseline against which cumulative impacts are measured, (not any presently existing, partially damaged condition), determining what the natural condition of the landscape and its ecosystems are (or might have been) is one of the principal objectives of a regional cumulative effects assessment. Third, due to our imperfect understanding of complex natural systems that make up the Y2Y bioregion, we cannot know with certainty when a threshold may be breached.

In this paper the density of linear disturbance is used as a proxy for cumulative effects. There are several reasons for adopting this approach. First, human use of the Y2Y has resulted in the construction of an extensive network of roads, trails, seismic lines, pipelines, and powerlines. Regardless of why or where these activities occur in the bioregion, they can result in long-lasting and extensive damage to vegetation, soils, and wildlife populations. Second, there is a growing body of literature that we can use to assist us in interpreting disturbance densities. Finally, using disturbance densities for assessing the health of the Y2Y simplifies cumulative effects assessment greatly.

Linear disturbances in the Y2Y

Within the Y2Y there are currently 676,957 km of linear disturbance (enough to go around the earth 16.8 times). The average linear disturbance density is 0.54 km/km^2. While this disturbance density may seem low, it is noteworthy that over 620,000 km^2 or 48% of the total area of the Y2Y is comprised of lands in the Yukon and Northwest Territories and northern British Columbia. These areas are relatively pristine and have very low disturbance densities. As a result the actual mean linear disturbance density for the balance of the Y2Y landscape is approximately 1.0 km/km^2. Those areas in the southern half of Y2Y that are not within existing protected areas have much higher mean disturbance densities because of the arithmetic effects of large national parks and wilderness areas on mean disturbance densities. The table below shows the area of lands within the Y2Y in various density classes.

Disturbance Density Class	Area (km2)
0 km/km2	800,205
>0 to 1.0 km/km2	108,466
>1.0 to 2.0 km/km2	118,725
>2.0 to 5 km/km2	104,886
>5.0 km/km2	10,920

Michael Sawyer is Executive Director of the Rocky Mountain Ecosystem Coalition. Dave Mayhood is President of Freshwater Research Limited.

1 Using data provided by Bill Haskins of the Ecology Center, Inc.

Another perspective on the extent of disturbance in the Y2Y can be had by considering the extent of linear disturbance by watershed. The total Y2Y area is encompassed in 320 5th- or 6th-order watersheds, of which 28 are entirely roadless. At the opposite end of the spectrum is the Latornell River basin in Alberta with a mean linear disturbance density of 4.5 km/km^2. Within that range, 176 watersheds have linear disturbance densities between 0.0 and 1.0 km/km^2; 79 watersheds have linear disturbance densities between 1.0 and 2.0 km/km^2; and 35 watersheds have linear disturbance densities greater than 2.0 but less than 5.0 km/km^2. All but four of the watersheds with linear disturbance densities greater than 2.0 km/km^2 occur in Canada, predominantly in Alberta.

An analysis of inter-regional differences in disturbance densities indicates that generally, the highest densities are expected in areas where intensive forestry and oil and gas activities occur concurrently. These areas fall within the Y2Y portion of the western Sedimentary Basin in northeastern British Columbia and along Alberta's east slopes. Areas where forestry occurs in the absence of oil and gas activity also tend to be heavily roaded but generally not to the same extent. An analysis of disturbance densities in the Alberta portion of Y2Y found mean disturbance densities of 2.7 km/km^2 and maximum densities in excess of 8.0 km/km^2.

It is the threshold phenomenon, coupled with the smallness of the individual impacts, that makes the problem of cumulative impacts so insidious. Each small bit of damage in itself might well be insignificant, but the cumulative damage is just as real as if it had occurred suddenly from some dramatic and obvious change.

What do these densities of linear disturbance mean for conservation planning in the Y2Y? To put that question into perspective, consider that the U.S. Forest Service (USFS) has developed a grizzly bear habitat effectiveness model based on road densities which shows the erosion of habitat effectiveness as road densities increase. At road densities of 0.8 km road/km^2, habitat effectiveness is reduced to 50%; at road densities of 1.6 km road/km^2, habitat effectiveness is further reduced to 25%. The USFS established a management goal of maintaining habitat effectiveness in occupied grizzly bear habitat at 80% of its potential. To meet this standard, road densities in occupied grizzly bear habitats should be maintained at below 0.3 km/km^2. Notwithstanding apparently low mean disturbance densities in the Y2Y as a whole, average habitat effectiveness for grizzly bears may be below 70%.

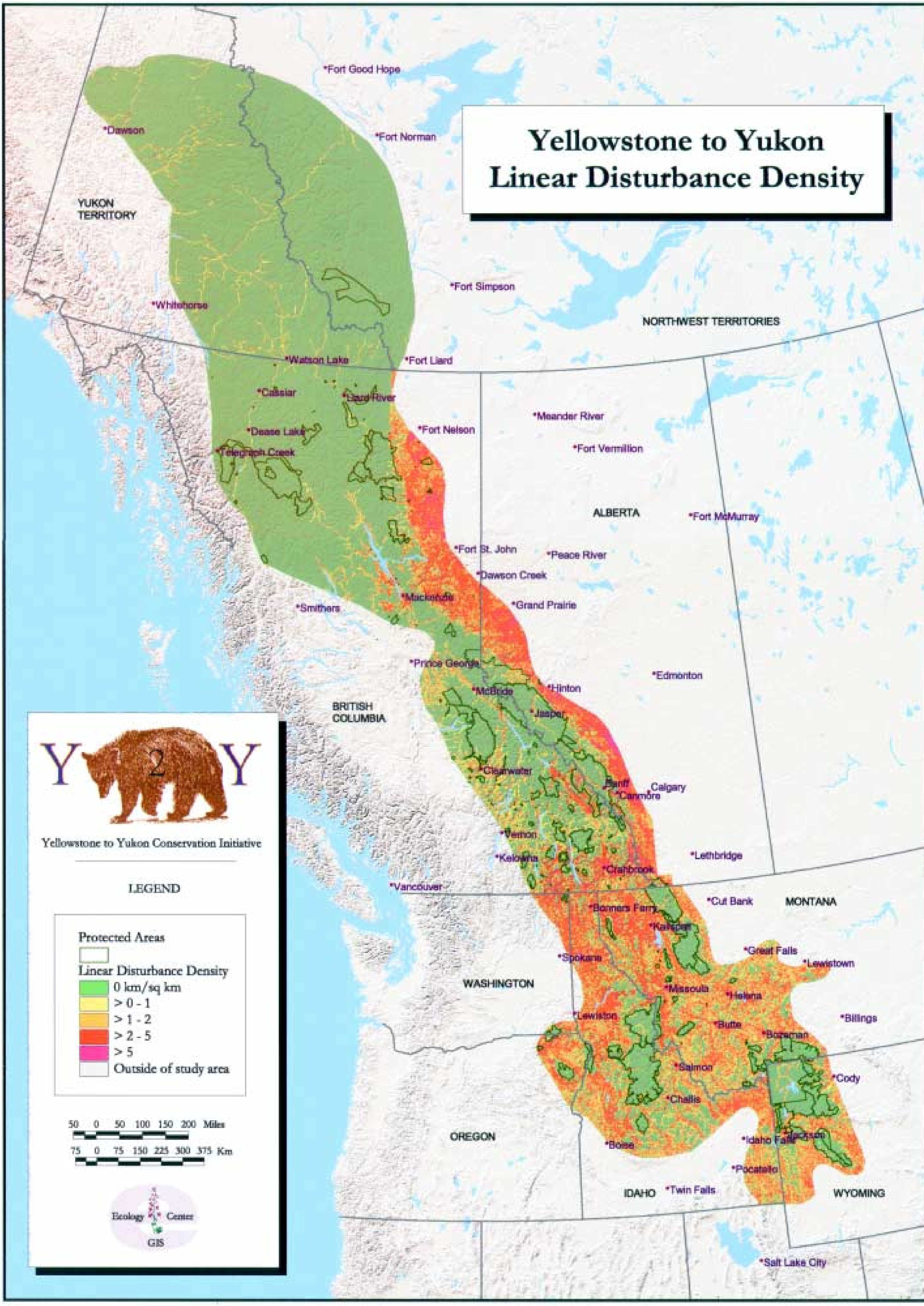
In some areas in the southern half of Y2Y outside of existing protected areas, average habitat effectiveness for grizzly bears is below 25%. This low level of habitat effectiveness likely has serious implications for large carnivore conservation efforts.

Core areas

Core areas were calculated by buffering all linear disturbances by 500 m and eliminating all resulting areas that were less than 10 km^2. This analysis resulted in 931,746 km^2 or 72% of the Y2Y being identified as core areas. The mean core area size was 426 km^2 and the maximum core area was a 182,493 km^2 area in the central Yukon, extending across the border into unroaded country in the Northwest Territories. As with disturbance densities, these results should be interpreted with caution, as they are heavily skewed by the large unroaded areas found in the Yukon, Northwest Territories and northeastern British Columbia. Although a separate analysis of the core areas in the southern half of the Y2Y has not been completed, it is expected that they will be considerably smaller than their northern counterparts. An analysis of core areas along Alberta's east slopes (but excluding national parks) determined that in the Alberta portion of Y2Y there were less than 900 core areas, with a mean size of 22 km^2 and maximum size of 932 km^2 (associated with the Willmore Wilderness north of Jasper National Park). These results are probably more representative of the southern areas of Y2Y.

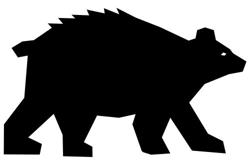
Conclusions

Clearly much more work needs to be done on the varying patterns of human disturbance across the Y2Y landscape and the effect that disturbance has on the ecological integrity of the region. Fully accepting that conclusion, this preliminary disturbance inventory indicates that bear populations in the southern half of Y2Y are living in a highly fragmented landscape with greatly reduced habitat effectiveness. In the northern Y2Y, habitat effectiveness and core area analysis indicates that there is currently sufficient habitat for viable grizzly bear populations, but that these areas do not currently have adequate protected areas (core areas) to ensure that future development pressures will not result in the loss of those areas of secure grizzly habitat.


Yellowstone to Yukon
Linear Disturbance Density
Y 2 Y
Yellowstone to Yukon Conservation Initiative
LEGEND
Protected Areas
Linear Disturbance Density
0 km/sq km
> 0 - 1
> 1 - 2
> 2 - 5
> 5
Outside of study area
50 0 50 100 150 200 Miles
75 0 75 150 225 300 375 Km
Ecology Center
GIS
YUKON TERRITORY
NORTHWEST TERRITORIES
BRITISH COLUMBIA
ALBERTA
WASHINGTON
OREGON
IDAHO
MONTANA
WYOMING
Fort Good Hope
Dawson
Fort Norman
Fort Simpson
Whitehorse
Watson Lake
Fort Liard
Cassiar
Liard River
Dease Lake
Fort Nelson
Telegraph Creek
Meander River
Fort Vermillion
Fort McMurray
Fort St. John
Peace River
Dawson Creek
Mackenzie
Grand Prairie
Smithers
Prince George
Edmonton
McBride
Hinton
Jasper
Clearwater
Banff
Canmore
Calgary
Vernon
Kelowna
Lethbridge
Cranbrook
Vancouver
Cut Bank
Bonners Ferry
Kalispell
Great Falls
Spokane
Lewistown
Missoula
Helena
Lewiston
Butte
Billings
Bozeman
Salmon
Cody
Challis
Jackson
Idaho Falls
Boise
Pocatello
Twin Falls
Salt Lake City

CONSERVATION, SPECIES AND NATURAL PROCESSES

Large Carnivore Conservation



Stephen Herrero

Grizzly bears, wolverines, wolves, cougars and other large carnivores are the essence of the wild landscapes that Y2Y seeks to protect in the Rocky Mountains of Canada and the United States. Populations of these carnivore species have already been extirpated from the most developed portions of the Rocky Mountains. But throughout the rest of the Rocky Mountains and the Mackenzie Mountains—the Y2Y landscape—the indigenous large carnivores still survive. They are one of the defining elements in this landscape, adding mystery and fascination, and, with regard to bears, wolves, and cougars, an element of challenge. For conservation-oriented scientists and land use planners, large carnivores help to define ecological integrity and the challenge of maintaining complex natural systems.

Within the last 100 years, grizzly bears, wolverines and wolves were still represented in the southern Rocky Mountains of the United States. Today, in the Rocky Mountains in the United States, they survive as potentially viable populations only in a few protected portions of the northern Rockies (Ruggiero et al. 1994). In Canada most carnivores have been reduced in number and habitat in developed areas such as major portions of the Rocky Mountain foothills in Alberta (Banci 1991; Nagy and Gunson 1990; Paquet and Hackman 1995). Generally, the status of large carnivores improves as one moves north in Canada's Rocky Mountains (Banci 1991; Paquet and Hackman 1995) and the number of people living in occupied large carnivore habitat decreases.

Because they have low reproductive rates, species like grizzly bears and wolverines are known to recover slowly—if at all—from excessive human-caused mortality. The potential for excessive hunting mortality exists everywhere in the Rockies and Mackenzies, except in protected areas. Even in protected areas such as Banff and Yellowstone national parks, human use has sometimes been so intensive and inadequately planned that high human-caused mortality rates for grizzly bears have existed over prolonged time spans (Gibeau et al. 1996; Mattson et al. 1992). The grizzly's status is further threatened because bears that survive in areas where people are the major cause of mortality avoid roads, areas near roads, and other development features, thus giving up some of their better habitat. As the human population both grows and increases its resource-related demands, we are dramatically expanding our exploitation of natural resources and hence landscapes—often the very land that carnivores and other species depend upon for habitat.

Species such as grizzly bears, wolves, and wolverines have been called landscape species because of the relatively large size of their home ranges and the long distance movements of individuals, especially adult males. None of the national parks in the Rocky Mountains appears to be large enough by itsef to protect viable populations of all large carnivores (Newmark 1985). Individuals of most large carnivore species typically enter several different land use jurisdictions in a year (Herrero 1995; Knight 1981; Raine and Riddell 1991). Management objectives within each jurisdiction should, but often don't, at least regulate mortality to allow for population persistence.

My objective in this paper is to examine some of the scientific concepts, methods, techniques, findings and limitations regarding large carnivore conservation in the Y2Y region. I focus primarily on grizzly bears because they are particularly difficult to maintain in developed landscapes, and because they are the best studied of the large carnivores in Y2Y.

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Indicator species and umbrella species

Grizzlies are widely recognized as an indicator species particularly sensitive to people's developments and activities (Herrero and Herrero 1996). This is mainly because of the increased mortality probabilities for grizzly bears, as well as habitat loss both directly and through avoidance, associated with development. As has sometimes been done in impact assessments, the grizzlies'status will also be used as a surrogate for the status of other large carnivore species (umbrella species) (Herrero and Herrero 1996).

Resilience, reproductive potential, mortality, and dispersal of grizzly bears

A primary focus in conservation biology is understanding factors affecting species persistence. The factors are literally life and death issues, such as mortality rates, population size needed for acceptable viability probabilities, and identification of habitat and population linkage areas. The concept of resilience as it applies to carnivores is fundamental to evaluating persistence probabilities. Weaver et al. (1996), in an important article on resilience and carnivore populations, draw on Holling's (1973:14) definition of resilience as "the ability of systems to absorb disturbance and still maintain the same relationships between populations or state variables." They evaluate resilience at three hierarchical levels: individual (behavioral plasticity in food acquisition); population (demographic compensation); and metapopulation (disperal ability). An understanding of the state of scientific knowledge regarding grizzly bears and each hierarchical level is fundamental to understanding grizzly bear conservation issues in the Y2Y region. Space does not permit summarizing the primary literature so I will highlight the conclusions of Weaver et al. (1996).

Grizzly bears show some behavioral plasticity in food acquisition. A critical point is that although grizzlies eat a varied diet, the nature of their simple carnivore digestive system requires that they be selective when feeding on vegetative matter. Most importantly, during years when high-energy forage species such as whitebark pine or various berry species fail to produce well, then major conflicts with people can quickly develop as bears seek food in human-occupied areas, resulting in significant grizzly bear mortality (Mattson et al. 1992).

Scientists have clearly demonstrated that grizzly bears are a reproductively conservative species with relatively little potential for demographic compensation (McLellan 1994). A combination of few young per year, cub mortality and relative inability to increase reproductive output despite mortality (a lack of compensation), means that grizzly bear populations recover slowly, if at all, from numerical decline. Mattson and his colleagues have compellingly argued that the primary variables influencing grizzly bear numbers are peoples' attitudes, geographic distribution and presence or absence of firearms (Mattson et al. 1992, 1996). People-caused mortality in grizzly bear populations is the fundamental variable requiring conservative management for population persistence.

Grizzly bear dispersal ability, the potential to naturally recolonize areas or to help maintain genetic diversity, is not well understood by scientists. What we know suggests caution regarding the species' ability to naturally recolonize distant areas. Weaver et al. (1996) cite Servheen (pers. comm.) who found that "none of the more than 460 grizzly bears radio-tracked in the American West over the past 25 years has been documented to move from one grizzly bear ecosystem to another where interecosystem distances vary from 60 to 384 km." This result suggests that grizzly bears may need habitat of a quality they can live in (not just pass through) during long-distance dispersal.

East-west transportation corridors such as the B.C./Alberta Highway 3 and the Trans-Canada Highway may be critical population-fragmenting elements for grizzly bears inhabiting the primarily north-to-south running Rocky Mountains.

The limits on grizzly bears' behavioral plasticity in food acquisition, demographic compensation, and long-distance dispersal ability are among the reasons that grizzly bears are considered good indicators of whether natural landscapes in the Y2Y are being managed sustainably.

Habitat, the CEM, core areas, and linkage zones for grizzly bears

One of the great challenges faced by scientists concerned about carnivore survival is linking habitat changes to population-level effects. Development pressures related to forestry, oil and gas, land development and subdivision, and mining have often forced scientists to translate a limited knowledge of grizzly bear landscape relationships into quantitative assumptions subsequently incorporated into model building. Such models are important in trying to quantitatively predict the effects of development on large carnivores such as grizzly bears. The two primary means of predicting the effects of development, and attendant habitat and access changes on grizzly bears, have been the Cumulative Effects Model and core area (security area) analysis.

The CEM. The Cumulative Effects Model (CEM) (Weaver et al. 1986; USDA Forest Service 1990) has emerged as an important tool for impact assessment related to proposed and existing developments and human use in grizzly bear habitat. Habitat effectiveness values determined in the CEM reflect the amount of disturbance from development in a given area. Habitat effectiveness values below 70–80% have been cautiously treated as a threshold for significant impact on grizzly bears (Gibeau in press; Herrero and Herrero 1996). Fundamental model parameters are seasonal habitat values for different ecological units within a landscape, and disturbance coefficients and zones of influence which try to reflect functional loss of potential habitat use based on human influences.

The model has been applied extensively in the Rocky Mountains for evaluating impacts of proposed developments, and in national parks for evaluating actual developments (Gibeau in press; Herrero and Herrero 1996; USDA Forest Service 1990; Weaver et al. 1986). No standardized means for determining habitat values has emerged; rather, in each application, available data have been interpreted and modeled. Until a consensus emerges regarding habitat quality evaluation this activity should not be regarded as firmly rooted in science.

The other major quantitative component of the CEM is disturbance coefficients and the geographic extent to which they are applied (zones of influence). This represents an attempt to spatially quantify how much human influences detract from potential grizzly bear habitat use. This approach quantifies, within the context of a model, the well-known and important negative influence of human access on grizzly habitat use.

Recent models developed for the Northern Continental Divide Ecosystem have used logistic regression to allow empirically determined habitat and activity layers to be combined to predict grizzly bear habitat use. Here logistic regression and multivariate analysis seem to represent significant improvements from older univariate models (Mace and Waller 1997; NCDE 1997).

Because the CEM has quantitative inputs and outputs it seems to be science based. Modelers are usually aware of the many assumptions behind the numbers, but regulatory bodies and managers may not be, or because of other factors, may be inclined to accept the models as the best science available. Despite the limitations of available data, development decisions are regularly made based on these models. The conservation of Rocky Mountain grizzly bears from Y2Y will move forward as models are empirically tested and generalized between different grizzly bear ecosystems.

Core area analysis. Core area analysis (also called security area analysis) is a recently developed technique that uses GIS technology to identify relatively undisturbed areas of a minimum size (typically about 10 km^2)to meet an average adult female grizzly bear's daily spatial needs (Mattson 1993; Puchlerz and Servheen 1994). Empirical research has demonstrated the importance of such areas to adult female grizzly bears (Mattson 1993; Puchlerz and Servheen 1994), although a threshold for the percentage of an adult female's home range that should be in core areas has not been determined. Core area analysis is emerging as an important first cut analysis to identify critical grizzly bear habitat.

Linkage zone analysis. Another new technique for assessing potential grizzly bear landscape-level use is linkage zone analysis (Servheen and Sandstrom 1993). Given the fundamental importance of maintaining linkages between carnivore populations along Y2Y, an understanding of barriers, filters and bridges affecting carnivore movement through a landscape is important. A linkage zone prediction model has been developed to identify and quantify potential areas of carnivore movement across linear features such as roads and valleys. Although the science behind this model is still evolving, the fundamentally important role of movement, and barriers and filters restricting movement, is not disputed.

In Banff National Park, a heavily used 4-lane highway, either fenced or unfenced, and with wildlife underpasses, appears to be a total barrier to crossing by adult female grizzly bears.

Habitat fragmentation occurs when areas of suitable habitat are interrupted by areas of unsuitable habitat such as large clearcuts, cultivated grasslands, linear corridors such as highways, or other development features. Fragmentation and isolation of small populations is recognized as one of the major challenges to large carnivore persistence (Noss and Cooperrider 1994; Paquet and Hackman 1995). The Yellowstone grizzly bear population now appears to be isolated, thus compromising its future (Mattson et al. 1995). Linkage zone analysis is a means to begin to quantitatively understand and identify potential connections for and barriers to animal movement (Servheen and Sandstrom 1993).

East-west transportation corridors such as the B.C./Alberta Highway 3 and the Trans-Canada Highway may be critical population-fragmenting elements for grizzly bears inhabiting the primarily north-to-south running Rocky Mountains. Apps (1997) used GIS and linkage zone models to identify areas that appeared to be the most suitable for allowing grizzly bears and other large carnivores north-south passage across Highway 3. In Banff National Park, a heavily used 4-lane highway, either fenced or unfenced, and with wildlife underpasses, appears to be a total barrier to crossing by adult female grizzly bears (Gibeau and Herrero 1997). There is some crossing by adult males. These researchers applied the linkage zone model to predict areas where appropriate structures might encourage crossing by adult female and male grizzly bears. Banff National Park is currently experimenting with a variety of under- and overpasses for wildlife, including large carnivores (Gibeau and Heuer 1996).

To date only one analysis of the relationship between grizzly bears and human activities and development has applied the CEM, core (security) area analysis and linkage zone analysis together (Gibeau et al. 1996). These researchers also used vegetation successional modeling to predict grizzly bear habitat quality in different future timeframes, and with different management practices in Banff National Park. The results of each of these techniques, combined with an assessment of mortality, created a comprehensive picture of the impacts of development and fire management on the Banff National Park grizzly bear population and its habitat. This resulted in significant, more grizzly bear friendly, changes to the Park management plan (Parks Canada 1997).

Core and matrix throughout the Rockies

Noss's (1995) classic model of strictly protected core areas, integrated management in buffer areas, and linkage zones to connect core/matrix areas, is especially useful in some southern portions of the Y2Y area, especially in the United States, where large carnivores survive primarily in protected areas and their environs. As one moves into northern British Columbia and the Yukon, an ever larger percentage of large carnivore habitat is not protected in reserves. To maintain large carnivores in landscapes subject to resource extraction will require management of total mortality to keep the intrinsic population growth rate (lambda) at equilibrium or positive. Grizzly bear habitat needs will have to be integrated into resource extraction operations (forestry, mining, etc.). McLellan (1989a,b) has shown that this can occur. The 1997 establishment of the Muskwa-Kechika conservation area (4.4 million ha, 10.8 million acres) in the Northern Rockies of British Columbia offers potential for large carnivore protection and resource harvest (Smith[1] pers. comm.).

New research techniques, such as "hair snagging" coupled with DNA analysis, offer scientific potential as a means for estimating and monitoring grizzly bear population numbers before, during, and after resource extraction. Adaptive management approaches (Holling 1973), if they have specific, verifiable large carnivore population targets, and the ability to manage mortality, access, and resource extraction, offer potential. The history of extirpated grizzly bear populations, however, shows that success is not common. The liabilities are mostly social and political—people seem to vote for maximum short-term profits from resource extraction operations and often disregard the implications for carnivore populations.

Science and other large carnivores

Each large carnivore species has its own resilience profile which influences conservation options and constraints in the Y2Y area (Weaver et al. 1996). While I have used grizzly bears as an indicator and umbrella species in this review, life history characteristics or human attitudes toward other large carnivores may make each species' conservation needs in the Y2Y region unique. Preliminary results from two studies of wolverines, for example, suggest that they may be particularly sensitive to human disturbance at maternal den sites, quickly abandoning the dens with very low levels of disturbance (Copeland 1996), and that heavily used highways may be significant filters for crossing (Austin and Herrero[2] pers. comm.). These characteristics, combined with a relatively low reproductive rate, suggest that wolverine status should be closely monitored as development is proposed in the Y2Y landscape. Only a few studies have been done on wolverines, and none of the modeling exercises useful in assessing potential impacts on grizzly bears has been done for wolverines.

Wolves are a species of large carnivore that has significant demographic and metapopulation resilience because of high reproductive rates and long distance movements (Weaver et al. 1996). Despite these adaptive characteristics, human attitudes toward wolves are highly polarized (Bath 1987). Wolves are so hated by some people that their persecution has resulted in extirpation throughout the southern Rocky Mountains in the United States. Wolf reintroductions are limited more by social constraints resulting from these polarized human attitudes than by biological characteristics of the wolves themselves.

Conclusions

The Yellowstone to Yukon conservation initiative was originally conceived of as a means to protect large carnivores. It has evolved as a vision to conserve large wildlands (Tabor 1996). One cannot separate carnivores from their natural habitats without creating some form of zoo. The future of large carnivore populations throughout Y2Y depends upon scientific understanding of factors affecting persistence, and upon human values that support science-based land use and population management actions compatible with large carnivore persistence. By maintaining viable large carnivore

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[2] Matt Austin, B.C. Ministry of Environment, Lands and Parks—Wildlife Division, Victoria, B.C., and Stephen Herrero, Faculty of Environmental Design, University of Calgary, AB.

populations in the Rocky Mountains we not only save wild nature, we also create areas where the impacts of human beings on the landscape are truly sustainable.

Literature cited

Apps, C. 1997. Identification of grizzly bear linkage zones along the Highway 3 corridor of southeast British Columbia and southwest Alberta. For World Wildlife Fund Canada and U.S., and B.C. Ministry of Environment, Lands and Parks. 45pp.

Banci, V. 1991. The status of the grizzly bear in Canada in 1991. COSEWIC status report, Ottawa. 171pp.

Bath, A. J. 1987. Attitudes of various interest groups in Wyoming toward wolf reintroduction in Yellowstone National Park. Master's thesis, Univ. of Wyo., Laramie.

Copeland, J. P. 1996. Biology of the wolverine in central Idaho. Master's thesis, Univ. Idaho, Moscow. 138pp.

Gibeau, M. L. In press. Grizzly bear habitat effectiveness model for Banff, Yoho and Kootenay National Parks, Canada. Int. Conf. Bear Res. And Manage. 10:000–000.

Gibeau, M. L., and S. Herrero. 1997. Eastern slopes grizzly bear project: A progress report for 1996. University of Calgary, Calgary, Alberta. 17pp. plus appendix.

Gibeau, M. L., and Heuer, K. 1996. Effects of transportation corridors on large carnivores in the Bow River Valley, Alberta. In G. L Evink, P. Garrett, D. Zeigler and J. Berry, eds. Trends in addressing transportation related wildlife mortality. Proceedings of the transportation related wildlife mortality seminar, State of Florida Dept. of Transportation, Environment Management Office, Tallahassee.

Gibeau, M. L., S. Herrero, J. L. Kansas, and B. Benn. 1996. Grizzly bear population and habitat status in Banff National Park. A report to the Banff Bow Valley Task Force, Parks Canada, Ottawa. 62pp.

Herrero, Stephen. 1995. The Canadian national parks and grizzly bear ecosystems: the need for interagency management. Int. Conf. Bear Res. and Manage. 9:7–21.

Herrero, S., and J. Herrero. 1996. Cheviot Mine project: specific and cumulative environmental effects analysis for mammalian carnivores. Prepared for Cardinal River Coals, Hinton, Alberta. 122pp. plus appendices.

Holling, C. S. 1973. Resilience and stability in ecological systems. Ann. Rev. Ecol. Syst. 4:1–23.

Knight, R. 1981. Notes on some behavior patterns in radio-instrumented grizzly bears. Interagency Grizzly Bear Research Team, Bozeman, Mont. 10pp.

Mace, R. D., and J. S. Waller. 1997. Final report: grizzly bear ecology in the Swan Mountains. Montana Fish, Wildlife, and Parks, Helena, Mont. 191 pp.

Mattson, D. J. 1993. Background and proposed standards for managing grizzly bear habitat security in the Yellowstone Ecosystem. Cooperative Park Studies Unit, Univ. of Idaho, Moscow. 17pp.

Mattson, D. J., B. M. Blanchard, and R. Knight. 1992. Yellowstone grizzly bear mortality, human habituation, and whitebark pine seed crops. J. Wildl. Manage. 56:432–442.

Mattson, D. J., R. G. Wright, K. C. Kendall, and C. J. Martinka. 1995. Grizzly bears. Pages 103–105 in E. T. Laroe, G. S. Farris, C. E. Puckett, P. D. Doran, and M .J. Mac, eds. Our living resources: a report to the nation on the distribution, abundance, and health of U.S. plants, animals, and ecosystems. U.S. National Biological Service, Washington, D.C.

Mattson, D. J., S. Herrero, R. G. Wright, and C. M. Pease. 1996. Science and management of Rocky Mountain grizzly bears. Cons. Biol. 10(4):1013–1025.

McLellan, B. N. 1989a. Dynamics of a grizzly bear population during a period of industrial resource extraction. II. Mortality rates and causes of death. Can. J. Zool. 67:1861–1864.

McLellan, B. N. 1989b. Dynamics of a grizzly bear population during a period of industrial resource extraction. III. Natality and rate of increase. Can. J. Zool. 67:1865–1868.

McLellan, B. N. 1994. Density-dependent population regulation of brown bears. Density-dependent population in black, brown, and polar bears. Int. Conf. Bear Res. and Manage. Monograph 3:15–24.

Nagy, J. A., and J. R. Gunson. 1990. Management plan for grizzly bears in Alberta. Wildlife Management Planning Series No. 2, Alberta Forestry, Lands and Wildlife, Edmonton. 164pp. plus appendices.

NCDE (Northern Continental Divide Ecosystem Group). 1997. From Jan. 1997 meeting.

Newmark, W. D. 1985. Legal and biotic boundaries of Western North American national parks: a problem of congruence. Biol. Consv. 33:197–208.

Noss, R. F. 1995. Maintaining ecological integrity in representative reserve networks. World Wildlife Canada and U.S., Toronto and Washington, D.C.

Noss, R. F., and A. Y. Cooperrider. 1994. Saving nature's legacy: protecting and restoring biodiversity. Defenders of Wildlife and Island Press, Washington, D.C.

Paquet, P., and A. Hackman. 1995. Large carnivore conservation in the Rocky Mountains. World Wildlife Fund, Toronto. 52pp.

Parks Canada. 1997. Banff National Park management plan. Minister of Public Works, Ottawa. 85pp.

Puchlerz, T., and C. Servheen. 1994. Grizzly bear/motorized access management. Interagency Grizzly Bear Committee Taskforce Report. USDA Forest Service, Missoula, Mont. 8pp.

Raine, R. M., and R. N. Riddell. 199l. Grizzly bear research in Yoho and Kootenay National Parks. Canadian Parks Service Report, Calgary, Alberta.

Ruggiero, L. F., K .B. Aubry, S. W. Buskirk, and L. J. Lyon. 1994. The scientific basis for conserving forest carnivores: American marten, fisher, lynx, and wolverine in western U.S. Tech. Rept. RM-254, Fort Collins, Colo. USDA Forest Service. 184pp.

Servheen, C., and P. Sandstrom. 1993. Human activities and linkage zones for grizzly bears in the Swan-Clearwater Valleys, Montana. USDI Fish and Wildlife Service, Missoula, Mont. 28pp.

Tabor, G. M. 1996. Yellowstone-to-Yukon: Canadian conservation efforts and continental landscape/biodiversity strategy. Henry P. Kendall Foundation. 30pp. plus appendices.

Weaver, J. L., R. E. F. Escano, and D. S. Winn. 1986. A framework for assessing cumulative effects on grizzly bears. North American Wildlife and Natural Resources Conference 52:364– 376.

Weaver, J. L., P. C. Paquet, and L. F. Ruggiero. 1996. Resilience and conservation of large carnivores in the Rocky Mountains. Cons. Biol. 10(4): 964–976.

Bird Conservation in the Yellowstone to Yukon

Geoff Holroyd

The Y2Y region lies at the western reaches of a broad geographic band that boasts the highest diversity of breeding birds in North America (Robbins et al. 1986). The band stretches east from Y2Y through the Boreal Mixedwood and Great Lakes Deciduous Forest ecoregions to the Maritimes. Although at least 275 species of birds breed in the Y2Y region, the cooler shorter summer climate in the mountains results in lower overall density of breeding birds than other ecoregions. Nevertheless, the Rockies support a variety of specialized avian inhabitants, some of which reach their highest densities in the Y2Y region.

The Rockies provide a rich diversity of intermixed avian habitats, varying by elevation, latitude and longitude. The valley bottom riparian systems, boreal and coniferous forests, and subalpine and alpine meadows of the Rockies all support a great variety of birds, many of which remain in the mountains throughout the year. Some species, such as northern goshawk, barred owl, brown creeper, and varied thrush, require large tracts of continuous mature forest to breed successfully.

Unfortunately, many of the species are declining, part of the continental decline of forest and grassland birds. Many threats to the long term viability of bird populations have been identified, including habitat loss and fragmentation due to industrial, urban, and agricultural developments; habitat degradation due to forestry, settlement, and climate change; nest parasitism; direct mortality from roads; and increased risks from pollution and toxic spills.

This paper discusses the importance of montane habitats to birds, presents examples of how birds use the region, and identifies some of the birds' conservation needs in the Y2Y region.

Wetlands and rivers

Most wetlands in the Rockies are in the bottoms of major valleys where human activity is concentrated. The warmer, low elevation habitats have more breeding birds of more species than higher elevation habitats (Holroyd and Van Tighem 1983). In Banff and Jasper national parks, the highest diversity and density of birds are found in the shrub-wetland complexes in the montane valley bottoms. The density of breeding birds in montane wetlands is four times that found in the alpine zone and more than double the density in subalpine coniferous forests. Most species of waterfowl and many species of passerines reach their maximum breeding densities in these low elevation wetlands. While the abundance of breeding waterfowl does not rival the prairie wetlands, the variety and density of waterfowl in the Y2Y region are high. Wetlands are simply not as extensive in the Rockies as they are further east.

Waterfowl and gulls use the wetlands and major rivers in Y2Y as seasonal staging habitat while moving from coastal wintering areas to interior nesting grounds and back (Holroyd and Van Tighem 1983; Weaver et al. 1979; Bartonek 1991). Large numbers of ducks and Canada geese that breed in Alberta spend the winter on the coastal estuaries from southern B.C. south to California (Weaver et al. 1979; Bartonek 1991). Gulls migrate from the Canadian prairies to the west coast (Houston 1977), crossing the Rockies through low valleys and passes (Holroyd and Van Tighem 1983). Likewise, some arctic waterfowl and seabirds, such as oldsquaw, scoters, and jaegers, pass through the Rockies (Holroyd and Van Tighem 1983). All of these waterfowl and gulls use lakes in the Rockies during their trans-mountain migration (Holroyd and Van Tighem 1983). Ferruginous hawks migrate from the Great Plains to the Great Basin through the Y2Y region, probably through valleys.

The rivers of the Y2Y region provide critical habitat for several avian species that are mountain specialists, such as harlequin ducks and American dippers. Harlequin ducks nest along fast-flowing mountain rivers. They arrive as pairs from the Pacific coast of southern B.C. in May and mate. The males leave by early July, while the females raise their broods through August.

American dippers spend their entire lives in the cool clear mountain streams. The dippers nest along subalpine streams, feeding on aquatic invertebrates and small fish. They build their moss nests most frequently on ledges on small cliffs over water, less frequently in mossy stream banks. A pair of dippers will often raise two broods in their domed nest. After fledging the first young, the male feeds the first brood while the female incubates the second clutch of eggs. In winter, dippers must have open water, so when nesting rivers freeze, the dippers concentrate in lower elevation rivers, often in areas of rapids, waterfalls, or other turbulence.

Forests

The deciduous and coniferous forests of Y2Y support an abundance of other species of birds (Holroyd and Van Tighem 1983). For example, boreal owl, northern three-

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toed woodpecker, spruce grouse, gray jay, and boreal chickadee are resident species that depend on large tracts of coniferous forest. Migrant species that breed in the same forests include varied thrush, ruby-crowned kinglet, blackpoll warbler, and Townsend's warbler. Several of these species depend on mature and old growth forests, and do not occur in younger stands.

Some species of forest birds, primarily finches, appear to wander the expanse of the boreal forest. White-winged and red crossbills breed whenever and wherever they find abundant conifer cone crops. An example of transcontinental movements is a purple finch banded in winter in southern Ontario and found dead at Fort St. John, British Columbia, in summer. Bohemian waxwings breed across the boreal forest, but in winter they search for abundant berry and tree seed crops. In years of poor berry crops they may move out onto the Great Plains or to the west coast in search of adequate food supply. Little is known of these movements and the importance of different habitats to the continued health of these mobile populations of small birds. However, large areas of mature forest that are old enough to have healthy cone, seed, and berry crops are needed to support these species.

The density of breeding birds in montane wetlands is four times that found in the alpine zone and more than double the density in subalpine coniferous forests. Most species of waterfowl and many species of passerines reach their maximum breeding densities in these low elevation wetlands.

In winter, the Rockies support fewer species of birds than in the summer. Despite the general exodus of birds in autumn, a few species actually arrive in the Rockies at this time of year. A notable example in the pine siskin, a finch about whose habits little is known. In winter, large numbers gather along road sides and pick up road salt and sand. Near Revelstoke, on the Trans-Canada Highway, large numbers of siskins are killed each year by vehicles, particularly large transport trucks (J. Woods pers. comm.). Bands recovered from these dead siskins were attached in New York and nearby states in summer (Yunick 1997). These siskins are trans-continental migrants moving primarily east-west.

Alpine and subalpine meadows

In the alpine and at treeline, white-tailed and willow ptarmigan, gray-crowned rosy finch, Brewer's sparrow, golden-crowned sparrow and water pipit are common species. White-tailed ptarmigan summer in alpine meadows, breeding in and near wet meadows. In winter, they move to shrub-dominated subalpine meadows where they gain weight feeding on nutritious willow buds.

In recent years, the migration of over 4000 golden eagles has been documented along the eastern ranges of the Rockies west of Calgary. The destination of the eagles is not known, but the best guess is that the eagles spend the winter in the grasslands of the Wyoming Basin, east of the southern end of the Y2Y region, migrate north along the boundary of Alberta and B.C., and spend the summer breeding in the Yukon and adjacent Northwest Territories and Alaska. The eagles do not appear to feed during this seasonal passage, but rather soar rapidly at high elevations along mountain ridges.

Prairie falcons hunt over alpine and subalpine meadows in the Rockies after breeding on prairie cliffs (Holroyd and Van Tighem 1983). While some prairie falcons stay on the prairies and switch from feeding on ground squirrels to birds, others move west and hunt Columbian ground squirrels and birds in the Rockies. The extent and importance of the Rockies as a post-breeding feeding region is unknown.

The precise movements of populations of rufous hummingbirds are not well known, but the Rockies may provide critical habitat for populations of birds that breed over a much larger area. Rufous hummingbirds are known to migrate from their winter range in southern Mexico north along the California coast. They nest in the U.S. northwest, B.C., western Alberta, southern Alaska, and the Yukon (Phillips 1975). After nesting, these hummingbirds disperse throughout the Rockies to feed, likely at higher elevations on later-flowering plants. In fall, they migrate south along the eastern ranges of the Rockies through western Colorado and back to Mexico. The rufous hummingbird requires expanses of prolific wildflowers at all these locations to gather enough nectar to live in these cool regions.

Gray-crowned and black rosy finches nest in rock cliffs adjacent to alpine meadows, then migrate through lower elevation meadows, grasslands, and roadsides to winter in the high plains of the western U.S. (Holroyd and Van Tighem 1983; French 1959). Little is known about their specific habitat needs over this wide area.

In late August and early September, alpine passes on the Alberta-B.C. divide are traversed by migrating passerines and raptors. Flocks of warblers, kinglets, sparrows, and other birds move west, flitting from krummholz to krummholz. Overhead and behind them sharp-shinned hawks migrate west while swooping after the songbirds, catching and eating them to gain energy to continue their migration. These birds that breed east of the Rockies then use low-elevation riparian woodlands and wetlands to continue their migration west.

Species-specific habitat needs

Each species uses the Y2Y region in different and complex ways, and each has specific habitat needs. To survive the harsh climate, for example, a number of species have evolved specialized life history characteristics. Some migrate altitudinally within the Rockies, often using lower elevation habitats in winter to survive the cold weather. Such migrations are not well documented, but the conservation of the full range of habitats that are used by these species is necessary if they are to survive. Other species migrate south to spend the winter in warmer climes, and for these we need to maintain a variety of quality habitats, well distributed for their use in summer, in winter, and during migration. Yet other species migrate north-south along the Rockies, while others move east-west across the mountains. Protection of adequate amounts of natural habitat is critical to the survival of these species in the Y2Y region.

Conservation of birds in the Y2Y will be a complicated. The bird's long-distance movements require that specific habitats be well distributed throughout their annual ranges. Conservationists need to consider the habitats and specific needs of each species, not just the habitats with the most species of birds.

A good example of such habitat specificity is provided by the pygmy nuthatch. These nuthatches are common in ponderosa pine forests, where they feed on the outer branches of mature pines. In winter, to conserve energy, the nuthatches roost communally in the cavities of old trees, with as many as 120 individuals sharing a single cavity (Cannings and Cannings 1996). Congregating in such numbers, the birds need a large stand of mature pines—including, obviously, old trees with cavities—so that they can feed during the day and return in the evening to the shared roost. Small forest fragments may support a few nuthatches in moderate winter weather, but unless there is enough forest of sufficient quality to support many nuthatches, the birds may not be able to keep warm on critically cold winter nights. The quality of these pine woodlands is maintained by frequent ground fires. Thus, the quality and size of the forest patch may affect the feeding and roosting efficiency, and ultimately the survival, of the pygmy nuthatch. And these nuthatches are not alone. Brown creepers and golden-crowned kinglets also need specific habitat in mature forests to survive the winter.

Another example of a species with a specific habitat need is the Clark's nutcracker. Clark's nutcrackers live near treeline in summer, but store food at lower elevations in autumn for use the following winter, spring, and summer. Nutcrackers require adequate stands of the conifers which produce the large seeds the nutcrackers eat and store. Conversely, the conifers depend on Clark's nutcrackers to disperse and plant their seeds. Suitable conifers include white-bark pine, ponderosa pine, and Douglas fir (Vander Wall 1988).

Conservation concerns

Many of the species that occur in Y2Y are declining in abundance, part of the continental decline of forest and grassland birds. The declines have been documented in trend analysis of breeding bird surveys across North America and in studies of radar images of bird migration over the Gulf of Mexico. Some of these species are neotropical migrants that breed in the Rockies and winter in tropical habitats of Central America (Yunick 1997). The declines may be driven by human impacts on habitats in North America, as well as by cutting of forests in the tropics.

While declines in long distance neotropical migrants are of concern, the alarming declines in resident species cannot be blamed on land use in the tropics. After expressing concern about the extent of habitat loss and fragmentation in eastern North America, Terborgh (1989) expressed his hope that bird populations were more secure in the "expansive virgin forests of the Northwest." Many of the forests in the Y2Y region, however, have been cut or are under forest management agreements and will be cut in the foreseeable future. Mature and old growth forests are most at risk since they are particularly attractive to the forest industry. While much research has focused on eastern North America, the decline of both migrant and resident birds in the west is just as severe.

Conservation of birds in the Y2Y region will be a complicated undertaking. Aside from the diversity of their habitats and the complex ways in which they use them, birds have the advantage of being able to fly over obstructions and unsuitable habitats, and travel far greater distances than even dispersing wolves and wolverines. Such long-distance movements require that specific habitats be well distributed throughout their annual ranges. Conservation initiatives need to consider the habitats and specific needs of each species, not just the habitats with the most species of birds.

An additional consideration that needs to be incorporated into avian conservation strategies is the speciation that occurred during the Pleistocene. The last Ice Age separated populations of species to the east and west of the Rockies. As a result of this isolation, populations evolved differences before the ice melted and the populations met again. Northern flickers have a western red-shafted form and an eastern yellow-shafted form. Likewise, yellow-rumped warblers, dark-eyed juncos, rosy finches, empidonax flycatchers, and possibly red crossbills have forms that co-occur in the Y2Y. Consequently there are many island populations of these species confined to altitudinal bands, and mixed populations in forest regions that need to be identified and conserved.

Threats to the long-term viability of avian populations can be found in all avian habitats. In the Y2Y, for example, the majority of human activity is concentrated in the major valleys bottoms, where human-induced flooding, draining, and filling results in the direct loss of wetland and riparian habitats. The lower elevation rivers are often adjacent to transportation corridors that travel along valley bottoms. River banks have been modified to accommodate roads and railroads in narrow valleys. The proximity of roads to wetlands and clear mountain rivers leads to contamination with oil droppings and road salt in the winter. The high volume of truck and train cargo, including toxic chemicals, that is transported through the valleys puts the wetlands at risk from spills. Populations of sensitive wetland species such as harlequin ducks and dippers may be affected by reduced water quality. Recreational and commercial river rafting (and likely canoeing and kayaking) disturbs harlequin ducks and may cause them to abandon staging and nesting areas.

Forest clearing for grazing, irrigation and extractive industries has destroyed as much as 90% of low-elevation riparian habitats in the region.

Habitat management in riparian zones must maintain multiple levels of vegetation, and mature cottonwood gallery forests that are free from cowbirds. Forest clearing for grazing, irrigation and extractive industries has destroyed as much as 90% of low-elevation riparian habitats in the region. Forests are further fragmented by ranchettes or acreage developments, which also add roaming cats as bird predators. Predators such as coyotes and raccoons become more abundant when forested areas are settled.

Human settlement in forested areas is usually followed by brown-headed cowbirds, whose nest parasitism can severely affect nesting success of songbirds and is known to affect productivity of some bird populations. The cowbird lays its eggs in other birds' nests after removing some or all of the host bird's eggs. Cowbirds are now more common due to increased presence of humans, agriculture, and livestock.

At higher elevations, in the deciduous and coniferous forests, numerous interior forest-dwelling species are adapted to large tracts of forest. Several of these species depend on mature and old-growth species, and do not occur in younger forest stands. Loss of these large forest tracts of mature trees, primarily through linear disturbances, forest harvesting, and agricultural activities, has resulted in severe habitat fragmentation, reduced patch size, increased mortality, and loss of quality nesting habitat for many species.

In addition to habitat loss and fragmentation, direct mortality may cause declines in some species. Unknown numbers of raptors are taken in trap lines, which may threaten populations in some areas (Siddle 1984). Road mortality may be high where paved roads travel along valleys that are productive habitat for saw-whet owls and other birds (Loos and Kerlinger 1993). Mass mortality of migrating songbirds has been documented at oil industry flare stacks (Bjorge 1987). Approximately 3000 passerines were found dead within 75m of a sour gas flare, presumably killed by emissions that were concentrated in the valley during inclement weather. The extent of mortalities such as this are unknown but are almost certainly annual events.

By providing protected areas with proper management, we can provide habitat for many species for part of the year. However, because few birds remain in protected areas year round, most birds need habitat both in and outside of protected areas to survive. Where habitat is secure, disturbance by humans, pollution, nest parasites, and increased predation are all of concern to the conservation of landbirds. Where habitat is not secure, the importance of these concerns are additive to the problems associated with inappropriate land management.

Conclusion

The solutions to bird conservation problems in the Y2Y region are complex. Implementing the solutions is an even greater challenge. Conservation of birds demands that a broad conservation initiative such as the Y2Y strategy must be encouraged. Local actions need to focus on the regional and continental issues. The destruction of any single hectare of habitat will not cause a species to decline noticeably. Yet the declines in bird numbers are due to the incremental impact of the loss of each single hectare of land. The Y2Y strategy can provide a broad rationale that will promote wise use of each hectare of land in the region.

Forestry and agriculture have by far the greatest impact on the lands and consequently on the birds in Y2Y. These human activities affect large tracts of land for long periods of time. Some species of birds will use the land in any form. Many species of birds, however, require large tracts of specific kinds of habitat which are destroyed by forestry and agricultural activity. Birds are excellent example of why we need large tracts of habitat and why the Y2Y approach is appropriate.

With so many species of birds, how should we set priorities for conservation efforts? While we must protect all species, the conservation efforts should take into account the regional and national distribution and abundance of each species. Species that occur in high density or great abundance in Y2Y, or that make specific seasonal use of the region, should have a high priority for conservation. We must develop species-specific conservation plans. We cannot treat birds as a single entity if we expect to successfully conserve them, no more than we can manage ungulates or carnivores as a group. Priority must be given to habitats that have the most human pressure. Ultimately any conservation strategy must look at high-priority species and the most threatened habitats, and recommend changes in human activities in order to accommodate both sustained economic uses and wildlife habitat needs.

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Literature cited

Bartonek, J. C. 1991. Summary of data on certain Canada geese banded in the western U.S. and Canada during 1955–73 and 1974–89. U.S. Dept. of the Interior, Fish and Wildlife Service, Portland, Oregon.

Bjorge, R. R. 1987. Bird kill at an oil industry flare stack in northwest Alberta. Can. Field-Nat. 101(3):346–350.

Cannings, R., and S. Cannings. 1996. British Columbia: a natural history. Greystone Books, Vancouver.

French, N. R. 1959. Distribution and migration of the black rosy finch. Condor 61:18–29.

Harding, L. E. 1994. Songbirds in decline. Pages 319–322 in L. E. Harding and E. McCullum, eds. Biodiversity in British Columbia: our changing environment. Canadian Wildlife Service, Environment Canada, Pacific and Yukon Region.

Holroyd, G. L., and K. J. Van Tighem. 1983. Ecological (biophysical) land classification of Banff and Jasper national parks, Vol. III: The wildlife inventory. Canadian Wildlife Service, Edmonton.

Houston, C. S. 1977. Movements of Saskatchewan-banded California gulls. Bird Banding 48:158–161.

Loos, G., and P. Kerlinger. 1993. Road mortality of saw-whet and screech owls on the Cape May Peninsula. J. Raptor Research 27(4):210–213

Phillips, A. R. 1975. The migrations of Allen's and other hummingbirds. Condor 77:196–205.

Robbins, C. S., D. Bystrak, and P. H. Geissler. 1986. The Breeding Bird Survey: its first fifteen years, 1965–1979. Resource Publication no. 157. U.S. Dept. of the Interior, Fish and Wildlife Service, Washington, D.C.

Siddle, C. 1984. Raptor mortality on northeastern British Columbia trapline. Blue Jay 42(3):184.

Terborgh, J. 1989. Where have all the birds gone? Princeton University Press, New Jersey. 207pp.

Vander Wall, S. B. 1988. Foraging of Clark's nutcrackers on rapidly changing pine seed resources. Condor 90:621–631.

Weaver, H. S., B. C. Turner, S. P. Pryor, and J. R. Allen. 1979. Recovery distribution from summer duck banding in Alberta. Alberta Waterfowl Technical Committee Special Report 2.

Yunick, R. P. 1997. Geographical distribution of re-encountered pine siskins captured in upstate, eastern New York during the 1989–1990 irruption. North American Bird Bander 22(1):10–15.

Selected Fishes of Yellowstone to Yukon: Distribution and Status[1]

Dave Mayhood, Rob Ament, Rich Walker, and Bill Haskins

Introduction

At least 118 species of fish have been reported from the Yukon to Yellowstone (Y2Y) region. We have mapped the distribution and status of five of these to illustrate some of the issues involved in conserving fish and aquatic ecosystems in Y2Y. The five species exemplify an anadromous fish (chinook salmon), a widespread interior salmonid (bull trout), a Y2Y endemic subspecies (westslope cutthroat trout), a widespread northern salmonid with disjunct southern stocks (Arctic grayling), and an invasive introduced fish (brook trout).

Methods

To make mapping practical for such a large study area, we divided the Y2Y region into over 340 watershed units. With only minor modifications, we used the U.S. Environmental Protection Agency's HUC4 units in the U.S., and the watershed groups defined by the B.C. Ministry of Environment, Lands and Parks (BCMELP) in British Columbia (FISS B.C. database). For the Yukon we combined the Canadian Department of Fisheries and Oceans' watershed groups (FISS Yukon database), some of which are very small, into larger watershed units. Watershed units have not been predefined for Alberta, so we defined our own to be ecologically meaningful and roughly comparable in area to the smaller units in the other jurisdictions.

Fish distribution and status were assessed from an extensive analysis of the primary scientific literature, published and unpublished technical and historical documents, government agency file data, and online computer databases. Major sources were Prince et al. (1912), Carl et al. (1959), McPhail and Lindsey (1970, 1986), Brown (1971), Scott and Crossman (1973), Lee et al. (1980), Crossman and McAllister (1986), Lindsey and McPhail (1986), Behnke (1992), Nelson and Paetz (1992), McPhail and Carveth (1993), and online or disk-based databases of the Interior Columbia River Basin Ecosystem Management Project (ICBEMP), the Montana Rivers Information System (MRIS), Idaho Rivers Information System, the Canadian Department of Fisheries and Oceans' Fisheries Information Summary System (FISS) databases for the Yukon and British Columbia, and the Fish Stocking Query Page of BCMELP. We adopted the categories of the ICBEMP (and used the ICBEMP data, where available) for mapping status or state of knowledge of the U.S. stocks (e.g., Rieman et al. 1997:1115). Suitable data were seldom available to apply the ICBEMP criteria for the categories Strong and Depressed in Canada. When used in the Canadian range, these classifications represent our subjective assessment based on other available information.

This is a preliminary study. There remain many relevant data on Y2Y fishes that we have not included, and some datasets on which we relied are still under development.

The Fishes

Chinook salmon (Oncorhynchus tshawytscha)

Chinook salmon use every major Pacific river system in Y2Y from the Columbia to the Yukon, penetrating to the very headwaters in the Fraser, Skeena, Nass, Taku, and Yukon systems, and formerly in the Columbia system as well (Figure 1). They are blocked by the Grand Canyon of the Stikine and by Iskut Canyon from attaining the upper reaches in those rivers, and now the Grand Coulee Dam on the Columbia blocks them from reaching former spawning areas in Washington, Idaho, and at the source of that river in Canada. Numerous other Columbia and Snake River dams impede movements of adult chinook into, and juveniles out of, these rivers.

In addition to the many Columbia River stock extinctions, at least five Y2Y chinook stocks in Oregon, Washington and Idaho are presently at risk (Nehlsen et al. 1991), and many more are depressed (Figure 1). Apart from the Columbia River stocks, Y2Y chinook spawning runs in Canada appear to be stable or perhaps increasing, with numerous important exceptions (Healey 1982; Slaney et al. 1996; Baker et al. 1996). The exceptions are important because there are few data for many stocks: their status is simply unknown at this time. The actual number of stocks at risk thus is undoubtedly higher than reported. Based on these evaluations, one unidentified chinook stock on the North Coast (possibly not from a Y2Y river) was judged to

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[1] This article is based upon a larger study of Y2Y fishes. The technical report on that study now in preparation will be available from the Y2Y office or the authors, and should be consulted for further details on the fishes treated here.

be declining and at moderate risk of extinction (Baker et al. 1996). At least four B.C. Y2Y chinook stocks (one each in the Nass, South Thompson, North Thompson and Nechako watershed groups) have been identified as at risk (Slaney et al. 1996). Dams are cited as a major factor in most of these extinctions or threats of extinction, but many other factors, including overfishing and habitat damage from forestry, were also often noted.

Bull trout (Salvelinus confluentus)

The bull trout is native to most inland waters in Y2Y on both sides of the Continental Divide (Cavender 1978; Haas and McPhail 1991; Figure 2). This fish closely resembles the Dolly Varden trout, a mainly coastal species with which it has been lumped until quite recently, especially in B.C. In that province the range of the two species broadly overlaps, so that many records of Dolly Varden there may in fact refer to bull trout. We have mapped Dolly Varden records in areas of known overlap with bull trout for that reason.

Damage from overexploitation, habitat damage and blockage of migration routes by dams in whole or in part has driven many stocks into decline, and has extirpated some throughout the accessible portions of Y2Y (Nelson 1965; Allan 1980; Roberts 1987; Mayhood 1995; Fitch 1997; Rhude and Stelfox 1997). In some cases, hybridization with introduced brook trout can quickly drive bull trout stocks to extinction (Leary et al. 1993), or competition or predation from introduced char species may destroy lake-dwelling stocks (Donald and Alger 1993; Donald and Stelfox 1997).

Presently bull trout are listed variously as of Special Concern (vulnerable) throughout the native range in the U.S. and Canada (Williams et al. 1989), of special concern in Alberta (Berry 1994), under review (vulnerable) in Canada (Campbell 1997), and as warranted for listing (Category 1) under the U.S. Endangered Species Act in the coterminous United States (USDI Fish and Wildlife Service 1997). Because many bull trout stocks carry genes at a high frequency that are rare in, or absent from, other stocks, retaining the full genetic diversity of bull trout means conserving as many local populations throughout the range as possible (Leary et al. 1993). Bull trout will have to be restored and conserved by maintaining, restoring and reconnecting many high-quality habitats throughout the range of the species (Rieman and McIntyre 1993), much of which lies in Y2Y, and exploitation rates will have to be kept low (Berry 1994).

Westslope cutthroat trout (Oncorhynchus clarki lewisi)

The contiguous native range of westslope cutthroat trout lies entirely within the Y2Y region in the upper Missouri, upper Kootenay[2], Flathead, Clark Fork, Bitterroot, Madison and Gallatin headwaters, Pend Oreille, Clearwater, Salmon, Bow and Oldman rivers (Behnke 1992; Van Eimeren 1996; Figure 3). The subspecies may also have been native in the Kicking Horse drainage above Wapta Falls (Columbia drainage), and in a few other Columbia headwater tributaries near Windermere and Columbia lakes (Prince et al. 1912; Mayhood 1995). In Y2Y, several small, disjunct populations are native to drainages in the South Thompson, Columbia mainstem (Revelstoke reservoir) and Kootenay Lake basins in south-central B.C., mostly above barrier falls (Dymond 1932; Behnke 1992). Outside Y2Y there are several more native disjunct populations in Oregon and Washington (Behnke 1992).

Most native populations of this subspecies are either extinct or are presently in grave danger of extirpation throughout the range (American Wildlands et al. 1997), primarily from habitat damage, hybridization with introduced black-spotted trouts, and competition with or predation by introduced exotic fishes.

In Montana, the fish now occupies only 19% of its native range (Van Eimeren 1996), and could be considered viable in just 10% of the native range. East of the Continental Divide, in the upper Missouri River Basin, westslope cutthroat still occur in less than 5% of the native range. Over 70% of 144 populations studied have a very high probability of extinction over 100 years (Shepard et al. 1997). Genetically pure populations in the upper Missouri Basin have been reduced to just 1% of the native range and some populations have recently gone extinct (USDA Forest Service/USDI Bureau of Land Management 1996). Similarly, west of the Continental Divide in Montana's Kootenai River Basin, pure populations have been reduced to 3% of their historical range (MRIS). Viable populations remain in 36% of the historical range in Idaho, but most of these are hybridized (American Wildlands et al. 1997; Rieman and Apperson 1989; Johnson 1992; Van Eimeren 1996). In Idaho, pure populations that survive in strongly protected habitat occupy approximately 4% of their historic range (Rieman and Apperson 1989; Van Eimeren 1996). In Wyoming six remnant introgressed populations of westslope cutthroat remain in the 12 to 15 streams that once held native stocks (Van Eimeren 1996).

In Alberta, westslope cutthroat occupy considerably less than 5% of the native range in the Bow drainage, being restricted to the extreme headwaters of a few of the major tributaries and the upper mainstem (Mayhood 1995). In the Oldman River drainage, westslope cutthroats still oc-

[2] Kootenai in Montana and Idaho. Most of the mainstem lies in B.C., so the B.C. spelling is used when we refer to the entire river; otherwise the spelling appropriate to the region of reference is used.

cupy most of the native range in the upper Oldman basin, but have been lost from native waters in the lower mainstem and most of its fish-accessible tributaries (Radford 1977; Fitch 1978; Mayhood et al. 1997). All stream populations in the Bow and Oldman systems that have been examined for it, except one, (out of several dozen) show evidence of introgressive hybridization (D. Mayhood, unpublished data).

In British Columbia, most of the presumptive native range in the Kicking Horse drainage above Wapta Falls now lacks cutthroats (Pole 1990; Mayhood 1995). Cutthroats (mainly hybrids) still occupy all native range within the Kootenay drainage of Kootenay National Park (Alger and Donald 1984; Mayhood 1995), and within the White River watershed. Nevertheless, several genetically pure westslope cutthroat trout populations continue to exist in native range in the upper Kootenay drainage in B.C. (Leary et al. 1987). The status of most other B.C. stocks remains undocumented, including that of most disjunct populations.

Westslope cutthroats have been widely transplanted outside the native range within Y2Y, including the Murray and Narraway watersheds (Peace drainage) (Nelson and Paetz 1992; FISS database), some Athabasca drainage lakes and headwater streams[3] (Ward 1974; Nelson and Paetz 1992; Barton et al. 1993), and the North Saskatchewan and Red Deer drainages (Nelson and Paetz 1992). Both pure stocks and those of uncertain origin have been introduced, sometimes with other species, into formerly fishless habitat above barrier falls in several streams in the Oldman, Bow, Kootenay and Columbia systems in Alberta and B.C. The state of Washington has stocked westslope cutthroats extensively in lakes of the Cascades (Behnke 1992). Although transplanted stocks are widespread, most individual populations appear to be small and localized.

The westslope cutthroat trout is designated as a species of special concern in Montana and Idaho (Johnson 1987), but there is no formal recognition of its precarious status in B.C. or Alberta. The Canadian Committee on the Status of Endangered Wildlife in Canada (COSEWIC) has given the subspecies no consideration as yet, and has no plans to do so (Campbell 1997). There are no provisions under Canadian federal law to protect most endangered species in any case. The U.S. Fish and Wildlife Service listed the subspecies prior to 1973 in its "Red Book" as a threatened or endangered species, but dropped the listing after the Endangered Species Act came into force. American Wildlands et al. (1997) have petitioned the USFWS under the Act to list westslope cutthroat trout as threatened throughout its range, and to designate critical habitat for the subspecies, citing habitat loss and degradation (from logging, grazing, agriculture and damming), overfishing, competition with introduced fish, and genetic introgression (hybridization) with introduced species as causes of decline and as reasons for expecting decline to continue.

Arctic grayling (Thymallus arcticus)

This species is indigenous to all of mainland Alaska and Canada south from the Arctic coast to northern British Columbia, Alberta, Saskatchewan and Manitoba eastward to the western shore of Hudson Bay (Scott and Crossman 1973). Disjunct populations were native to parts of Michigan and the upper Missouri drainage of Montana. In Y2Y the species is widespread in the Yukon, Liard, Peace, Athabasca, Taku, and Stikine systems (Scott and Crossman 1973; Lee et al. 1980; Nelson and Paetz 1992; McPhail and Carveth 1993; Figure 4), and still exists in remnant populations in Montana (Liknes and Gould 1987).

Grayling are easily caught, making them highly susceptible to overexploitation wherever they are readily accessible (Falk and Gilman 1974, and references therein; Tripp and Tsui 1980; Michiel 1989:149-151). They are widely believed to be especially sensitive to pollution, although the evidence for this view is rather unsatisfying. There is some evidence that native grayling populations have suffered from competition with, or predation from, introduced salmonids (Eriksen 1975; Feldmeth and Eriksen 1978).

Whatever the cause, Arctic grayling populations are depleted in parts of Y2Y that are most accessible and developed, including Montana and much of the southern part of their range in Alberta. For example, the Big Hole River drainage holds the single remaining native fluvial stock in Montana (Kaya 1991), where it is now classified as Category 1 (warranted but precluded for listing) under the Endangered Species Act (C. Kaya[4], pers. comm. 1997). Arctic grayling were indigenous to virtually all of Alberta's Fisheries Management Area 4 (east and north of Jasper National Park), yet 28 of 42 streams recently surveyed in FMA 4 held no grayling at all, and the species was rated as common or abundant in just six others (Hunt et al. 1997). The Embarras River, which flows among the Coal Branch mining towns of Alberta's road-laced foothills, produced the provincial record Arctic grayling in 1966 (1.3 kg). But "now it is difficult to catch even one grayling in this river" (Alberta Fisheries Management Division 1997). Grayling populations are said to be depleted in all the streams along the Alaska Highway (B.C. and Yukon), and one must hike several miles away to find any (Michiel 1989:150).

Overall, Arctic grayling appear to have been extirpated from at least eight watershed units in Y2Y, of the 95 to which it is believed indigenous. Of those watershed units remain-

[3] Some of these may have been Yellowstone cutthroat stocks, rather than westslope.

[4] Montana State University, Bozeman, Montana.

ing, nine have depressed stocks, the populations of two are believed to be strong, and the status of grayling in the great majority is unknown.

Brook trout (Salvelinus fontinalis)

Brook trout are native to northeastern North America from northern Labrador, Quebec and the southwestern drainages of Hudson Bay, southward to Minnesota, through the upper Mississippi and Great Lakes drainages to the Appalachians as far south as Georgia (Scott and Crossman 1973). They have been introduced widely throughout the west, including Y2Y (Figure 5). Introductions in our study area began in the 1880s in Montana (Brown 1971), Idaho (Simpson and Wallace 1982), Alberta and B.C. (Mayhood 1992), and have persisted to the present day. Brook trout are now found in every major Y2Y basin south of and including the Stikine (one population) and Peace. They are widespread and often abundant in the headwater lakes and streams of the Columbia, Kootenay, Athabasca, Saskatchewan, and Missouri systems.

Brook trout replace native fishes such as cutthroat trout and bull trout in their native streams. Cutthroats often can be found only in steep gradient reaches, typically headwaters, in streams where both species exist (Griffith 1988). Bull trout in a stream can be driven to extinction by hybridizing with introduced brook trout (Leary et al. 1993). There is some evidence suggesting that brook trout may competitively replace Arctic grayling in lower-elevation streams (Feldmeth and Eriksen 1978), or eliminate them through predation on their fry (Eriksen 1975). Brook trout thus are potentially a serious threat to the continued survival of native fish stocks in Y2Y.

Discussion

The most widespread native fishes—chinook salmon, bull trout and Arctic grayling—have all sustained significant stock losses and population declines in the accessible southern parts of their ranges in Y2Y, but appear to be reasonably secure in the less developed, less accessible northern parts of the study area. Native westslope cutthroat trout are in a much more precarious state. Confined as a native fish to the southern part of Y2Y, this endemic subspecies has suffered serious declines and extirpations throughout its original range, and has few secure indigenous populations anywhere. In contrast, non-native brook trout introduced throughout the southern half of Y2Y have flourished, now being much more widespread and often more abundant than the native westslope cutthroat, replacing that species in many instances.

Many reasons for the decline of native fish stocks in Y2Y have been advanced, including overfishing; habitat damage; habitat alienation and fragmentation; and competition or hybridization with, or predation from, introduced species. These factors are not independent, and several usually are present simultaneously, implying that in many cases several conservation problems must be addressed at once. Or on a more positive note, several problems may be solved at once by judicious selection of conservation technique. For example, decommissioning roads into the watershed of a depressed fish stock could simultaneously (1) reduce exploitation rates; (2) reduce erosion and siltation, major causes of habitat damage; (3) remove roadbeds and culverts that often block access to critical habitat and isolate stocks; and (4) render introduction of exotics less likely.

The motivating idea of Y2Y is the concept of connectedness; the major problem to be solved that of reconnecting the fragments isolated by human activity. At least in the case of the fishes discussed here, reconnection implies radical[5] action. To give just one example, the greatest chinook salmon losses in Y2Y are attributable to habitat fragmentation and alienation caused by the Columbia basin dams. Restoring chinook salmon in Y2Y means reconnecting the fish to their fragmented and alienated habitats. Inevitably this will require decommissioning dams, since many years of attempting less fundamental solutions have not worked, as evidenced by the continuing declines in many stocks. The challenge to Y2Y is not to abandon a sound concept because it requires radical action to achieve, but to find realistic ways of making such fundamental changes in the way humans use the land and water.

Acknowledgements

We gratefully acknowledge the many colleagues who assisted in conducting this study. They are individually recognized in the technical report.

[5] Far-reaching; thorough; going to the root (radical change) (Concise Oxford Dictionary, 8th edition).

Following pages

Figure 1. Distribution and status of chinook salmon in Y2Y.

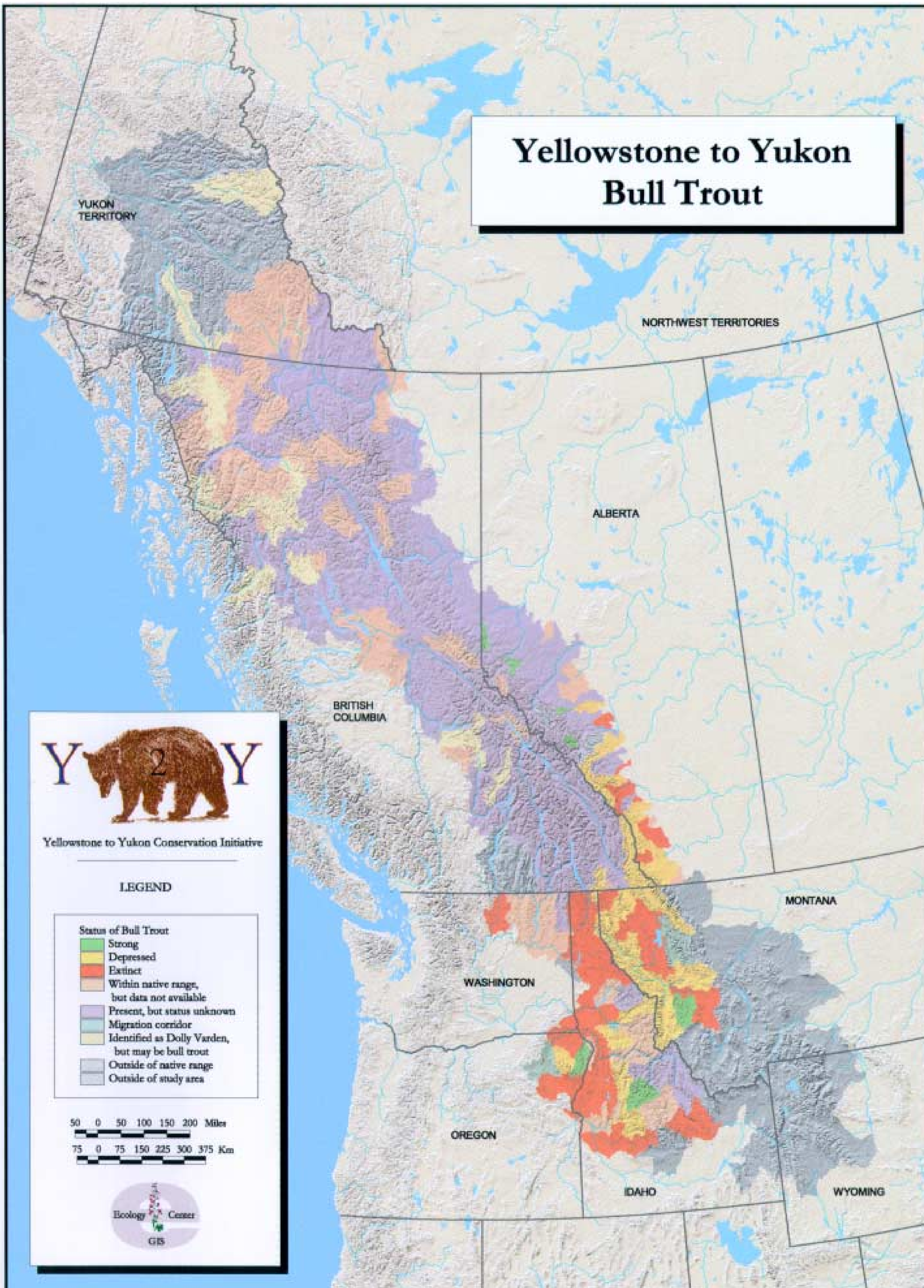
Figure 2. Distribution and status of bull trout in Y2Y. Dolly Varden has been mapped in known areas of overlap with bull trout in watershed units where Dolly Varden is the only riverine char record. These may in fact be bull trout records.

Figure 3. Distribution and status of westslope cutthroat trout in Y2Y, including watershed units in which only isolated, disjunct native populations are known.

Figure 4. Distribution and status of Arctic grayling in Y2Y. Introduced populations in some watershed units may not be viable in the long term.

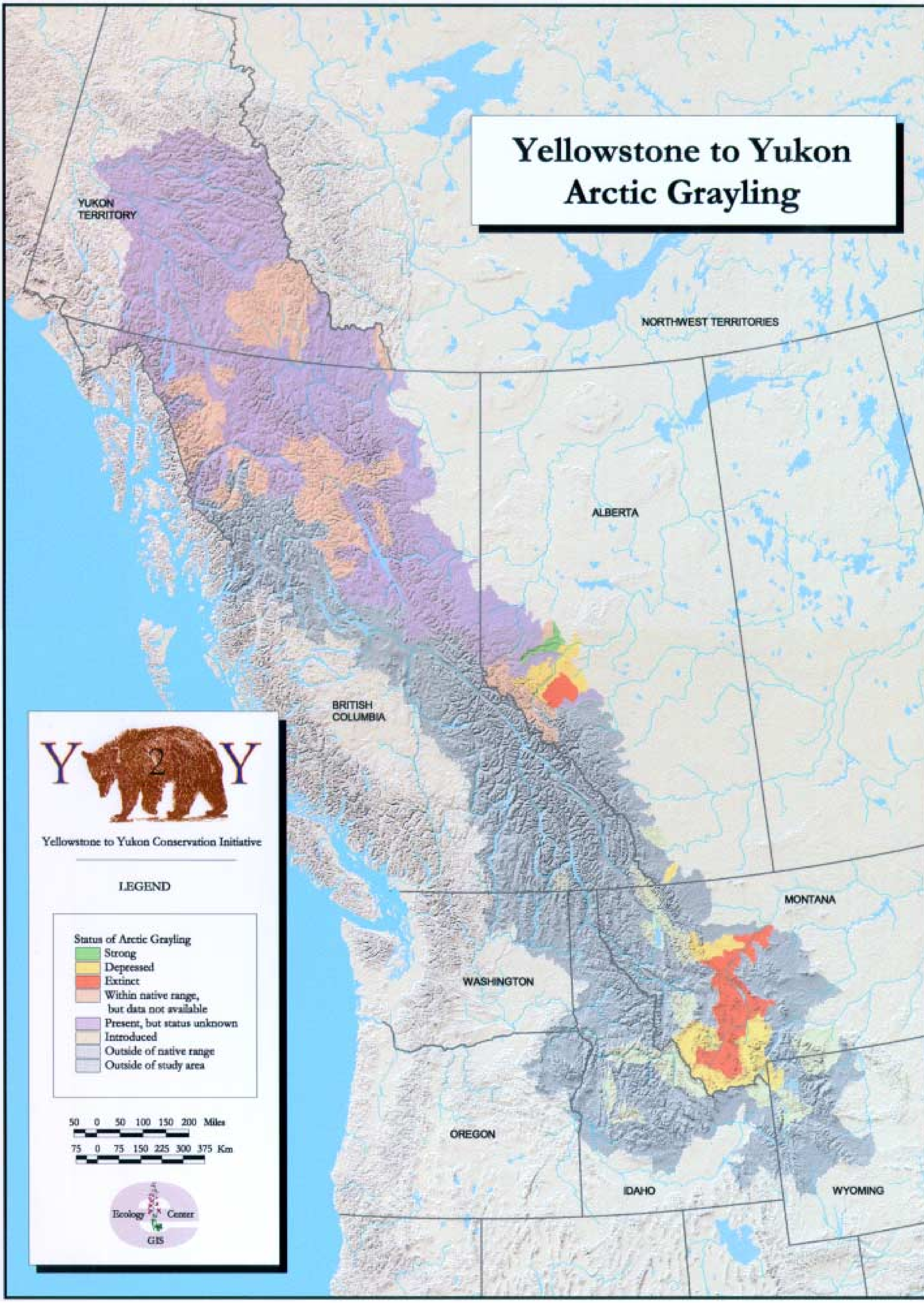
Figure 5. Distribution and status of brook trout in Y2Y. All watershed units known to have received hatchery stocks, or those known to have self-recruiting stocks, are shown.

Yellowstone to Yukon
Chinook Salmon
YUKON TERRITORY
NORTHWEST TERRITORIES
ALBERTA
BRITISH COLUMBIA
MONTANA
WASHINGTON
OREGON
IDAHO
WYOMING
Y 2 Y
Yellowstone to Yukon Conservation Initiative
LEGEND
Status of Chinook Salmon
Depressed
Extinct
Within native range, but data not available
Present, but status unknown
Migration corridor
Outside of native range
Outside of study area
50 0 50 100 150 200 Miles
75 0 75 150 225 300 375 Km
Ecology Center
GIS



Yellowstone to Yukon
Bull Trout
YUKON TERRITORY
NORTHWEST TERRITORIES
ALBERTA
BRITISH COLUMBIA
MONTANA
WASHINGTON
OREGON
IDAHO
WYOMING
Y 2 Y
Yellowstone to Yukon Conservation Initiative
LEGEND
Status of Bull Trout
Strong
Depressed
Extinct
Within native range, but data not available
Present, but status unknown
Migration corridor
Identified as Dolly Varden, but may be bull trout
Outside of native range
Outside of study area
50 0 50 100 150 200 Miles
75 0 75 150 225 300 375 Km
Ecology Center
GIS


Yellowstone to Yukon
Westslope Cutthroat Trout
YUKON TERRITORY
NORTHWEST TERRITORIES
ALBERTA
BRITISH COLUMBIA
MONTANA
WASHINGTON
OREGON
IDAHO
WYOMING
Y 2 Y
Yellowstone to Yukon Conservation Initiative
LEGEND
Status of Westslope Cutthroat Trout
Strong
Depressed
Extinct
Within native range, but data not available
Present, but status unknown
Introduced
Outside of native range
Outside of study area
50 0 50 100 150 200 Miles
75 0 75 150 225 300 375 Km
Ecology Center
GIS


Yellowstone to Yukon
Arctic Grayling
YUKON
TERRITORY
NORTHWEST TERRITORIES
ALBERTA
BRITISH
COLUMBIA
MONTANA
WASHINGTON
OREGON
IDAHO
WYOMING
Y 2 Y
Yellowstone to Yukon Conservation Initiative
LEGEND
Status of Arctic Grayling
Strong
Depressed
Extinct
Within native range, but data not available
Present, but status unknown
Introduced
Outside of native range
Outside of study area
50 0 50 100 150 200 Miles
75 0 75 150 225 300 375 Km
Ecology Center
GIS


Yellowstone to Yukon
Brook Trout
Yukon
Territory
Northwest Territories
Alberta
British
Columbia
Montana
Washington
Oregon
Idaho
Wyoming
Y 2 Y
Yellowstone to Yukon
Conservation Initiative
Status of Brook Trout
Introduced
Not present
Outside of study area
75 0 75 150 225 300 375 Km
50 0 50 100 150 200 Miles
Data compiled by David Mayhood
and Richard Walker
Base map by the Ecology Center

Literature cited

Documents

Alberta Fisheries Management Division. 1997. Annual report on the state of Alberta's fisheries. Pages 59–72 in Alberta guide to sportfishing regulations. Sport Scene Publications, Inc., Edmonton, Alberta. 96pp.

Alger, D. J., and D. B. Donald. 1984. Limnological studies in Kootenay National Park. Part 2: the streams. Report prepared for Parks Canada by the Canadian Wildlife Service, Edmonton, Alberta. 112pp.

Allan, J. H. 1980. Life history notes on the Dolly Varden char (Salvelinus malma) in the upper Clearwater River, Alberta. Manuscript report, Fish and Wildlife Division, Alberta Energy and Natural Resources, Red Deer, Alberta. 59pp.

American Wildlands, Clearwater Biodiversity Project, Idaho Watersheds Project, Inc., Montana Environmental Information Center, Pacific Rivers Council, Trout Unlimited–Gallatin Chapter, and Bud Lilly. 1997. Petition for a rule to list the westslope cutthroat trout (Oncorhynchus clarki lewisi) as threatened throughout its range. Petition to the Office of Endangered Species, Fish and Wildlife Service, United States Department of the Interior, Washington, D.C. 62pp.

Baker, T. T., A. C. Wertheimer, R. D. Burkett, R. Dunlap, D. M. Eggers, E. I. Fritts, A. J. Gharrett, R. A. Holmes, and R. L. Wilmot. 1996. Status of Pacific salmon and steelhead escapements in southeastern Alaska. Fisheries (Bethesda) 21(10):6–18.

Barton, B. A., D. J. Paton, and L. Seely. 1993. Special fish collections, upper Athabasca River, September and October 1992. Northern River Basin Study Project Report No. 10., Edmonton, Alberta. 50pp.

Behnke, R. J. 1992. Native trout of western North America. Amer. Fish. Soc. Monogr. 6:1–275.

Berry, D. K. 1994. Alberta's bull trout management and recovery plan. Alberta Fish and Wildlife Division, Department of Environmental Protection, Edmonton, Alberta. 22pp.

Brown, C. J. D. 1971. Fishes of Montana. Big Sky Books, Bozeman, Montana. 207pp.

Campbell, R. R. 1997. Rare and endangered fishes and marine mammals of Canada: COSEWIC Fish and Marine Mammals Subcommittee Status Reports: XI. Can. Field-Nat. 111:249–257.

Carl, G. C., W. A. Clemens, and C. C. Lindsey. 1959. The fresh-water fishes of British Columbia. British Columbia Provincial Museum Handbook No. 5, Victoria, B.C. 192pp.

Cavender, T. M. 1978. Taxonomy and distribution of the bull trout, Salvelinus confluentus (Suckley), from the American northwest. Calif. Fish Game 64:139–174.

Crossman, E. J., and D. E. McAllister. 1986. Zoogeography of freshwater fishes of the Hudson Bay drainage, Ungava Bay and the Arctic Archipelago. Pages 53–104 in C. H. Hocutt and E. O. Wiley, eds. The zoogeography of North American freshwater fishes. John Wiley and Sons, New York. 866pp.

Donald, D. B., and D. J. Alger. 1993. Geographic distribution, species displacement, and niche overlap for lake trout and bull trout in mountain lakes. Can. J. Zool. 71:238–247.

Donald, D. B., and J. D. Stelfox. 1997. Effects of fisheries enhancement and access on adfluvial bull trout populations in mountain lakes of southern Alberta. Pages 227–234 in W. C. Mackay, M. K. Brewin and M. Monita, eds. Friends of the Bull Trout conference proceedings. Bull Trout Task Force (Alberta), c/o Trout Unlimited Canada, Calgary, Alberta. ix + 464pp.

Dymond, J. R. 1932. Trout and other game fishes of British Columbia. Department of Fisheries, Ottawa, Ontario. 49pp.

Eriksen, C. H. 1975. Physiological ecology and management of the rare "southern" grayling Thymallus arcticus tricolor Cope. Verh. Int. Verein. Limnol. 19:2448–2455.

Falk, M. R., and D. V. Gilman. 1974. Impact of a sport fishery on Arctic grayling in the Brabant Island area, Northwest Territories. Environment Canada, Fish. Mar. Serv. Tech. Rept. No. CEN/T-74-7, 21pp.

Feldmeth, C. R., and C. H. Eriksen. 1978. A hypothesis to explain the distribution of native trout in a drainage of Montana's Big Hole River. Verh. Int. Verein. Limnol. 20:2040–2044.

Fitch, L. 1978. A report on biological inventories of 11 streams in the Crowsnest Drainage District of Alberta. Fish and Wildlife Division, Alberta Recreation, Parks and Wildlife, Lethbridge, Alberta. 92pp.

Fitch, L. 1997. Bull trout in southwestern Alberta: notes on historical and current distribution. Pages 147–160 in W. C. Mackay, M. K. Brewin and M. Monita, eds. Friends of the Bull Trout conference proceedings. Bull Trout Task Force (Alberta), c/o Trout Unlimited Canada, Calgary, Alberta. ix + 464pp.

Griffith, J. S. 1988. Review of competition between cutthroat trout and other salmonids. Amer. Fish. Soc. Symp. 4:134–140.

Haas, G. R., and J. D. McPhail. 1991. Systematics and distributions of Dolly Varden (Salvelinus malma) and bull trout (Salvelinus confluentus) in North America. Can. J. Fish. Aquat. Sci. 48:2191–2211.

Healey, M. C. 1982. Catch, escapement and stock-recruitment for British Columbia chinook salmon since 1951. Can. Tech. Rept. Fish. Aquat. Sci. 1107:iv + 77.

Hunt, C. W., R. Hawryluk, and D. Hildebrandt. 1997. Bull trout status in Alberta's Fish Management Area Four. Pages 171–186 in W. C. Mackay, M. K. Brewin and M. Monita, eds. Friends of the Bull Trout conference proceedings. Bull Trout Task Force (Alberta), c/o Trout Unlimited Canada, Calgary, Alberta. ix + 464pp.

Johnson, D. B. 1992. Status and distribution of westslope cutthroat trout on the North Fork Ranger District, Clearwater National Forest. Fisheries Biologist Report, Clearwater National Forest.

Johnson, J. E. 1987. Protected fishes of the United States and Canada. American Fisheries Society, Bethesda, Maryland. 42pp.

Kaya, C. M. 1991. Rheotactic differentiation between fluvial and lacustrine populations of Arctic grayling (Thymallus arcticus), and implications for the only remaining indigenous population of fluvial "Montana grayling." Can. J. Fish. Aquat. Sci. 48:53–59.

Leary, R. F., F. W. Allendorf, and K. L. Knudsen. 1987. Genetic divergence among populations of westslope cutthroat trout in the upper Kootenay River drainage, British Columbia. Population Genetics Laboratory Report 87/1, University of Montana, Missoula. 18pp.

Leary, R. F., F. W. Allendorf, and S. H. Forbes. 1993. Conservation genetics of bull trout in the Columbia and Klamath river drainages. Cons. Biol. 7:856–865.

Lee, D. S., C. R. Gilbert, C. H. Hocutt, R. E. Jenkins, D. E. McAllister, and J. R. Stauffer, Jr., eds. 1980. Atlas of North American freshwater fishes. North Carolina State Museum of Natural History, Raleigh, North Carolina. x + 867pp.

Liknes, G. A., and W. R. Gould. 1987. The distribution, habitat and population characteristics of fluvial Arctic grayling (Thymallus arcticus) in Montana. Northwest Sci. 61:122–129.

Lindsey, C. C., and J. D. McPhail. 1986. Zoogeography of fishes of the Yukon and Mackenzie basins. Pages 639–674. in C. H. Hocutt and E. O. Wiley, eds. The zoogeography of North American freshwater fishes. John Wiley and Sons, New York. xiii + 866pp.

Mayhood, D. W. 1992. Approaches to managing freshwater fishes in North American parks and reserves. Part 2 of a fish management plan for Jasper National Park. Report prepared for Canadian Parks Service, Jasper National Park, Jasper, Alberta. 118pp.

Mayhood, D. W. 1995. The fishes of the central Canadian Rockies ecosystem. FWR Freshwater Research Limited Report 950408, prepared for Parks Canada, Banff National Park, P.O. Box 900, Banff, Alberta T0L 0C0. 59pp.

Mayhood, D. W., W. Haskins, and M. D. Sawyer. 1997. Cumulative effects on fish. Pages 173–188 in M. D. Sawyer, ed. Southern east slopes cumulative effects assessment. Hayduke and Associates Ltd., Calgary, Alberta. 192pp. + appendices.

McPhail, J. D., and R. Carveth. 1993. Field key to the freshwater fishes of British Columbia. Fish Museum, Department of Zoology, University of British Columbia, Vancouver, B.C. ii + 239pp.

McPhail, J. D., and C. C. Lindsey. 1970. Freshwater fishes of northwestern Canada and Alaska. Fish. Res. Board Can. Bull. 173. 381pp.

McPhail, J. D., and C. C. Lindsey. 1986. Zoogeography of the freshwater fishes of Cascadia (the Columbia system and rivers north to the Stikine). Pages 615–637 in C. H. Hocutt and E. O. Wiley, eds. The zoogeography of North American freshwater fishes. John Wiley and Sons, New York. xiii + 866pp.

Michiel, P. 1989. North America's Arctic grayling. Pages 141–156 in R. Broughton, ed. Grayling: the fourth game fish. The Crowood Press, Ramsbury, Marlborough, Wiltshire U.K. 224pp.

Nehlsen, W., J. E. Williams, and J. A. Lichatowich. 1991. Pacific salmon at the crossroads: stocks at risk from California, Oregon, Idaho, and Washington. Fisheries (Bethesda) 16(2):4–21.

Nelson, J. S. 1965. Effects of fish introductions and hydroelectric development on fishes in the Kananaskis River system, Alberta. J. Fish. Res. Board Can. 22:721–753.

Nelson, J. S., and M. J. Paetz. 1992. The fishes of Alberta, 2nd ed. University of Alberta Press, Edmonton, and University of Calgary Press, Calgary, Alberta. xxvi + 437pp.

Pole, M. J. 1990. Draft fisheries management plan, Yoho National Park. Parks Canada, Field, B.C. 76pp.

Prince, E. E., T. H. McGuire, and E. Sisley. 1912. Dominion Alberta and Saskatchewan Fisheries Commission 1910–11. Report and recommendations with appendices. Government Printing Bureau, Ottawa, Ontario. 71pp.

Radford, D. S. 1977. A report on biological inventories of 17 streams in the Livingstone Drainage District of Alberta. Alberta Fish and Wildlife Division, Department of Recreation, Parks and Wildlife, Lethbridge, Alberta. 82pp.

Rhude, L. A., and J. D. Stelfox. 1997. Status of bull trout in Alberta's Fish Management Area Three. Pages 161–169 in W. C. Mackay, M. K. Brewin and M. Monita, eds. Friends of the Bull Trout conference proceedings. Bull Trout Task Force (Alberta), c/o Trout Unlimited Canada, Calgary, Alberta. ix + 464pp.

Rieman, B. E., and K. A. Apperson. 1989. Status and analysis of salmonid fisheries: westslope cutthroat trout synopsis and analysis of fisheries information. Idaho Department of Fish and Game, Job Performance Report, Project 73-R-11, Subproject II, Job 1, Boise, Idaho.

Rieman, B. E., and J. D. McIntyre. 1993. Demographic and habitat requirements for conservation of bull trout. Gen. Tech. Rep. INT-302, Intermountain Research Station, USDA Forest Service, Ogden, Utah. 38pp.

Rieman, B. E., D. C. Lee, and R. F. Thurow. 1997. Distribution, status, and likely future trends of bull trout within the Columbia River and Klamath River basins. N. Amer. J. Fish. Mgmt. 17:1111–1125.

Roberts, W. E. 1987. The bull trout—endangered in Alberta. Pages 129–131 in G. L. Holroyd, W. B. McGillivray, P. H. R. Stepney, D. M. Ealey, G. C. Trottier, and K. E. Eberhart, eds. Proceedings of the workshop on endangered species in the prairie provinces. Provincial Museum of Alberta, Occas. Pap. 9. 367pp.

Scott, W. B., and E. J. Crossman. 1973. Freshwater fishes of Canada. Fish. Res. Board Can. Bull. 184:1–966.

Shepard, B. B., B. Sanborn, L. Ulmer, and D. C. Lee. 1997. Status and risk of extinction for westslope cutthroat trout in the upper Missouri River basin, Montana. N. Amer. J. Fish. Mgmt. 17:1158–1172.

Simpson, J. C., and R. L. Wallace. 1982. Fishes of Idaho. University of Idaho Press, Moscow, Idaho. 238pp.

Slaney, T. L., K. D. Hyatt, T. G. Northcote, and R. J. Fielden. 1996. Status of anadromous salmon and trout in British Columbia and Yukon. Fisheries (Bethesda) 21(10):20–35.

Tripp, D. B., and P. T. P. Tsui. 1980. Fisheries and habitat investigations of tributary streams in the southern portion of the AOSERP study area. Volume I: summary and conclusions. Alberta Oil Sands Environmental Research Program Report 92. 224pp.

U.S., Dept. of Agriculture, Forest Service/U.S., Dept. of Interior, Bureau of Land Management. 1996. Administrative summary: extinction risk for westslope cutthroat trout on federal lands within the upper Missouri River basin in eastern Montana.

U.S., Dept. of Interior, Fish and Wildlife Service. 1997. Administrative 12-month finding on the petition to have bull trout listed as an endangered species. Pages 99–114 in W. C. Mackay, M. K. Brewin and M. Monita, eds. Friends of the Bull Trout conference proceedings. Bull Trout Task Force (Alberta), c/o Trout Unlimited Canada, Calgary, Alberta. ix + 464pp.

Van Eimeren, P. 1996. Westslope cutthroat trout. Pages 1–10 in D. A. Duff, ed. Conservation assessment for inland cutthroat trout: distribution, status and habitat management implications. USDA Forest Service, Intermountain Region, Ogden, Utah. 120pp. + appendices.

Ward, J. C. 1974. The fishes and their distribution in the mountain national parks of Canada. Report prepared by the Canadian Wildlife Service for Parks Canada, Calgary, Alberta. v + 41pp.

Williams, J. E., J. E. Johnson, D. A. Hendrickson, S. Contreras-Balderas, J. D. Williams, M. Navarro-Mendoza, D. E. McAllister, and J. E. Deacon. 1989. Fishes of North America endangered, threatened, or of special concern: 1989. Fisheries (Bethesda) 14(6):2–20.

Online Databases

Fisheries Information Summary System (FISS). Department of Fisheries and Oceans Canada, Pacific Region. http://habitat.pac.dfo.ca/heb/fhiip/index.htm.

Fish Stocking Query Page. British Columbia Ministry of Environment, Lands and Parks. http://www.env.gov.bc.ca:80/fsh/ids/dman/releases.html

Idaho River Information System (IRIS).

Aquatic Issues in the Yellowstone to Yukon

D. W. Schindler

Introduction

The Yellowstone to Yukon corridor connects several mountain ranges and includes several national, provincial and state parks, wilderness areas, and tracts of public land. These are interspersed with areas of private ownership and human industry. Even in protected areas, long-term high levels of human visitation and past mismanagement of waters in well-known parks such as Yellowstone, Glacier, Banff and Jasper, as well as the parks' special mandates for ecological protection, pose unique aquatic management problems. Here, I give a brief summary of what I consider to be some of the major aquatic problems (Schindler and Pacas 1996).

Waters of the Yellowstone to Yukon

Most lakes and rivers of the Y2Y are cold and oligotrophic (nutrient-poor and unproductive). At lower elevations, they support populations of coldwater fish species, most notably several species of salmonids. Within the region are several large reservoirs, such as Williston Lake on the Peace, the world' s largest reservoir, several large lakes on the Columbia River in southern B.C., and many smaller reservoirs. Because of the high elevation of the "backbone" of much of the corridor, the area supplies freshwater to lowland regions in excess of what would be expected based on area alone. For example, headwaters in the Canadian mountain national parks account for 87% of the flow of the Saskatchewan River, while representing only 12% of the drainage basin area (Schindler and Pacas 1996).

Special aquatic features of the Y2Y include the geysers of Yellowstone, the hot springs of Yellowstone, Banff, Jasper, and at many locations in British Columbia, and aquatic caves found at several locations. The hot springs and caves tend to have unique species assemblages. For example, one species of snail is found only in the hot springs near Banff, Alberta. A subspecies of fish, the Banff longnose dace, once occurred in the same springs, but is now extinct. Albino eyeless amphipods and isopods (Crustacea) have been found in caves in the mountain parks of Alberta (Schindler and Pacas 1996).

Stocking of non-native fish species

Perhaps the greatest aquatic problem to date in most of the Y2Y area is the introduction and establishment of non-native species. These species were usually introduced deliberately to enhance sport fishing. Although some stocking continues today, most of the damage was done during the first half of the twentieth century. Species of sport fish native to Europe, eastern North America, and other regions were deliberately introduced into fishless lakes, or added to lakes whose native species were regarded as poorer sport fish than the fish being stocked. The score is impressive: in the western U.S., 60% of fishless alpine lakes have been stocked (Bahls 1992). In the six mountain national parks of the Canadian Rockies, at least 305 of the 1464 fishless lakes have been stocked at least once, and many of them repeatedly, often with several species of fish. At least 21 non-native species were added to the Bow River in Banff and its tributaries. Originally, 12 fish species occupied the Bow Valley. Today, there are 21, including 10 non-native species. One endemic fish, the Banff longnose dace, was extirpated by introduced fish (mosquitofish, introduced early in the twentieth century for mosquito control). Modification of its hot spring habitat by humans may have contributed to this species' extirpation (Schindler and Pacas 1996).

Perhaps the greatest aquatic problem to date in most of the Y2Y area is the introduction and establishment of non-native species. These species were usually introduced deliberately to enhance sport fishing....In the Bow Valley of Banff, brook trout have invaded 100% of stream habitat for bull trout.

In other cases as well, the stocked fishes eliminated native species. For example, stocked brook trout eliminated bull trout, now threatened in much of the Y2Y corridor, from several lakes in Banff. In the Bow Valley of Banff, brook trout have invaded 100% of stream habitat for bull trout. Only six bull trout lakes in Banff National Park have not been stocked with exotic species or otherwise modified by humans. Where non-native species have survived, they are difficult if not impossible to remove. In extreme cases, they have eliminated and replaced native stocks that are endangered, such as bull trout (Schindler and Pacas 1996).

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Some stocked alpine lakes are again fishless, for stocked species did not reproduce. Even where the stocked non-natives did not survive, however, they did permanent harm to some aquatic communities. Fish eliminated the crustaceans that were originally top predators, resulting in dramatic shifts in invertebrate species community composition, and in some cases leading to domination by species that were not recorded from the lake prior to stocking. Such lakes have proved to be restorable, but only slowly and with considerable effort, including the restocking of eliminated invertebrate species (Parker and Schindler 1995). Many systems where non-native species have been stocked, however, cannot be restored. Their communities have been permanently altered, at least until new restoration techniques are devised.

Overfishing

Overfishing also had early effects on fisheries in the area. In the Athabasca River, it is possible that grayling were eliminated from the upper reaches, in Jasper National Park, by the turn of the twentieth century. Nineteenth century journals contain frequent references to "grayling," and tributaries of the Athabasca in the adjacent Willmore Wilderness Area are some of the world' s best grayling waters (Mayhood 1992). On the other hand, it is possible that nineteenth-century fishermen were calling mountain whitefish "grayling," and that grayling were never present in the upper reaches of the river. No specimens or scientific data were kept, and we will probably never know for sure.

Clearcut areas can increase the inputs of silt, nutrients and other chemicals to streams and rivers. In addition, removal of the forest canopy exposes many smaller streams to full sunlight for the first time in centuries. Recent studies have shown that this can cause sensitive stream invertebrates to be damaged by UV radiation, whereas previously the forest canopy acted as a UV shield.

In the early part of the twentieth century, it was common for fishermen to catch and keep as many fish as possible. Early photos from the mountain parks show fishermen holding huge stringers of trophy-size fish. Bull trout were regarded as an inferior species, and many fishermen simply tossed them out on the bank to die and rot.

Although fishing is now more closely controlled, some problems still persist. As human visitation and resident populations have grown, so has fishing pressure. Many areas show signs of declining fish stocks. For example, in the province of Alberta, the catch per unit of angling effort has declined by about 50% in many waters containing sport fish. More stringent regulations, including catch and release fisheries, lower bag limits, and periodic closures, are inevitable.

Impoundment

Few of the rivers in the southern half of the Y2Y corridor have not been impounded, or had their flows otherwise modified, by irrigation, road and railway right-of-ways, hydroelectric reservoirs, and other projects. The Columbia and the Missouri have been dammed at several places. In the former system, sea run salmon stocks are nearly extinct as a result. The Saskatchewan has also been dammed where it leaves the mountain national parks. Even within the Canadian national parks, the effects of modification are impressive. For example, over 40% of the waters in the Bow Valley within Banff National Park have had their flows modified in some way. The valley contains a large hydroelectric reservoir (Lake Minnewanka), and many smaller impoundments along roads and railways through the river valley, for water supply, bathing, and other human purposes. These impoundments have multiple effects: destruction of floodplain and deltaic habitats that support fish and aquatic mammals, obstruction of fish passage, conversion of stream to lacustrine habitat, and seasonal drawdowns that lay bare large stretches of littoral habitat. Many of the impediments to flow could be removed, but in most cases it would take decades for streams and lakes to regain their original form (Schindler and Pacas 1996).

Farther north, Bennett Dam on the Peace River has destroyed two major tributaries to form Williston Lake, possibly the world' s largest reservoir. Reduced flows below the dam have severely degraded the wetlands of the Peace-Athabasca Delta, causing severe losses of migratory birds, furbearers, fishes, and aboriginal lifestyles (Green 1992).

Railways and major highways traverse the Y2Y at several points. In addition to disrupting wildlife movements, these tend to impound water and impede the migration of fishes. The Trans-Canada Highway through Banff and the Yellowhead Highway through Jasper, and the CN and CPR rail lines all disrupt natural flow and fish movement patterns within the parks, despite the protection supposedly provided by the parks' mandate (Schindler and Pacas 1996).

Contaminant deposition

Due to its relatively low human populations and light industrial activity, the Y2Y corridor has generally been considered to be an area of low air pollution. Nevertheless, predatory fishes from high-elevation lakes in the Y2Y were recently found to contain moderate to high concentrations of organochlorine pollutants such as toxaphene, PCBs, DDT, and hexachlorohexane (HCH) (Donald et al. 1993). Our investigation of snowpacks has revealed that deposition of such pollutants is rather high, with up to 40-fold increases per thousand metres increase in elevation. This appears to be the result of increased snowfall at higher elevation (roughly 7-fold per thousand metres in the area of Banff) and lower revolatilization of contaminants from snowpacks at high elevation, due to colder temperatures (Blais et al. 1998). While concentrations of these chemicals in fish are not presently above health guidelines (at least in Canada), increased industrial pollution may cause problems in the future.

Eutrophication

Eutrophication, the overfertilization of lakes and streams with plant nutrients, is an emerging problem, particularly at sites of increasing human population or activity. For example, the towns of Banff and Lake Louise add much phosphorus and nitrogen to the Bow River. The former element, which is of most concern because it limits algal growth in most waters of the Y2Y, increases over 7-fold in concentration in the Bow River from a point just above Lake Louise to one just below Banff. Lake Louise contributes 75% of the phosphorus in the Bow River at the point where it discharges into the river. Further downstream, Banff sewage contributes 58% of the phosphorus at that point, and the remaining 42% is contributed largely by Lake Louise (Schindler and Pacas 1996). A similar situation exists in the Athabasca River as it passes the town of Jasper. The main effect of nutrients in the rivers is to increase the growth of algae attached to rocks on the river bottom. Nutrient inputs and algal growth may be higher than normal for several kilometres downstream of sewage effluent. Just outside the park boundary, the town of Hinton discharges to the river a combined effluent from the town sewage and a bleached kraft pulp mill (Chambers 1996).

Effects of nutrients on high elevation rivers are poorly known, although algal growths that exceed British Columbia guidelines occur on some parts of the Thompson River, B.C. (Bothwell 1992). Sewage effluents probably affect the many rare stream invertebrate species in the area.

Lake Louise has recently opened a new sewage treatment plant which will reduce inputs of phosphorus to the river by over 90%. Banff has plans for a similar facility, although it is still in the planning stages. The need for such "tertiary treatment" is being debated in Jasper.

In general, as population centers increase in size, nutrient problems worsen. Even if tertiary treatment is used for sewage effluents, indirect sources such as lawn fertilizer and pet excrement can enter rivers via storm drains. Also, areas where forests are cleared or land is tilled generally yield increasing amounts of phosphorus and nitrogen to rivers. In brief, the problem of eutrophication in the Y2Y can be expected to worsen as human population and industrial development in the area increase.

Mining

Mining for coal, copper, gold and other minerals in the Y2Y has many effects on freshwaters. In the past, gold mining has caused severe siltation and stream bed disruption, as well as adding arsenic and mercury to rivers and lakes.
A proposed coal mine just outside Jasper National Park would destroy stream habitats for the rare subspecies Athabasca rainbow trout, in addition to destroying bull trout habitat. Any large open-pit mine, of the sort common in Montana and Alberta, disrupts groundwater patterns and usually destroys stream courses and sometimes smaller lakes.

Forestry

Forestry causes aquatic as well as terrestrial problems. In the past, pulp mill effluents caused enormous damage to fisheries and water quality. Bleached kraft pulp mills such as those at Prince George, Hinton, Williston Lake, Grande Prairie, and other locations discharged dioxins, furans and other organochlorine chemicals to rivers, contaminating fish to levels that made them unsuitable for human consumption for hundreds of kilometres of river course. The pulp mill at Hinton once caused the Athabasca River to run anoxic (oxygen-free) under winter ice for tens, if not hundreds, of kilometres. Although these problems were recognized and effluent quality was improved in the late 1980s and early 1990s, dioxins and furans remain, for they degrade only very slowly (Northern River Basins Study 1996).

Clearcut areas can increase the inputs of silt, nutrients and other chemicals to streams and rivers (Nicolson 1975). In addition, removal of the forest canopy exposes many smaller streams to full sunlight for the first time in centuries. Recent studies have shown that this can cause sensitive stream invertebrates to be damaged by UV radiation, whereas previously the forest canopy acted as a UV shield (D. Kelly and J. Clare1, unpublished data).

Summary

Despite the low densities of human populations in the Y2Y, there have been a number of major insults to aquatic habitats. Increased protection of the area would benefit not only large carnivores, but also waters that are key to the produc-

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tion of salmon, trout and other coldwater species. As human populations and exploitation increase, more vigilant protection of these areas will be necessary to protect biodiversity and water quality.

Literature cited

Bahls, P. 1992. The status of fish populations and management of high mountain lakes in the western United States. Northwest Science 66:183-193.

Blais, J. M., D. W. Schindler, D. C. G. Muir, D. B. Donald, and B. Rosenberg. 1998. Accumulation of persistent organochlorines in mountains of western Canada. Nature (in press).

Bothwell, M. L. 1992. Eutrophication of rivers by nutrients in treated kraft pulp mill effluent. Wat. Poll. Res. J. Canada 27:447-472.

Chambers, P. A. 1996. Nutrient enrichment in the Peace, Athabasca and Slave Rivers: assessment of present conditions and future trends. Northern River Basins Study, Synthesis Report no. 4. Alberta Environmental Protection, Edmonton, Alberta. 107pp.

Donald, D. B., R. Bailey, R. Crosley, D. Muir, P. Shaw, and J. Syrgiannis. 1993. Polychlorinated bipheynls and organochlorine pesticides in the aquatic environment along the continental divide region of Alberta and British Columbia. Environment Canada, Inland Water Directorate, Regina, Saskatchewan. 98pp.

Green, J. R. 1992. A preliminary assessment of the effects of the W. C. Bennett Dam on the Athabasca River Delta and the Athabasca Chipewyan Band. Athabasca Chipewyan Band, Fort Chipewyan, Alberta. 38pp.

Mayhood, D. W. 1992. A preliminary assessment of the native fish stocks of Jasper National Park. Prepared for Canadian Parks Service, Jasper National Park, Jasper, Alberta, by Freshwater Research Ltd., Calgary, Alberta. 296 pp.

Fire in the Yellowstone to Yukon

Ian Pengelly and Cliff White

Fire: The Dominant Ecological Process Of The Past

Throughout western North America, forest fires have played a dominant ecological role in shaping vegetation communities (Habeck and Mutch 1973). Kilgore and Heinselman (1990) recognize eight ways that fire structures ecosystems .

Table 1. The role of fire in ecosystems.

THE ROLE OF FIRE	MECHANISMS
influences plant community composition	triggers release of seeds, alters seedbeds, stimulates vegetative reproduction of many species when the overstory is removed, reduces competition for moisture, nutrients, heat and light, controls species and age composition
interrupts and alters succession	depending on frequency, timing and severity of fire, multiple pathways of post-fire succession are possible
regulates fuel accumulations	in most coniferous forests the production of plant biomass exceeds decomposition; fire is the major recycling agent
influences nutrient cycles and energy flows	releases nutrients stored in downed biomass in soluble form that is readily available to plants
affects wildlife habitat	increases quantity and quality of browse, quantity and availability of seeds and berries, creates "edge" to provide more feeding areas adjacent to cover
interacts with insects and diseases	counteracts the tendency toward uniformity-the resultant mosaic is better protected against disease and infestations than are large, uniform stands
influences ecosystem productivity, diversity and stability	speeds up the recycling of nutrients, stabilizes the system as a whole through ever-changing mix of successional stages, communities and stand ages in the vegetation mosaic of most ecosystems
influences the scale of the vegetation mosaic	depends on the scale of fires, fire regime, and the character of the terrain

Historical Fire Studies

A popular belief has been that, due to early European exploration, settlement and development activities, forest fires were more frequent and extensive during the late 1800s and early 1900s than in pre-European times (Johnson et al. 1990). Recent fire history studies, however, consistently demonstrate that forest fires were common during the past hundreds, and probably thousands, of years (Johnson et al. 1990).

The term “fire cycle” is commonly used to indicate the size and frequency of fires in an area. The “fire cycle” of an area is the time required to burn an area equal in size to the whole forest. During a fire cycle some areas may randomly burn more than others, and some not at all. In areas where

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low intensity fires are the norms, fire history studies are based on the intervals between fire scars (due to partial death of the cambium) of fire-resistant trees. If the probability of burning is constant with stand age in a homogeneous environment over time, the average fire interval will equal the fire cycle (Johnson and Van Wagner 1985).

Table 2. Mean historic fire intervals (years) for various forest types.

Area	Ponderosa pine	Douglas fir	Lodgepole pine	Western Red Cedar	Subalpine fir	Reference
Yellowstone NP, WY		20-50	150-250		300	Houston 1973; Romme 1982; Barrett 1994
Selway, ID/Bitterroot, MT	22	119	47-112	197	166	Brown et al. 1995
E. Idaho				70-120		Arno 1980
W. Montana		35-40				Arno & Gruell 1983
Glacier NP, MT		36	46	261	202	Barrett et al. 1991
Bob Marshall, MT			40			Gabriel 1976
Waterton Lakes NP, AB		36	71		200	Barrett 1996
Kananaskis, AB			90		153	Hawkes1980
Banff NP, AB		42	94-130		181	White 1985
Jasper NP, AB		18-27	74			Tande 1979

Where intense stand-replacing fires are common, fire scar evidence is often lost in subsequent burns which kill and consume the previously scarred trees. However, the distribution of stand ages can be used to calculate the fire cycle (Van Wagner 1978; Johnson and Van Wagner 1985) if certain conditions are met. Although these studies must be interpreted with caution (Agee 1996; Finney 1995; Barrett 1996), they also show how prevalent forest fires have been during the past 3–5 centuries (Table 3).

Table 3. Historic fire cycles in coniferous forests (various forest types) in the central Canadian Cordillera.

Location	Historic Period	Fire Cycle	Reference
Glacier NP, B.C.	1760 – 1988	110 years	Johnson et al. 1990
Kootenay NP, B.C.	1421-1931	130 years, 110 years	Masters 1990; Van Wagner 1995
Yoho NP, B.C.	1520-1980	132 years, 209 years	Tymstra 1991; Van Wagner[1] pers. comm. 1993
Banff NP, AB	1660-1940	155 years	Van Wagner 1995
Jasper NP, AB	1735-1915	150 years	Van Wagner 1995
Waterton Lakes NP, AB	1633-1940	84 years	Barrett 1996
Kananaskis Valley, AB	1730-1980	90 years, 121 years	Johnson & Larsen 1991, Van Wagner pers. comm. 1993
Northern B.C.	ca. 1700-present	100-200 years	Parminter[2] pers comm. 1997

Three Examples Of Present-day Fire Regimes In The Y2y Corridor

1. The central region

Based on the mean historic fire cycles in Tables 2 and 3, 50–100% of the subalpine coniferous forests in the central Canadian Rockies would have burned during the period 1910–1996 if the fire regimes of the reference period had continued to the present, and had not been interrupted by fire suppression. On the east slope of the Rockies, however, fires have generally burned less than 10% of the forested land base; areas on the west slope of the Rockies and Columbia mountains (Glacier National Park) have a slightly more active fire regime, burning between 16% and 28% of the study areas (Table 4).

Some studies suggest that fire activity declined due to climate change in the mid–1700s (Johnson et al. 1990; Johnson and Larsen 1991; Johnson 1992; Johnson and Wowchuk 1993; Johnson et al. 1995), with a further decline in the late 1800s and early 1900s, again due to climate change (Johnson et al. 1995). Proxy climate data based on dendrochronology, however, do not indicate any large scale climate change in the mid–1700s (Luckman and Seed 1995; Case and MacDonald 1995), and the change in fire cycles may be only an apparent one due to data limitations and the model used (Finney 1995; Rogeau 1996).

In the last century, a widespread decline in fire activity occurred in Canada during the 1940s and 1950s (Van Wagner 1988). A decline in mean temperature in North America during the same period probably resulted in weather conditions that enhanced the relatively primitive fire suppression technology of the time (Luckman and Seed 1995). However, despite that fact that the severity of fire weather in Banff National Park during the early part of the twentieth century was comparable with that of the later part of the century, (Balling et al. 1992; Fuenekes and Van Wagner 1995; Luckman and Seed 1995), a much greater area burned during the earlier period. Fire history studies indicate that the nearly fire-free period of the last 5–7 decades is unprecedented during the past 4–5 centuries. This is strong evidence that a lack of human ignitions and increasingly effective fire suppression are altering long-term ecosystem processes and conditions (Feunekes and Van Wagner 1995; Van Wagner 1995).

Table 4. Percentage of forested areas burned by wildfires 1910–1949 and 1950–1996.

Area	Flammable Terrain	% burned 1910-49	% burned 1950-96
Waterton Lakes NP, AB	230 km^2	6.0%	0
Kananaskis Valley, AB	480 km^2	35.6%	1.0%
Banff NP, AB	3800 km^2	8.4%	0.1%
Jasper NP, AB	6500 km^2	4.0%	0.5%
Kootenay NP, B.C	1000 km^2	20.0%	2.5%
Yoho NP, B.C.	650 km^2	7.4%	8.6%
Glacier NP, B.C.	600 km^2	15.6%	12.3%

Within the Yellowstone to Yukon corridor, fire suppression is most effective in the cool, moist subalpine coniferous forest. In this ecoregion multiple lightning ignitions are rare and are usually contained or extinguished before the onset of severe weather conditions in which fires become uncontrollable. The main ecological effect of reduced fire activity in the subalpine forest is a lack of post-fire successional vegetation and wildlife habitats.

The similarity of fire cycles on both sides of the Continental Divide—in spite of the large differences in density of lightning-caused fire starts—is evidence of the importance of historic burning by Native Americans, particularly on the east side of the divide. For example, although Montana's Glacier National Park contains approximately equal areas of east slope and west slope terrain, O'Brien (1969) noted that between 1910–1968, 90% of 525 reported lightning fires occurred on the park's western slopes.

Another study analyzed the distribution of more than fourteen thousand lightning fires in the Central Rockies and Columbia Mountains. Although the area east and west of the Continental Divide was nearly equal, 87% of the fire starts and 87% of the area burned occurred on the west side

1 C. E. Van Wagner, pers. comm. August 8, 1993. Retired fire researcher, Canadian Forestry Service, Deep River, Ontario.

2 J. Parminter, pers. comm. August 1997. Forest ecology researcher, British Columbia Forest Service.

of the divide. In this study the density of lightning-ignited fires in the Columbia Mountains and B.C. Interior Plateau was much greater than on the west slopes of the Rockies, but again the historic fire cycles were similar. While the reasons for these differences in lightning-ignited fire activity are unclear, spatial and temporal analysis shows that the pattern is consistent over time (Wierzchowski and Heathcott 1997).

2. The Intermountain West and southern interior of British Columbia

Dry forests in the Intermountain West and the interior of southern British Columbia tend to have active lightning fire regimes. As forest fuels are very dry through much of the summer, there is high potential for fires to spread soon after ignition (possibly because fuels have accumulated). The area burned by wildfires has increased during the past two decades in spite of very large fire suppression expenditures (Arno 1996). Where lightning fires are not suppressed, a significant amount of area may be burned.

An example is the Selway-Bitterroot Wilderness (SBW), which extends over 526,293 ha in northern Idaho and western Montana. The prescribed natural fire (PNF) program which has been in place over the entire SBW since 1979 is generally considered to be one of the most successful fire restoration programs in the United States. During the 12-year period after the program was put in place, more than 60,704 ha burned, 39% of this during the 1988 fire season. A comparison of the area burned prior to effective fire suppression (1935) and the recent past (1979–1990), however, indicated that the presuppression area burned was 1.5 times greater for stand-replacing fire and at least 1.9 times greater for understory fire (Brown et al. 1995).

Although the SBW is very large, the scale of natural fires in the region still dictates that many fires are managed as wildfires with some suppression action to prevent fires from crossing the boundaries and threatening property. In many other wilderness areas, the constraints on prescribed natural fire programs are much greater, and increased use of manager-ignited prescribed fire has been advocated to augment PNF programs (Agee 1995; Mutch 1995).

Lengthening the interval between fires in non-lethal and mixed-severity fire regimes where historic fire return intervals were generally less than fifty years has resulted in more extensive densely stocked forests which are susceptible to stress from drought and forest insects, and more likely to experience lethal stand-replacing fires when they do burn. Although the higher intensity crown fires may be more difficult to suppress and thus somewhat larger than historic fires, it is unlikely that infrequent conflagration fires will maintain fire regimes over the long term.

3. The sub-boreal and boreal forest regions

In boreal and sub-boreal forests, crown fires may occur under moderate temperatures and winds due to the highly flammable nature of black spruce forests. In these regions multiple lightning ignitions often occur in remote areas where fire suppression is difficult, and large fires are still common (Simard 1997). Because lightning ignitions tend to be evenly distributed across the landscape and fires continue to be ignited by both native and non-native people for various reasons, there are few areas that are largely fire-free (unlike the central parts of the corridor).

An example of a very active fire regime is the Muskwa/Kechika area in the Northern Rocky Mountains of British Columbia. Prescribed burning to create habitats for big game hunting has shifted the vegetation from spruce forests—which formerly burned on a cycle of about 150 years— to aspen/grassland savannah typical of a fire cycle of about 20 years (J. Parminter, pers. comm. August 1997).

Heterogeneity In Fire Histories And Fire Regime

Within the Y2Y region, fire history and fire regimes have been heterogeneous, as have the effects of recent fire suppression. For example, high-elevation landscapes were historically characterized by infrequent but large, severe fires, and remain so today. Low-elevation landscapes, on the other hand, were formerly shaped by frequent, low-intensity fires, but because of recent fire suppression and changes in fuels, they are now experiencing a fire regime more like that of high-elevation landscapes.

In addition, there appears to be a latitudinal gradient in fire cycles within those landscapes characterized by severe crown fires. As one moves from north to south, intervals between successive fires appear to lengthen, and the age class structure of forest stands on the landscape becomes progressively older.

The Role Of Humans In Fire History And Fire Regimes

As indicated earlier, there is no doubt that humans historically have played a major role in determining fire frequency and area burned in the Y2Y region. There are other critical determinants of fire behavior, however, including the large-scale atmospheric processes (Johnson and Wowchuk 1993).

While ignition sources and fuels are important in controlling relatively small fires burning under moderate weather conditions, the large fires which are responsible for most of the burned area each decade or century are controlled primarily by severe weather conditions (Turner and Romme

1994). Specifically, Native American burning had little effect on fire history in high elevation landscapes such as Yellowstone, where generally wet conditions preclude extensive fire except during extreme summers like that of 1988—when lightning is a sufficient ignition source.

THE FUTURE OF FIRE IN THE YELLOWSTONE TO YUKON CORRIDOR

The lack of human-ignited fires and fire suppression are having a profound effect on vegetation and wildlife in many parts of western North America (Kay et al. 1994; Pyne 1995). These effects are particularly evident in changes in the structure and function of low elevation landscapes. In high elevation landscapes, however (especially in the southern end of Y2Y in regions like the Yellowstone Plateau), long intervals between large fires have been the norm, and twentieth-century fire suppression probably did not change landscape dynamics significantly.

The recognition that the fire-adapted landscape is, to some extent, a cultural one of Native American origin points to the need to choose goals for the use of fire in the future.

Today, people and organizations from diverse backgrounds recognize that the ecological effects of greatly extended fire cycles are undesirable. Restoring fire to wildland areas has been advocated for a variety of reasons such as (1) to reduce forest fuels and thus the intensity of wildfires, (2) to reduce the extent and severity of forest insects and diseases which threaten timber in harvested forests, (3) to maintain wildlife species and populations adapted to post-burn habitats, and (4) to maintain the diversity of native vegetation (Mutch and Cook 1996).

At present, most government forest management agencies have programs for planned ignition or prescribed natural fire, and for limiting suppression of wildfires where possible. The challenge is to extend programs to the landscape level while keeping costs and other impacts at an acceptable level, and while recognizing the heterogeneity of fire cycles within the region. The constraints are both social (overcoming fear of escaped fire and aversion to smoke), and technical (protecting communities, facilities and commercial forests).

Within the Yellowstone to Yukon corridor, the landscape is becoming increasingly fragmented by settlement and industrial land uses, especially in lower elevation areas. Restoring fire in this environment will be challenging. Since the effects of modern human activities on the long-term fire regime are most significant at low elevations, restoration programs will need to be different in high-elevation and low-elevation areas. The challenge for future fire research in the Yellowstone to Yukon region is to delineate and quantify the gradient of human impact with elevation, and to restore where possible natural fire regimes where they have been altered by current human land uses. Restoring fire will be difficult in some parts of the region. Conservation of the native flora and fauna, however, will not be achieved without it.

Literature cited

Agee, J. K. 1995. Alternatives for implementing fire policy. Pages 107–112 in J. K. Brown, R. W. Mutch, C. W. Spoon, and R. H. Wakimoto, tech. coords. Proceedings: symposium on fire in wilderness and park management. Gen.Tech. Rep. INT-GTR-320, USDA Forest Service, Intermountain Research Station, Ogden, Utah.

Agee, J. K. 1996. Fire regimes and approaches for determining fire history. Pages 12–13 in C. C. Hardy and S. F. Arno, eds. The use of fire in forest restoration. Gen. Tech. Rep. INT-GTR-341, USDA Forest Service, Intermountain Research Station, Ogden, Utah.

Arno, S. F. 1980. Forest fire history in the northern Rockies. J. For. 78:460–465.

Arno, S. F. 1996. The seminal importance of fire in ecosystem management—impetus for this publication. Pages 3–5 in C. C. Hardy and S. F. Arno, eds. The use of fire in forest restoration. Gen. Tech. Rep. INT-GTR-341. USDA Forest Service, Intermountain Research Station, Ogden, Utah.

Arno, S. F., and G. E. Gruell. 1983. Fire history at the forest-grassland ecotone. J. Range Manage. 36:332–336.

Balling, R. C., Jr., G. A. Meyer, and S. G. Wells. 1992. Climate change in Yellowstone National Park: is the drought-related risk of wildfires increasing? Climatic Change 22:35–45.

Barrett, S. W. 1994. Fire regimes on andesitic mountain terrain in northeastern Yellowstone National Park. Int. J. Wildland Fire 4(2):65–76.

Barrett, S. W. 1996. The historic role of fire in Waterton Lakes National Park, Alberta. Report to Parks Canada, Waterton Lakes National Park, Waterton Lakes, Alberta.

Barrett, S. W., S. F. Arno, and C. H. Key. 1991. Fire regimes of western larch-lodgepole pine forests in Glacier National Park, Montana. Can. J. For. Res. 21:1711–1720.

Brown, J. W., S. F. Arno, L. S. Bradshaw, and J. P. Menakis. 1995. Comparing the Selway-Bitterroot fire program with presettlement fires. Pages 48–54 in J. K. Brown, R. W. Mutch, C. W. Spoon, and R. H. Wakimoto, tech. coords. Proceedings: symposium on fire in wilderness and park management. Gen. Tech. Rep. INT-GTR-320, USDA Forest Service, Intermountain Research Station, Ogden, Utah.

Case, R. A., and G. M. MacDonald. 1995. A dendroclimatic reconstruction of annual precipitation on the western Canadian prairies since A.D. 1505 from Pinus flexilis James. Quat. Res. 44:267–275.

Finney, M. A. 1995. The missing tail and other considerations for the use of fire history models. Int. J. Wildland Fire 5(4):197–202.

Fuenekes, U., and C. E. Van Wagner. 1995. A century of fire and weather in Banff National Park. Report to Parks Canada, Natural Resources Branch, Ottawa, Ontario. 12pp.

Gabriel, H. W. 1976. Wilderness ecology: the Danaher Creek drainage, Bob Marshall Wilderness, Montana. Ph.D. Diss., University of Montana, Missoula. 224pp.

Habeck, J. R., and R. W. Mutch. 1973. Fire dependent forests in the northern Rocky Mountains. Quat. Res. 3(3):408–424.

Hawkes, B. C. 1980. Fire history of Kananaskis Provincial Park—mean fire return intervals. Pages 42–45 in M. A. Stokes and J. H. Dieterich, eds. Proceedings of the fire history workshop. Gen. Tech. Rep. RM-81, USDA Forest Service.

Houston, D. B. 1973. Wild fires in northern Yellowstone National Park. Ecology 54:1111–1117.

Johnson, E. A. 1992. Fire and Vegetation Dynamics: Studies from the North American Boreal Forest. Cambridge University Press, Cambridge U.K.

Johnson, E. A., and C. P. S. Larsen. 1991. Climatically induced change in fire frequency in the southern Canadian Rockies. Ecology 72:194–201.

Johnson, E. A., and C. E. Van Wagner. 1985. The theory and use of two fire history models. Can. J. For. Res. 15:194–201.

Johnson, E. A., and D. R. Wowchuk. 1993. Wildfires in the southern Canadian Rocky Mountains and their relationship to mid-tropospheric anomalies. Can. J. For. Res. 23:1213–1222.

Johnson, E. A., G. I. Fryer, and M. J. Heathcott. 1990. The influence of man and climate on frequency of fire in the interior wet belt forest, British Columbia. J. Ecol. 78:403–412.

Johnson, E. A., K. Miyanishi, and J. M. H. Weir. 1995. Old-growth, disturbance, and ecosystem management. Can. J. Botany 73:918–926.

Kay, C. E., B. Patton, and C. A. White. 1994. Assessment of long-term terrestrial ecosystem states and processes in Banff National Park and the central Canadian Rockies. Resource Conservation, Banff National Park.

Kilgore, B. M., and M. L. Heinselman. 1990. Fire in wilderness ecosytems. Pages 297–335 in J. C. Hendee, G. H. Stankey, and R. C. Lucas, eds. Wilderness management, 2nd ed. North American Press, Golden, Colo.

Luckman, B. H., and E. D. Seed. 1995. Fire-climate relationships and trends in the mountain national parks. Report to Parks Canada, Ottawa. 204pp.

Masters, A. M. 1990. Changes in forest fire frequency in Kootenay National Park, Canadian Rockies. Can. J. Botany 68:1763–1767.

Mutch, R. W. 1995. Prescribed fires in wilderness: how successful? Pages 38–41 in J. K. Brown, R. W. Mutch, C. W. Spoon and R. H. Wakimoto, tech. coords. Proceedings: symposium on fire in wilderness and park management. Gen. Tech. Rep. INT-GTR-320, USDA Forest Service.

Mutch, R. W., and W. A. Cook. 1996. Restoring fire to ecosystems: methods vary with land management goals. Pages 9–11 in C. C. Hardy and S. F. Arno, eds. The use of fire in forest restoration. Gen. Tech. Rep. INT-GTR-341, USDA Forest Service, Intermountain Research Station, Ogden, Utah.

O'Brien, D. M. 1969. Occurrence of lightning caused fires in Glacier National Park. Unpub. report on file, Resource Management Division, Glacier National Park, Montana.

Pyne, S. J. 1995. World fire: a cultural history of fire on earth. Henry Holt and Co., New York. 379pp.

Rogeau, M. P. 1996. Understanding age-class distribution in the southern Canadian Rockies. Master's thesis, Dept. Forest Science, University of Alberta, Edmonton. 139 pp.

Romme, W. H. 1982. Fire and landscape diversity in subalpine forests of Yellowstone National Park. Ecol. Monogr. 52:199–221.

Simard, A. J. 1997. Wildland fire in Canada. Initial Attack (Spring 1997):3–5.

Tande, G. F. 1979. Fire history and vegetation pattern of coniferous forests in Jasper National Park, Alberta. Master's Thesis, University of Alberta, Edmonton. 169pp.

Turner, M., and B. Romme. 1994. Landscape dynamics in crown fire ecosystems. Landscape Ecology 9(1):59-77.

Tymstra, C. 1991. Fire history of Yoho National Park, British Columbia and implications for fire management. Master's thesis, University of Alberta, Edmonton. 151pp.

Van Wagner, C. E. 1978. Age-class distribution and the forest fire cycle. Can. J. For. Res. 8:220–227.

Van Wagner, C. E. 1988. The historical pattern of annual burned area in Canada. For. Chron. 64(3):182–185. Plus "Erratum" in 64(4):319.

Van Wagner, C. E. 1995. Analysis of fire history for Banff, Jasper and Kootenay National Parks. Report to Parks Canada, Ottawa. 21pp.

White, C. A. 1985. Wildland fires in Banff National Park 1880–1980. Occ. Pap. 3. National Parks Branch, Parks Canada, Environment Canada, Ottawa. 106pp.

Wierzchowski, J.,3 and M. Heathcott.4 1997. Lightning and lightning fire in the mountain park window. Unpublished manuscript.

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APPROACHES TO CONSERVATION

Defining Grizzly Bear Habitat in the Yellowstone to Yukon

Troy Merrill
and David J. Mattson

INTRODUCTION

Historically, densities of grizzly bears varied over time and space because of differences in fecundity, which were dependent on food abundance and competition with other grizzly bears or other species. Although potentially lethal to each other, grizzly bears seem to have evolved behavioral means of minimizing lethal conflict between adults. Mortality among neonates was high, but among most reproductive-age adults, mortality rates were low.

Technological humans are an "extra-normal" evolutionary phenomenon for grizzly bears. We kill bears with relative ease and impunity, something they have not experienced until very recent times. Bears exhibit no morphological or behavioral features "designed" to minimize risk of predation by humans. If anything, their behavior tends to aggravate this risk. The density of grizzly bears in the Y2Y is now dictated by variation in mortality rather than fecundity. Mortality is dependent on the number and behavior of humans.

Conservation of grizzly bears in the Y2Y presents a unique challenge. Grizzly bears are wide-ranging, adaptive animals with the ability to kill people. It is humans, however, that do the killing. Bears need large spaces free from human beings because the more that bears come into contact with humans, the more likely they are to be killed. By mapping zones of human activity, we have identified areas where bears are less likely to come into contact with humans. These areas, therefore, provide potential grizzly bear habitat. Many of these areas are not currently occupied by grizzly bears. Some may lack adequate food resources for bears. We feel, however, that the identification of areas of potential habitat can serve as a guide in developing a system of protected areas in the Y2Y that will benefit more than just grizzly bears.

Because humans dominate an increasing portion of the landscape, bear populations are becoming more isolated from each other. Small isolated populations are vulnerable to extirpation from environmental and demographic stochasticity (random events with some probability of occurrence; e.g., extreme storms, or the loss of all reproductive-age males from a population). Therefore it is vital to the continued survival of grizzly bears that populations remain connected. Based on the distribution of potential grizzly bear habitat in Y2Y it appears that grizzly bears in the U.S. are in danger of becoming separated from grizzly bears in Canada.

Troy Merrill is a research consultant with LTB Consulting. In association with the Hornocker Wildlife Institute, Troy is currently researching conservation plans for grizzly bears and Siberian tigers. Dave Mattson is a research wildlife biologist with the U.S. Gological Service's Biological Resources Division, working out of the Forest and Rangeland Ecosystem Science Center at the University of Idaho. He has worked on grizzly bear/ habitat relations for 19 years.

Figures next pages:
Figure 1. Grizzly bear habitat suitability for the Selkirks and Cabinet-Yaak. Habitat suitability is a relative index with two main components: (1) Habitat productivity—can a grizzly bear find adequate food? (2) Habitat effectiveness—will a grizzly bear have a lethal encounter with humans? Lighter grey indicates higher suitability.
Figure 2. Grizzly bear habitat suitability for the Selkirks and Cabinet-Yaak scaled to the average life range of a female grizzly bear. To represent the landscape consistent with the way grizzly bears use it we used a "moving window" to average habitat suitability values over a 300 km^2 area.
Figure 3 (next facing page). Potential grizzly bear habitat in the Yellowstone to Yukon. The map was created using data on the number of resident humans, distance from a population center, road density, average travel distance and behavior of forest users. Potential habitat are those areas where grizzly bears have relatively low probability of encountering humans. The map does not include information on habitat productivity; therefore, some areas shown as *potential* habitat may not be *suitable* habitat. Dark green indicates lowest potential of encountering humans, light green next lowest, yellow green next lowest and light pink highest potential of encountering humans.

Figure 1. Grizzly bear habitat suitability for the Selkirks and Cabinet-Yaak.

Figure 2. Grizzly bear habitat suitability for the Selkirks and Cabinet-Yaak scaled to the average life range of a female

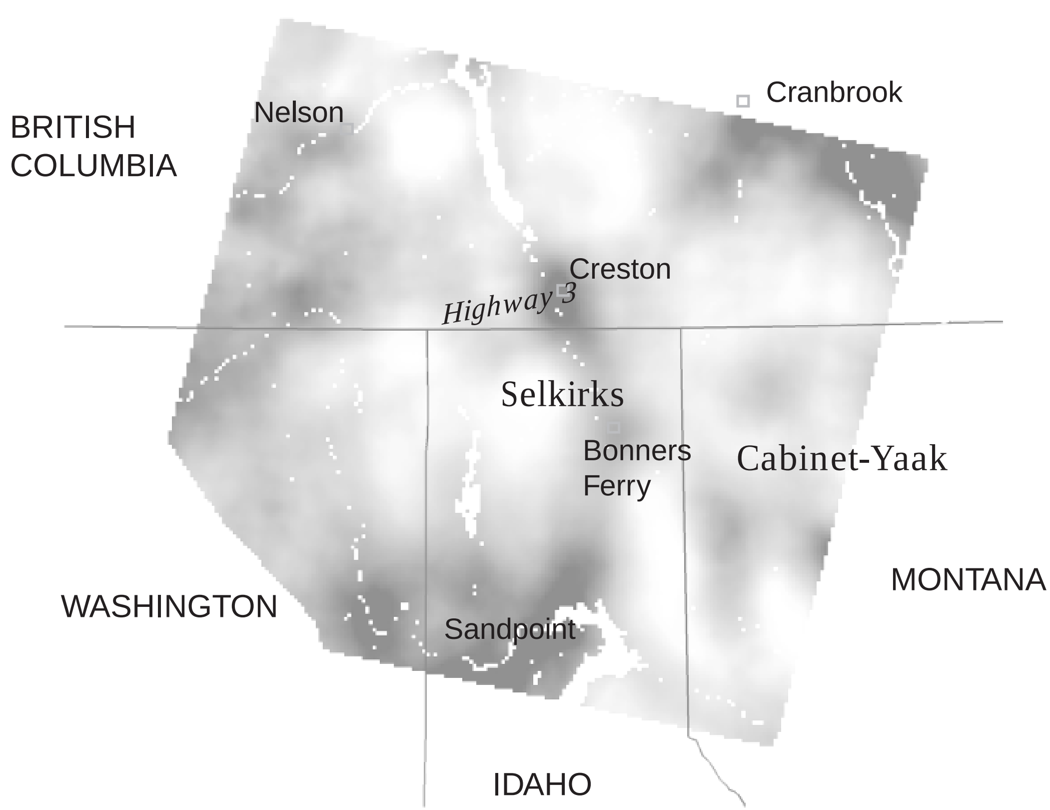



Figure 3
Potential Grizzly Bear Habitat in Yellowstone to Yukon
YUKON TERRITORY
NORTHWEST TERRITORIES
ALBERTA
BRITISH COLUMBIA
MONTANA
WASHINGTON
OREGON
IDAHO
WYOMING
Y 2 Y
Yellowstone to Yukon Conservation Initiative
LEGEND
Protected Areas
Potential Habitat
High potential
Medium potential
Low potential
No potential
Outside of study area
Troy Merrill, LTB Consulting
Committed to the conservation of things that can eat us

A detailed analysis of habitat suitability in the Selkirks and Cabinet-Yaak shows that, at present, contiguous suitable grizzly bear habitat connects these two imperiled populations with grizzly populations in Canada. If we double the impact of humans, however, reflecting the doubling of the human population that is expected to occur in the next 30 to 40 years, these grizzly bear populations become completely isolated.

These results show that in the face of increasing human population, we need to act now to preserve the wildness of Y2Y. Grizzly bears will not persist in Y2Y if we do not reserve large wild areas for them. That alone may not be sufficient unless we also change our attitude towards bears. Bears will remain cantankerous, potentially dangerous neighbors conflicts between bears and humans will continue. We must develop the willingness and ability to resolve these conflicts in ways that are not lethal to the bears.

Methods

We view suitable grizzly bear habitat as having two main components. The first component is habitat productivity: does the area produce enough food to support a grizzly bear? The second component is habitat effectiveness: can a grizzly bear avoid a lethal encounter with humans long enough to breed and successfully rear cubs? While the first component, productivity, is ecologically determined, the second component, effectiveness, is determined by the distribution and behavior of humans. Habitat suitability is a relative index of the likelihood that a bear will find adequate food to successfully breed and rear offspring and not have a lethal encounter with humans. It is calculated by subtracting habitat effectiveness from habitat productivity.

Modeling habitat effectiveness in the Y2Y

We developed a Geographic Information System (GIS) which allowed us to model the distribution of habitat effectiveness for grizzly bears throughout the entire Y2Y based on the interaction between the number of humans, distance from human population centers, and road density (Figure 3). Data on the number and distribution of humans in the U.S. were obtained from the United States Department of Commerce Census Bureau's 1990 census of population and housing. Data on the number and distribution of humans in Canada were obtained from Statistics Canada's 1996 census. Data on roads were developed for the Y2Y initiative by Bill Haskins, The Ecology Center, Missoula, and Mike Sawyer, Rocky Mountain Ecosystem Coalition, Calgary, based on U.S. Census Bureau TIGER files (at a scale of 1:100,000), 1:50,000-scale provincial data for Alberta, and TRIM data for British Columbia. Information on human behavior and the distance humans will travel to engage in forest recreation, obtained from the U.S. Forest Service and other research on forest recreation (McLaughlin et al. 1989; Smith 1983; Wallwork et al. 1980), was used to modify the relationship between numbers of humans, distance from population centers, and road density.

The GIS had a resolution of 1 km^2 and the model was run at this resolution. Grizzly bears, regardless of the resolution of the data, use the landscape consistent with their needs for food, reproduction, and socialization. Bears are wide ranging, eat a variety of foods, and are quick to exploit new food sources. The most meaningful resolution to represent a landscape for grizzly bears is the size of an average female life range. This is the area in which a female grizzly conducts her life. Here she finds a mate, bears young, and raises juvenile bears until they leave in search of life ranges of their own. In the Greater Yellowstone this is around 900 km^2. In areas of north Idaho and southern British Columbia under the Pacific Maritime influence female life ranges are about 300 km^2. In order to present the most conservative results we chose to average habitat effectiveness values over 900 km^2, the life range of a female in the Greater Yellowstone.

We were not able to develop reliable data on habitat productivity for the entire Y2Y. The resulting map, therefore, shows only the distribution of habitat effectiveness, which we consider to be potential grizzly bear habitat. Some of these areas may not have adequate food resources to meet the nutritional requirements of grizzly bears and may not, because of this, be suitable habitat.

Modeling habitat suitability and connectivity in the Selkirks and Cabinet-Yaak

For the trans-boundary grizzly bear populations in the Selkirks and Cabinet-Yaak we were able to identify suitable habitat. Our primary interest was in determining whether there is connectivity between the Selkirk and Cabinet-Yaak trans-boundary grizzly bear populations and larger grizzly

Figures next page.

Figure 4. Core habitat in the Selkirks and Cabinet-Yaak. At present, contiguous suitable habitat connects U.S. and Canadian grizzly bear populations. There are apparent bottlenecks, particularly along Canadian Highway 3. There is a fracture point in the Selkirks along Highway 3, and the configuration of suitable habitat in the Cabinet-Yaak makes it extremely vulnerable to fragmentation.

Figure 5. Core habitat in the Selkirks and Cabinet-Yaak with a doubled human population. A doubling of the human population will seriously fragment suitable habitat in the Selkirks and Cabinet-Yaak, isolating bears in the U.S. from bears in Canada. Areas of remaining suitable habitat are buffered 20 km (black lines) to show the degree of fragmentation.

Figure 4. Core habitat in the Selkirks and Cabinet-Yaak.

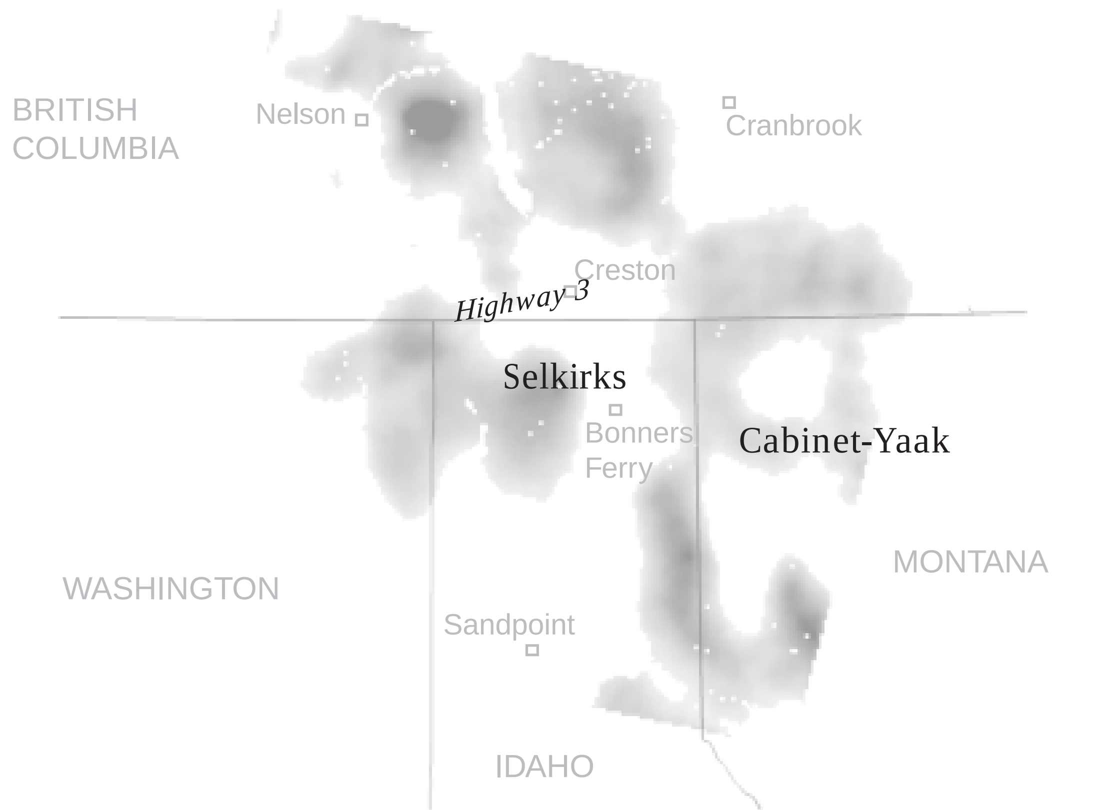
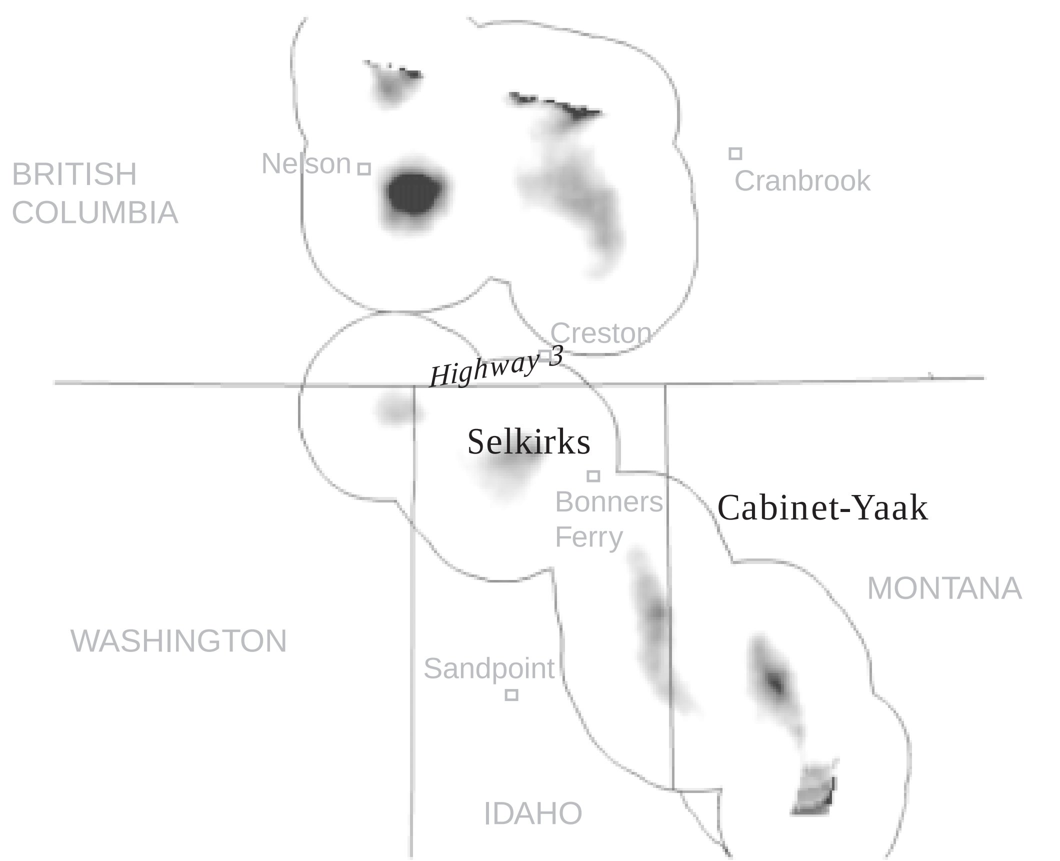


Figure 5. Core habitat in the Selkirks and Cabinet-Yaak with a doubled human population.



bear populations in Canada and what impact projected increases in human population would have on that connectivity.

We used the same data sources for modeling habitat effectiveness in the Selkirks and Cabinet-Yaak as we did for the entire Y2Y, but we were able to work at a finer resolution. Landsat satellite imagery was used to develop a map of habitat productivity. The satellite imagery was classified into 14 land cover classes. This classified image was combined with a map of habitat productivity for Idaho developed by Merrill et al. (in press) based on vegetation mapped and described by Caicco (1989). The weighted average of Idaho habitat productivity values occurring within a land cover class was assigned to that class, resulting in a map of grizzly bear habitat productivity for southeast British Columbia, northwest Washington, northern Idaho and northeast Montana.

These habitat productivity values were then modified by an index of topographic complexity to reflect increased productivity resulting from larger actual surface area per unit area map projection, and the greater security for bears feeding in more topographically complex areas. A final modification of productivity values was made using an index of vegetation density derived from the Landsat satellite image, using a tasseled cap transformation, to identify areas of high soil reflectance (Crist et al. 1986; Crist and Kauth, 1986). This index (value 0 to 1, mean .922, StDv .073) reduced the productivity value of areas of sparse vegetation (such as ridgelines, roads, and new clearcuts) relative to areas of denser vegetation. Finally, habitat effectiveness was factored in to create a map of habitat suitability (Figure 1).

Grizzly bears use a wide variety of foods and range widely in search of these foods. If in the search for food the bear must move through areas with higher potential for lethal encounters with humans the likelihood of persistence in that area is decreased. To reflect this a moving window was used to average suitability values over the area of the life range of a female grizzly bear, which is 300 km^2 for this study area (Figure 2).

The map of habitat suitability scaled to a female grizzly's life range is a relative index with values ranging from .319 to .964. In a previous analysis of occupied grizzly habitat we identified core habitat in the Idaho portion of the Selkirk and Cabinet-Yaak ecosystems (Merrill et al. in press). Based on that analysis we could determine the habitat suitability value below which bears are not likely to persist. Areas with habitat suitability below this value are no longer suitable grizzly habitat.

The U.S. Forest Service's Interior Columbia Basin Ecosystem Management Project estimates that human population in the Interior Columbia Basin will increase at 6.5% per year, which would result in a doubling of human population in approximately 40 years (USDA Forest Service 1997). Population growth in British Columbia shows a similar rate of increase (Statistics Canada 1996). In order to assess the impact of this increase in human population we held all other variables constant while doubling the value of the variable incorporating the effects of numbers of humans, distance to a population center, and recreational behavior. Since we could not project how or where road density would change in relation to increased human population we did not incorporate increased roads in our projection of future conditions. As road density is likely to increase in the future, which will increase the impact of the larger human population, our projection is probably a "best case" scenario.

The validity of our analysis for the Selkirk and Cabinet-Yaak was assessed by comparing our results to a map of grizzly bear distribution and density (Demarchi et al. 1993) developed by the British Columbia Ministry of Environment, Lands and Parks. We found good correspondence between bear distribution and density as mapped by Demarchi et al and our habitat suitability values. Demarchi et al. mapped distribution at a scale of 1:2,000,000, while our analysis was conducted at a scale approximating 1:100,000. This may explain why we show areas of unsuitable habitat within polygons mapped by Demarchi et al. as having moderate or plentiful density. Results were also compared with results of a previous analysis of suitable grizzly bear habitat in Idaho (Merrill et al. in press). More rigorous statistical evaluations of these results are currently being conducted but were not complete at press time.

Results

We cannot at present map suitable grizzly bear habitat for the entire Y2Y. We have mapped one component of suitability, habitat effectiveness (Figure 3). Some of the areas shown as potential habitat will not support grizzly bears, or will support them only at low densities. This is particularly true in the Yukon, where the lack of people makes everything look good. There is a general decrease in effective habitat from north to south, as expected. There is also a high correspondence between national parks and wilderness areas and potential grizzly bear habitat. Again this is expected. It demonstrates that the model is sensitive to both road density and numbers of resident humans, both of which are associated with grizzly bear mortality rates.

The most interesting, and disturbing, finding of this model of potential grizzly bear habitat is the scarcity of potential habitat close to the 49th parallel. It needs to be emphasized that this is an incomplete model of grizzly bear habitat and these results need to be interpreted with caution. Unfortunately the potential for loss of connection across the 49th parallel cannot be ignored. There is also a possibility that Canadian bears will be pushed farther to the north. There is, however, much potential habitat outside of existing national parks and wilderness areas which, if properly managed, would maintain connectivity from north to south.

When we looked at the Selkirk and Cabinet-Yaak population we found suitable habitat to be distributed in two large contiguous blocks (Figure 4). The largest of these blocks stretches from State Highway 200 northward along the Idaho/Montana border to the Canadian border, widening eastward to Provincial Route 93 in southeast British Columbia. This block is connected by a narrow bridge of suitable habitat to a large block of suitable habitat to the north and west. Although the Cabinet-Yaak ecosystem appears to be connected to larger grizzly populations to the north, its configuration makes it vulnerable to fragmentation with minor changes in either habitat productivity or human activity or access.

When we model a doubling of human population, this large contiguous block of suitable habitat is fragmented into five widely separated blocks (Figure 5). The closest block of suitable habitat in Canada is approximately 75 km distant, greater than the distance sub-adult male grizzlies are likely to disperse (Blanchard and Knight 1995). All suitable habitat in the Yaak/Purcell region is lost and bears in the Cabinet-Yaak are effectively isolated.

Current conditions in the Selkirk ecosystem show a similar pattern to those in the Cabinet-Yaak. There is a fracture line just north of the U.S./Canadian border that corresponds to Canadian Highway 3. While the gap in habitat is much less than average dispersal distances of sub-adult bears, it is wide enough to separate bears in their daily and/or seasonal movements. When human population doubles, the U.S. portion of the Selkirk population is functionally isolated from Canadian populations, the closest habitat block being 40 km distant. This makes immigration of Canadian bears very unlikely.

Discussion And Recommendations

Some species, because of their large size or aggressive nature, or because of the economic value of their meat, fur, or tusks, are dependent upon wildness for survival (Mattson 1996). Grizzly bears are an effective umbrella species for the Rocky Mountains (Noss et al. 1996, Mattson and Merrill in prep.) not solely because of their need for large, ecologically diverse areas, but also because they dependent on wildness. There is substantial overlap between grizzly habitat and habitat for other wildness-dependent species such as lynx, marten, fisher, and wolverine. Most of the potential grizzly bear habitat is occupied or is being recolonized by wolves, for whom, like bears, man is the greatest source of mortality. Northern goshawks, black-backed woodpeckers, and many other species of birds need features most found in the places where bears can live. These areas of potential bear habitat contain headwater streams that harbor stocks of native fishes. Insuring that grizzly bears persist throughout Y2Y is not the entire solution to the problem of biodiversity conservation. It is, however, a large part of the solution.

Humans now define where bears can and cannot live. We know that grizzly bear populations occupying areas of less than 20,000 km^2 in 1920 did not exist in 1970 (Mattson and Merrill in prep.). We know that populations with few individuals seldom persist over time. Yet we continue to gnaw away at the last wild places with roads, mines, clearcuts and recreational developments.

The map of potential habitat that we produced is a useful tool for deciding where there is adequate space for a grizzly bear population to have a chance of survival over time. It is a useful tool for deciding where connectivity is being lost. It is not a solution to the problem. Humans want the gold in the Greater Yellowstone, Cabinet-Yaak, and Flathead; the timber in the Selkirks; the malls in the Bow Valley; and the cows in the Castle-Crown—and we want to go everywhere. If we want grizzly bears we must define areas where human wants are secondary to the bears' needs.

Human population will double in Y2Y over the next 30 to 40 years. There will be a greater likelihood of human activity in even the most remote areas of Y2Y. We need to reserve all remaining wildlands. We need to re-wild areas to create secure connective habitat between core habitat areas. We need to re-establish bears in all core habitat areas with sufficient legal protection to insulate them from hostile extractive politics. Even so, the increase in surrounding human population and the associated increase in bear/human conflicts could result in the extirpation of grizzly bears from the continental U.S. and southern British Columbia and Alberta unless we redefine our relationship with bears and the wildlands they inhabit.

Conservation of grizzly bears is about more than saving bears. It is also about saving lynx, marten, and other species dependent upon wildness. It is about feeling shame at slaughtering wolves and bison to protect livestock and increase sport hunting opportunities. It is finally about how we define ourselves as humans. Will we accept, with humbleness and good will, our role as citizens of the natural community, or must we continue as dictators, ordering imprisonment and death to the wild?

Literature cited

Blanchard, B. M., and R. R. Knight. 1995. Biological consequences of relocating grizzly bears in the Yellowstone Ecosystem. J. Wildl. Manage. 59:560–565.

Caicco, S. L. 1989. Manual accompanying the map of existing vegetation of Idaho. College of Forestry, Wildlife, and Range Sciences, University of Idaho, Moscow.

Crist, E. P., and R. J. Kauth. 1986. The tasseled cap de-mystified. Photogrammetric Engineering and Remote Sensing 52(1):81–86.

Crist, E. P., et al. 1986. Vegetation and soils information contained in thematic mapper data. Proceedings of IGARSS 86 Symposium, ESA Publications Division, ESA SP-254.

Demarchi, R., D. Demarchi, and D. Blower. 1993. Wildlife distribution mapping: grizzly bear. British Columbia Ministry of Environment, Lands and Parks, Wildlife Branch and Integrated Management Branch, Victoria. Map.

Hovey, F. W., and B. N. McLellan. 1996. Estimating population growth of grizzly bears from the Flathead River drainage using computer simulations of reproduction and survival rates. Can. J. Zool. 74:2080–2088.

Kasworm, W. F., and T. J. Thier. 1994. Cabinet-Yaak Ecosystem grizzly and black bear research 1993 progress report. USDI Fish and Wildlife Service, Grizzly Bear Recovery Coordinator's Office, Missoula, Mont.

Layser, E. 1978. Grizzly bears in the southern Selkirk Mountains. Northwest Sci. 52:77–91.

Mace, R. D., J. S. Waller, T. L. Manley, J. L. Lyon, and H. Zuring. 1997. Relationships among grizzly bears, roads, and habitat in the Swan Mountains, Montana. J. Appl. Ecol. 33:1395–1404.

Mattson, D. J. 1996. Wilderness-dependent wildlife: the large and the carnivorous. Int. J. Wilderness 3(4):34–38

Mattson, D. J., and T. Merrill. In prep. Extirpation of grizzly bears in the western United States of America, 1850–1970.

McLaughlin, W. J., C. C. Harris, J. F. Tynon, and S. E. Timko. 1989. The 1987 leisure travel and recreation study: analysis for Region II. Final report. Department of Wildland Recreation Management, University of Idaho, Moscow.

Merrill, T., D. J. Mattson, R. G. Wright, and H. B. Quigley. 1998 (in press). Defining landscape suitable for restoration of grizzly bears *(Ursus arctos)* in Idaho. Biological Conservation.

Noss, R. F., H. B. Quigley, M. G. Hornocker, T. Merrill, and P. C. Paquet. 1996. Conservation biology and carnivore conservation in the Rocky Mountains. Conservation Biology 10(4):949–963.

Pease, C. M., and D. J. Mattson. In press. Demography of the behaviorally structured Yellowstone grizzly bear population. Ecology.

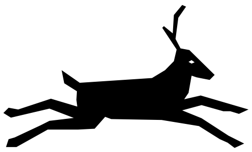
Smith, S. 1983. Recreation geography. Longman, Inc., New York.

Statistics Canada. 1996. GeoRef. CD-ROM

U.S., Dept. of Agriculture, Forest Service. 1977. Interior Columbia Basin Ecosystem Management Project. Eastside Draft Environmental Impact Statement, Vol. I.

Wallwork, S. S., M. L. Lenihan, and P. E. Polzin. 1980. Montana outdoor recreation survey. Bureau of Business and Economic Research, School of Business Administration, University of Montana, Missoula.

Corridors: Key to Wildlife from Yellowstone to Yukon



Richard Walker
and Lance Craighead

Introduction

Habitat reduction and fragmentation at a variety of spatial scales has been widely acknowledged as a primary cause of the decline of many species worldwide (Ehrlich 1986; Lovejoy et al. 1986; Harris 1984). Habitat fragmentation generally leads to smaller and more isolated animal populations. Smaller populations are then more vulnerable to local extinction, due to periodic extreme events (e.g. fires, disease, etc.) (Shaffer 1978, 1981; Gilpin and Soulé 1986), and they are more susceptible to the negative effects of inbreeding depression. To reduce the isolation of habitat fragments, many conservation biologists (e.g. Noss 1983, 1987; Noss and Harris 1986; Craighead et al. 1998; Craighead and Vyse 1995; Paetkau et al. 1998) have recommended maintaining landscape "connectivity"—preserving habitat for movement of species between remaining fragments.

At regional scales, connecting large core areas of wildlife habitat requires corridors—land managed for its function as routes for wildlife movement and dispersal (Saunders and Hobbs 1991). The notion of connective habitat corridors implies a system of corridors and the core areas of habitat which they serve to link. Conceptual models of core areas, movement corridors and buffer zones have been proposed by several scientists (Noss 1992; Noss et al. 1996) as frameworks for long-term regional-scale conservation of wildlife.

The Ninth U.S. Circuit Court Of Appeals provided a working definition of a wildlife corridor[1]:

> ...avenues along which wide-ranging animals can travel, plants can propagate, genetic interchange can occur, populations can move in response to environmental changes and natural disasters, and threatened species can be replenished from other areas.

While there is general agreement on the need for corridors, few scientific studies have as yet attempted to delineate them over a region such as the northern Rockies of the United States. For our research, we used the best available habitat and roads information to determine the routes offering the best potential as corridors for a key umbrella species—the grizzly bear. The purpose of this mapping exercise is to identify probable movement corridors with the least risk to wildlife moving between the three large core protected areas in the U.S. northern Rockies: the Greater Yellowstone, Salmon-Selway, and Northern Continental Divide ecosystems. If habitat for grizzly bears is protected, there is evidence to suggest that the needs of many other species will also be met.

Corridors In The Y2y

The region from Yellowstone to the Yukon harbors some of the last vestiges of North America's great biological heritage. Here are the last remaining populations of wild grizzly bears and free-ranging bison. In several areas, the full complement of large native predators present at the time of Columbus's arrival in the New World still persists.

With increasing human development, however, wildlife habitat in the region is becoming ever more fragmented. New roads, housing developments, and natural resource extraction activities have caused major changes in the natural landscapes over the past few decades, and in the process have removed or isolated areas of habitat formerly available to wildlife. Projections are for this trend of habitat fragmentation to continue and accelerate, as the U.S. northern Rockies is one of the fastest growing regions in the country in terms of human population (USDA Forest Service 1996).

One result of the regional-scale fragmentation in the U.S. northern Rockies is the current situation of the grizzly bear, which is now isolated in a handful of remnant disjunct populations. The bear populations are centered in large, relatively undeveloped and undisturbed areas including the Greater Yellowstone Ecosystem, the Northern Continental Divide Ecosystem and, to a much lesser degree, in the mountains of northern Idaho and northwest Montana (USDI Fish and Wildlife Service 1993). A process has been initiated to restore the grizzly to the Salmon-Selway area in central Idaho.

The grizzly bear is a sensitive regional indicator of fragmentation and the effects of human development. It is considered an "umbrella species"—a species whose proper long-term management would likely help to ensure the persistence of many other species which also occur in the ecosystem. Because they require large areas of relatively

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[1] Marble Mountain Audubon Society v. Rice, 914 F2d 179, 180 n. 2 (1990)

undisturbed habitat, solving for the habitat requirements of grizzlies can assist in defining large core protected areas, smaller protected areas to serve as nodes in a networked regional landscape habitat system, and corridors to facilitate bear movement between the protected areas.

Modeling Potential Grizzly Bear Corridors In The U.s. Y2y

Understanding the need for a scientific assessment of potential linkage habitat for wildlife movement in the region, American Wildlands began a 3-year project in 1995 entitled "Corridors of Life," envisioned and supported by Clif Merritt and Sally Ranney. The authors were employed to establish a GIS lab and conduct the analysis reported in this paper. As scientists, we sought an objective understanding of the best potential routes linking the three large protected areas in the U.S. portion of Y2Y. Because bears are now absent from many of the potential corridor routes, it was necessary to employ a model to account for habitat quality and impediments on a site-specific basis.

The region from Yellowstone to the Yukon harbors some of the last vestiges of North America's great biological heritage. Here are the last remaining populations of wild grizzly bears and free-ranging bison. In several areas, the full complement of large native predators present at the time of Columbus's arrival in the New World still persists.

Using Geographic Information System (GIS) computer software and the best available spatial data on habitats and human developments, we modeled potential regional-scale grizzly bear corridors between the three large U.S. core protected areas. Our approach offers a biologically defensible assessment of probable corridor routes and suggests one means (least-cost) of estimating the relative "connectivity" of alternate routes. For our purposes, delineating corridors at a regional scale entailed determining which routes, based upon the observed needs of wildlife, would offer an animal the best chance of survival if it were to disperse between core protected areas. In this effort we have attempted to balance two general factors affecting wildlife movements: the most suitable connected habitat (in the absence of humans) and the degree to which human-related impediments are present in the landscape.

We do not make the claim that these routes are the most likely to be used by dispersing individuals. Due to highly variable individual behavior this would be a very tenuous assumption. Rather, our analyses indicate that other routes, while perhaps equally likely to be taken by an individual, would reduce his/her probability of survival in the process of dispersing from one core protected area to another, generally because of increased transit time and risk of encountering significant impediments.

Thus the route delineations from our analyses are "prescriptive" rather than strictly "descriptive." The objective of protecting such corridors would be to leave the best routes open to wildlife, but without implying any mechanism of forcing animals to choose those routes (other than the fact that increasing development and change outside of potential corridors will continually make those areas less suitable habitat for most wildlife species).

Methods

Model assumptions

Wildlife responds to landscapes (and habitat) at several scales. Foraging and hunting activities, for example, can be geared to microsite occurrences of vegetation or prey (e.g., see Apps 1996). We assumed that dispersing animals are less sensitive to local environments, and respond to a larger landscape in their movements. For modeling best regional scale corridor routes we made the following assumptions:

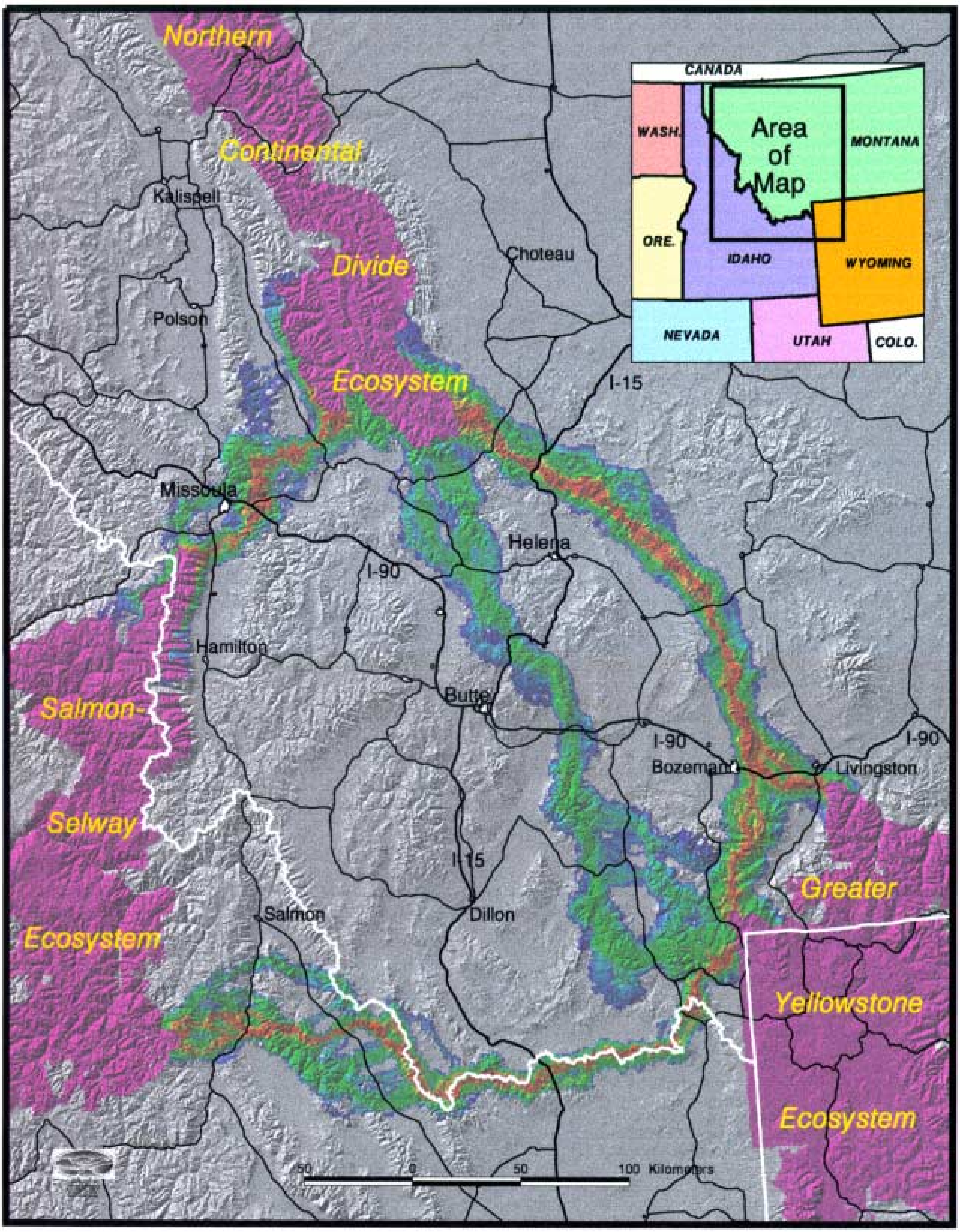
1. good corridors are comprised primarily of preferred habitat types;
2. humans pose problems for successful wildlife transit;
3. current human developments are permanent;
4. "least-cost paths" constitute best routes of transit.

GIS model inputs

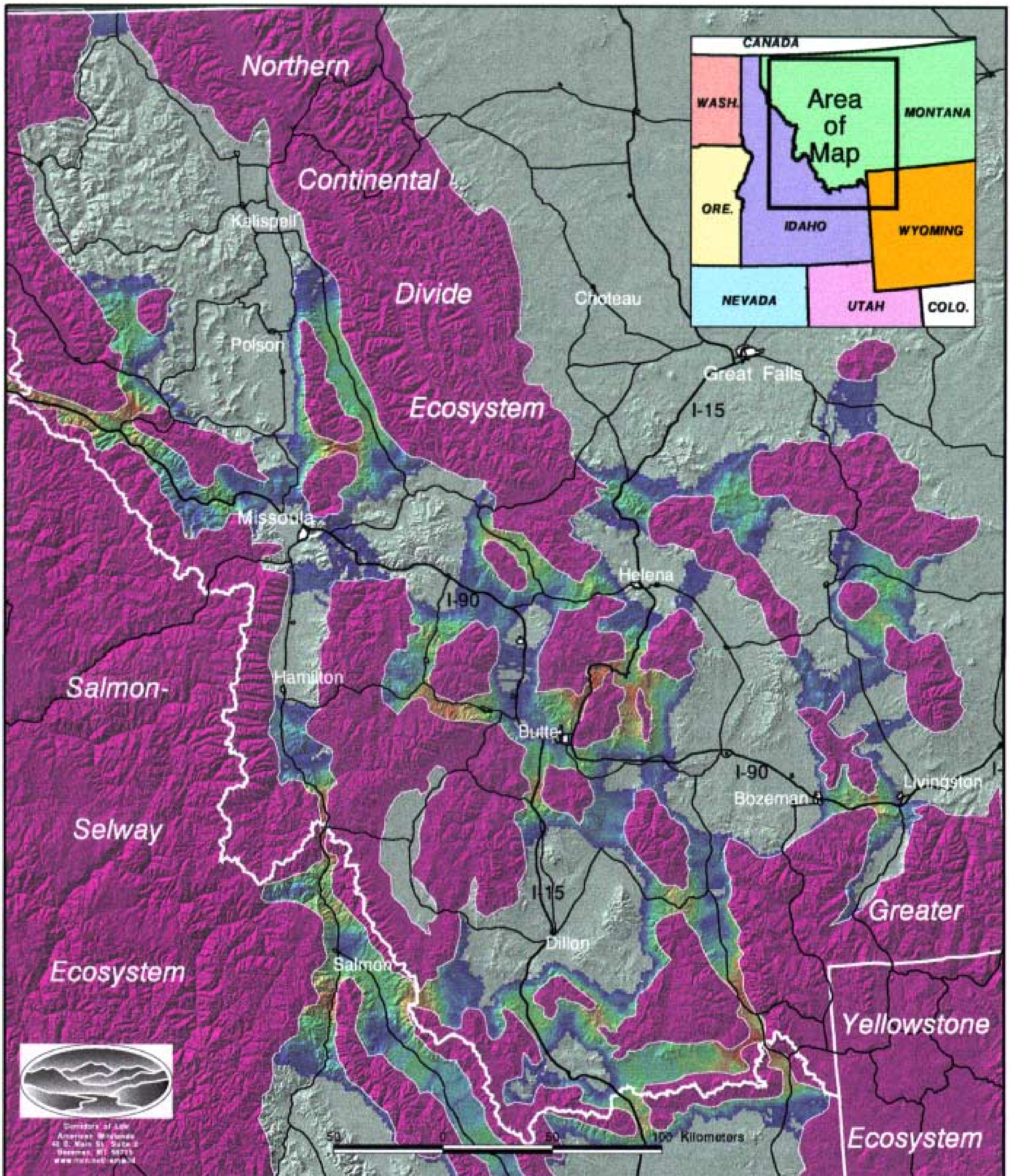
We developed three input GIS coverages to model best potential corridor routes: (1) habitat quality (per species per vegetation type), (2) amount (length) of forest and shrub/grassland interface, and (3) road density. The first two are measures of the quality of an area in terms of its utility to

Figure 1 (next page): For the long-term future of wildlife in the US Northern Rockies, the three large core protected areas (shown in magenta) need viable corridors connecting them. The best potential corridors are displayed in red, green and blue. Red indicates the centers of the potential corridors, while green and blue indicate progressively more peripheral corridors. Four-lane freeways are displayed as wider black lines, with secondary highways and roads as narrower black lines.

To produce the maps, Corridors of Life Project scientists used the best available data on habitat and human use. GIS was used to model the routes according to a 'least-cost path' methodology, which balances the factors of habitat quality and barriers with the shortest possible distances between core areas. The work has identified a small but important subset of a whole range of corridors that will be important to the future of wildlife throughout the US Northern Rockies and the whole of the Y2Y ecoregion.



Potential Main Wildlife Corridors Connecting Three Core Ecosystems of the US Northern Rockies



Potential Regional Wildlife Corridors of the U.S. Northern Rockies

grizzlies, while the third is a good indicator of the amount of human use and disturbance in the area. These measures are similar to the parameters developed for the computer-based Cumulative Effects Model for the Grizzly Bear, by researchers with the Interagency Grizzly Bear Committee (ICE6 1994), and others.

Habitat quality. The Montana Gap Analysis project recently produced detailed GIS coverages of dominant vegetation cover for most of western Montana and central and northern Idaho. For our habitat quality model we used a computer-based map containing more than 50 different cover types, including some which were not native vegetation (e.g. barren, agriculture). Based upon an extensive review of the literature, we then rated each vegetation type according to its quality for grizzly bears. Rating values ranged from 0 (unsuitable) to 3 (highly preferred).

Habitat quality, however, is not strictly a function of the presence of preferred types. The spatial pattern of type mixtures can enhance or detract from the overall habitat quality. Grizzly bears are known to prefer a mixture of cover (for security) and open areas (for food or prey) over singular forest or grassland types. To indicate this "metatype" quality of habitat mixes, we derived the length of forest/grassland and forest/shrubland boundaries for the Gap Analysis region.

Because they require large areas of relatively undisturbed habitat, solving for the habitat requirements of grizzlies can assist in defining large core protected areas, smaller protected areas to serve as nodes in a networked regional landscape habitat system, and corridors to facilitate bear movement between the protected areas.

Roads data. We extracted roads information from two digital sources—U.S. Census Bureau TIGER files and U.S. Forest Service Cartographic Feature files. While some inconsistencies in the source files were evident, overall the quality of the data was high. Since all roads do not have equal impact on wildlife and the landscape, we weighted the roads according to their estimated use. Major highways were given a weight of 3, other major roads a weight of 2, and all other roads and railroads a weight of 1. The weights are roughly proportional to amount of disturbance or degree of difficulty an animal might have in attempting to cross the given road.

Integrating landscape variables at regional scale

A central question in modeling wildlife habitat and corridors is determining the best scale, or set of scales, at which to perform the analyses. Many ecological studies demonstrate that animals learn and "map" their home range areas and know where food, cover and other requirements are located on a "micro-scale" that can often be measured at a scale as fine as square metres. In order to reach areas they prefer, however, animals such as grizzly bears regularly move over long distances through habitat that is not of any particular value to them. In addition, dispersing individuals may wander for days through poor habitat before encountering better habitat where they can find food.

For regional-scale corridor routes, estimating habitat variables at the scale of 30 metres (the resolution of Landsat Thematic Mapper and Montana Gap Analysis) cannot be supported by the level of detail of the data. A model using data of such fine scale would be highly sensitive to local small changes in suitability rating, and might be unrealistic in its results. Thus, to examine possible regional-scale movement routes, given the limitations of GIS data and habitat characterization, we integrated habitat quality and roads data over larger areas. The choice of area unit size was critical—too coarse a scale could obscure important variations in suitability of the landscape for a wildlife corridor.

For this analysis we integrated the landscape (and habitat) variables at a resolution of one square kilometre. This scale offered a reasonable balance between the fine-scaled information base (30m in the case of habitat data, continuous in the case of roads data) and a broader scale unit (e.g. a small watershed). Ignoring the filtering effect of the 2.5 hectare minimum mapping unit of the Montana Gap Analysis database, integrating the habitat value coverage involved averaging approximately 1110 30m cells per square kilometre.

Based upon the literature and expert opinion, we derived mean habitat quality values for each UTM-based square kilometre cell for the grizzly bear. The mean values varied from 0 to 3. For each cell we also derived the total length of forest/shrubland edge and forest/grassland interface. These values ranged from 0 to about 11 kilometres per square kilometre. Though they are not strictly independent, the habitat value and edge length coverages provided us with two measures of the suitability of each square kilometre for these species.

Road density was obtained in a similar manner to the forest edge coverage. Roads were assigned weightings according to their approximated traffic load, then the weighted length totals were derived for each UTM cell. The range of the cells was very wide—from 0km/km^2 in roadless and wilderness areas to nearly 20km/km^2 in highly urbanized areas.

Figure 2 (previous page): Based upon GIS analysis of elk, cougar, and grizzly bear habitat effectiveness, scientists at American Wildlands delineated potential links between areas still containing significant good habitat (shown in magenta). In the prospective corridors, warmer colors offer the best potential, transitioning through the cooler colors to areas of lower potential.

Results

Using GIS inputs, we created a map of best potential grizzly corridors connecting the three large core protected areas of the U.S. northern Rockies (Figure 1). The corridors in this figure are color-coded, with warmer colors indicating better areas of habitat connectivity. Bottlenecks are indicated in parts of the corridors which are more constricted. Obstacles are likely where corridors cross roads or pass near urban areas. For the core areas we took units managed specifically for wilderness on public lands which were contiguous within an ecosystem. The potential routes determined by this analysis shown in Figure 1 tend to follow tree cover and mountainous terrain, as bears are less likely to successfully negotiate the expanses of wide open grasslands and shrublands which occur in the region.

The Greater Yellowstone–Northern Continental Divide connection

The distance between the Greater Yellowstone Ecosystem (GYE) and the Northern Continental Divide Ecosystem (NCDE) is approximately 200 kilometres. The area in between consists of a complex of forested mountains and open grassland/sagebrush valleys, with varying connectivity among them. Two major corridor routes for grizzly bears are depicted, with one route being superior to others. According to our work, the potential corridor offering the best chance of successful transit consists of the Gallatin, Bridger, and Big Belt mountain ranges. A secondary route for bears, inferior to the primary in this analysis, due largely to intense roading in the Helena National Forest, is to the west and is comprised primarily of the Taylor-Hilgard, Gravelly, Tobacco Root, Whitetail/O'Neil, and Boulder mountain ranges.

The Greater Yellowstone–Salmon-Selway connection

Grizzly bears originating in either the GYE or Salmon-Selway Ecosystem (SSE), according to our model, might best transit this roughly 380-kilometre distance along a route comprised mainly of the Centennial Mountains dividing Montana from Idaho. From the east this corridor begins from the south end of the Madison Range, follows nearly 200 kilometres along the Continental Divide (following the Centennial Mountains), and then crosses over the Lemhi Valley to the Lemhi Range of Idaho. From the Lemhi Range two routes fork and head west into the Frank Church–River of No Return Wilderness Area.

The Salmon-Selway–Northern Continental Divide connection

The minimum distance between the Salmon-Selway (SSE) and Northern Continental Divide Ecosystems (NCDE) is much shorter in air miles than the routes between the other core areas. Within the constraints of the methods, the best routes cross from the Bitterroot Mountains to the north end of the Sapphire mountains, then arc to the north, passing west of the Rattlesnake Wilderness Area. The corridor then takes a fairly direct route to the southwest lobe of the Bob Marshall Wilderness complex. This route passes close to the densely inhabited area around Missoula, Montana. Another, higher-cost route passes north of Missoula through the Evaro Hill area.

Summary

Radiotracking and genetic data in the Northern Rockies show that wildlife disperse on a regional basis (Paquet and Hackman 1995). Some species such as wolves or cougars can cover the distance between protected reserves in a single season; others, such as grizzly bears, fisher, lynx, or pine marten, may take several generations to move from one large reserve to another. We used a first approximation model to define the areas most useful to maintain this regional level connectivity for grizzly bears. With grizzlies as the umbrella species, the results of our regional scale wildlife corridor analyses define several routes which may provide the best opportunities for successful animal transits between core protected areas in the U.S. northern Rockies. Applying this least-cost-path analysis between smaller, intermediate "nodes" of suitable grizzly habitat outlines a regional network of habitat patches and connecting corridors. The resultant map (Figure 2) was based upon grizzly bear habitat effectiveness, but overlaps those based upon elk and cougar habitat effectiveness. This map can be considered a first step in designing a regional reserve network for the U.S. northern Rockies. Subsequent analysis should focus on refining these simple habitat models and focusing on finer spatial scales.

Acknowledgements

This paper reports the results of American Wildlands' (AWL) "Corridors of Life" project. We would like to particularly acknowledge Clif Merritt and Sally Ranney, former board members of AWL: Clif's vision and understanding are the foundation of this project; Sally's enthusiasm and support made the project possible. The staff of AWL saw the project through difficult times and this report summarizes the light at the end of the tunnel. Finally, this work would not have been possible without the financial support of many foundations and individuals (too many to list) and the moral support of the Y2Y family of conservationists. We are indebted to you all.

Literature Cited

Apps, C., 1996. Bobcat *(Lynx rufus)* habitat selection and suitability assessment in southeast British Columbia. Master's thesis, University of Calgary.

Craighead, F. L., and E. Vyse. 1996. Brown/grizzly bear metapopulations. Pages 325-351 *in* D. McCullough, ed. Metapopulations and wildlife conservation management. Island Press, Washington, D.C. and Covelo, Calif.

Craighead, L., M. Gilpin, and E. R. Vyse. 1998. Genetic considerations for carnivore conservation in the Greater Yellowstone Ecosystem. *In* T. Clark, S. Minta, and P. Karieva, eds. Greater Yellowstone carnivores. University of Chicago Press, Chicago. In press.

Ehrlich, P. R. 1986. The loss of diversity. Pages 21–27 *in* E. O. Wilson, ed. Biodiversity. National Academy Press, Washington, D.C.

Gilpin, M. E., and M. E. Soulé. 1986. Minimum viable populations: Processes of species extinction. Pages 19–34 *in* M. E. Soulé, ed. Conservation biology: the science of scarcity and diversity. Sinauer Associates, Inc., Sunderland, Mass.

Harris, L. 1984. The fragmented forest: island biogeography theory and the preservation of biotic diversity. University of Chicago Press, Chicago.

ICE6. 1994. ICE6 tool kit for cumulative effects analysis. Systems for Environmental Management, Missoula, Mont.

Lovejoy, T. E., R. O. Bierregaard, Jr., A. B. Rylands, J. R. Malcolm, C. E. Quintela, L. H. Harper, K. S. Brown, Jr., A. H. Powell, G. V. N. Powell, H. O. R. Schubart, and M. B. Hays. 1986. Edge and other effects of isolation on Amazon forest fragments. Pages 257–285 *in* Soulé, M. E., ed. Conservation biology: the science of scarcity and diversity. Sinauer Associates, Inc., Sunderland, Mass.

Noss, R. F. 1983. A regional landscape approach to maintain diversity. BioScience 33:700–706.

Noss, R. F. 1987. Protecting natural areas in fragmented landscapes. Nat. Areas J. 7:2–13.

Noss, R. F. 1992. The Wildlands Project: land conservation strategy. Wild Earth (special issue):10–25.

Noss, R. F., and L. D. Harris. 1986. Nodes, networks, and MUMs: preserving diversity at all scales. Env. Manage. 10:299–309.

Noss, R. F., H. B. Quigley, M. G. Hornocker, T. Merrill, and P. C. Paquet. 1996. Conservation biology and carnivore conservation in the Rocky Mountains. Cons. Biol. 10(4):949–963.

Paetkau, D., L. Waits, P. Clarkson, L. Craighead, E. Vyse, R. Ward, and C. Strobeck. 1998. Dramatic variation in genetic diversity across the range of North American brown bears. Cons. Biol. In press.

Paquet, P., and A. Hackman. 1995. Large carnivore conservation in the Rocky Mountains: a long-term strategy for maintaining free-ranging and self-sustaining populations of carnivores. World Wildlife Fund Canada, Toronto.

Saunders, D. A., and R. J. Hobbs, eds. 1991. Nature conservation 2: the role of corridors. Beatty and Sons, Surrey, U.K. 442 pages.

Shaffer, M. 1978. Determining minimum viable population sizes: a case study of the grizzly bear *(Ursus arctos)*. Ph. D. diss., Duke University.

Shaffer, M. 1981. Minimum population sizes for species conservation. BioScience 31:131–134.

U.S., Dept. of Agriculture, Forest Service. 1996. Status of the Interior Columbia Basin: summary of scientific findings. PNW-GTR-385. Portland, Ore. 144 pp.

Age and Species Composition of Forests, Grizzly and Other Species Densities, Wilderness Watersheds, and Threats to Yellowstone to Yukon in British Columbia

Rick Zammuto

"In the Pacific Northwest…there are species and processes that depend upon old-growth forest as habitat…existing old-growth forests are our only source of reserves…we must see the larger task—stewardship of all of the species on all of the landscape." (J. Franklin 1993).

Forest age and species diversity of British Columbia forests

Half of the forested land in British Columbia has been clearcut, burned, or settled. This has happened to a lesser degree in the Y2Y planning area, however, than in other parts of B.C. (Fig. 1; MacKinnon 1996). Forests over 140 years old are found on 25% of the British Columbia landbase (15% coastal and 10% interior). Fifty percent of these forests are at high elevations (Fig. 1; MacKinnon 1996; MacKinnon and Vold 1997). Only 3% of British Columbia's forests over 140 years old are presently protected. The Y2Y area contains over 75% of the unprotected forests over 140 years old left in the British Columbia interior (Fig. 1).

Forests over 250 years old are usually termed "ancient forests." Most of these forests are rainforests (over 1 metre of precipitation per year). Eight percent of the British Columbia landbase is forested with ancient forests over 250 years old (Fig. 1; MacKinnon 1996; MacKinnon and Vold 1997). This 8% exists in four major areas: (1) Mid-coast of the British Columbia mainland, (2) Vancouver Island, (3) Robson and Parsnip valleys, (4) Upper Nass Valley. The latter two contain most of the remaining larger tracts (>2000 ha) of ancient forest left in the British Columbia interior and are contained in the Y2Y. Smaller patches (<500 ha) of ancient forest exist throughout the Y2Y, especially in southeastern British Columbia (Fig. 1).

Ancient rainforests of the British Columbia interior that have been in climax for thousands of years have been recognized as distinct ecotypes among ancient forests. Recently they have been termed "antique forests," or, more technically, oroboreal (Goward 1994, 1995, 1996a). The Y2Y contains almost all of the interior ancient forests over 400 years old and almost all of the known antique forests left in the British Columbia interior (Fig.1; MacKinnon 1996).

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The oldest, wettest, and least fragmented old-growth forests contain more lichen species (British Columbia's most diverse primary producer), more rare lichen species, and more endemic lichen species than younger, drier, or more fragmented forests (Goward 1994, 1995, 1996a, b). Preliminary studies suggest trees, insects, birds, and mammals are also more diverse in the oldest, wettest, and least fragmented old-growth forests, especially at low elevations (Fig. 2; Bunnell and Kremsater 1990; Ketcheson et al. 1991; Lattin 1993; Zammuto and Howard 1994; Zammuto 1993; Zammuto unpubl. data).

Small patches (<500 ha) of old growth forest display interesting island effects in British Columbia. These patches allow old-growth-dependent vertebrate species to exist because species disproportionately overuse each patch. Many species travel long distances to use these patches for food, shelter, rearing, and movement (Zammuto 1993, unpubl. data). For example, marten, wolverine, lynx, grizzly, cougar, and wolf tend to travel from one old-growth patch to the next, especially in riparian habitat, many times noticeably avoiding openings (see also Weaver et al. 1996; Weaver unpubl. data). All data indicate that British Columbia's high biodiversity can be maintained only by protecting almost all the remaining old-growth forest of interior British Columbia, including the smaller patches, especially at lower elevations and in riparian areas.

Fragmentation, edge effects, and undeveloped wilderness watersheds

Many wildlife, plant, lichen, and other species need unfragmented old-growth structures and functions for their survival. For example, 30–65% of the bird and mammal species of British Columbia need old dead trees inside unfragmented forests for breeding (Bunnell and Kremsater 1990, Zammuto unpubl. data). Much of the old-growth in British Columbia is fragmented or discontinuous enough to display edge effects that degrade habitat quality for most old-growth-dependent species. Many of these species are disappearing from British Columbia and have been listed on government red/blue lists (BCMOE 1991; Zammuto unpubl. data).

When a forest patch is less than 30 ha (550 x 550 m) in size it contains little unfragmented interior forest unaffected by edge effects (Morrison 1988). Using this criterion, only 6.3 million ha of interior forests over 140 years old in British Columbia can be considered unfragmented by roads (Fig. 1; MacKinnon 1996; see p. 000 for road densities in Y2Y).

Over 75% of British Columbia's undeveloped, unprotected, wilderness watersheds over 5000 ha are in the Y2Y bioregion (Figs. 3a, 3b, 3c, 3d; BCMOF 1992). Northern British Columbia contains significantly more large wilderness watersheds (one group is 5 million ha) than southern British Columbia, where the largest one left is 100,000 ha (Figs. 3a, 3b, 3c, 3d; BCMOF 1992).

Grizzly bear habitat

Prime grizzly habitat (one bear:15km2, 6mi2) is roughly n-shaped in British Columbia, being in the extreme west, the extreme east, and arcing across the north of the province (Fig. 4; BCMOELP 1995). Figures for old-growth (Fig. 1), roadless areas (see p.000), and undeveloped watersheds (Figs. 3a, 3b, 3c, 3d) display almost the same configuration. The Y2Y contains over 60% of the prime and good density grizzly bear habitat (one bear:45km2, 18mi2) in British Columbia (Fig 4). Historic prime and good grizzly habitat has been reduced by 40–60% throughout British Columbia due to almost uncontrolled development, habitat fragmentation, hunting, and poaching pressures (compare Figs. 4 and 5; BCMOELP 1995; Fuhr and Demarchi 1990).

In human-settled, logged, or roaded areas, especially at low elevations along rivers, many prime sites have been degraded to good or low density grizzly bear habitat (one bear:135km2, 55mi2), or extirpation has occurred (Figs. 4 and 5). This habitat degradation trend is likely to continue without the intervention of successful conservation measures. The current government strategy consists of designating "Grizzly Bear Management Areas" (GBMAs), which are theoretical zones where only hunting would be restricted. No habitat protection whatsoever is afforded. Not a single GBMA (which can be designated only by legislation) has been considered to date, and it is extremely doubtful the GBMA program will stabilize the population decline of grizzly bears in British Columbia.

Caribou

Northern caribou, which are found throughout much of the northern British Columbia portion of the Y2Y planning area, number over 10,000 individuals. They feed on ground lichens and ground cover and are hunted. Mountain caribou, which are found only in southeastern British Columbia, number less than 2000 individuals (Stevenson and Hatler 1985). They feed on arboreal lichens and are protected from hunting. Because mountain caribou feed only in old growth over 150 years old, their habitat is completely eliminated by clearcutting and agriculture. Y2Y contains the entire range of the mountain caribou, whose populations are highest where the largest areas of old growth are found (Fig. 1).

Conclusions

One approach to identifying core areas in the British Columbia portion of Y2Y is to overlay maps of British Columbia's old forests (Fig. 1), diverse tree species composition (Fig. 2), high grizzly density (Fig. 4), and undeveloped roadless areas (Figs. 3a, 3b, 3c, 3d; p. 000). Significant overlapping suggests possible core areas (see Shaffer 1992 and Noss et al. 1996 for discussion).

Acknowledgements

We thank Andy MacKinnon (MOF) for use of Figs. 1, 2, 3a, 3b, 3c, and 3d and his unpublished manuscripts, Matt Austin (MOELP) for use of Figs. 4 and 5, Alison Marchant for assisting with the figures, and The Wilburforce Foundation for financial support.

Figure 1. Age class groups in British Columbia's forests.

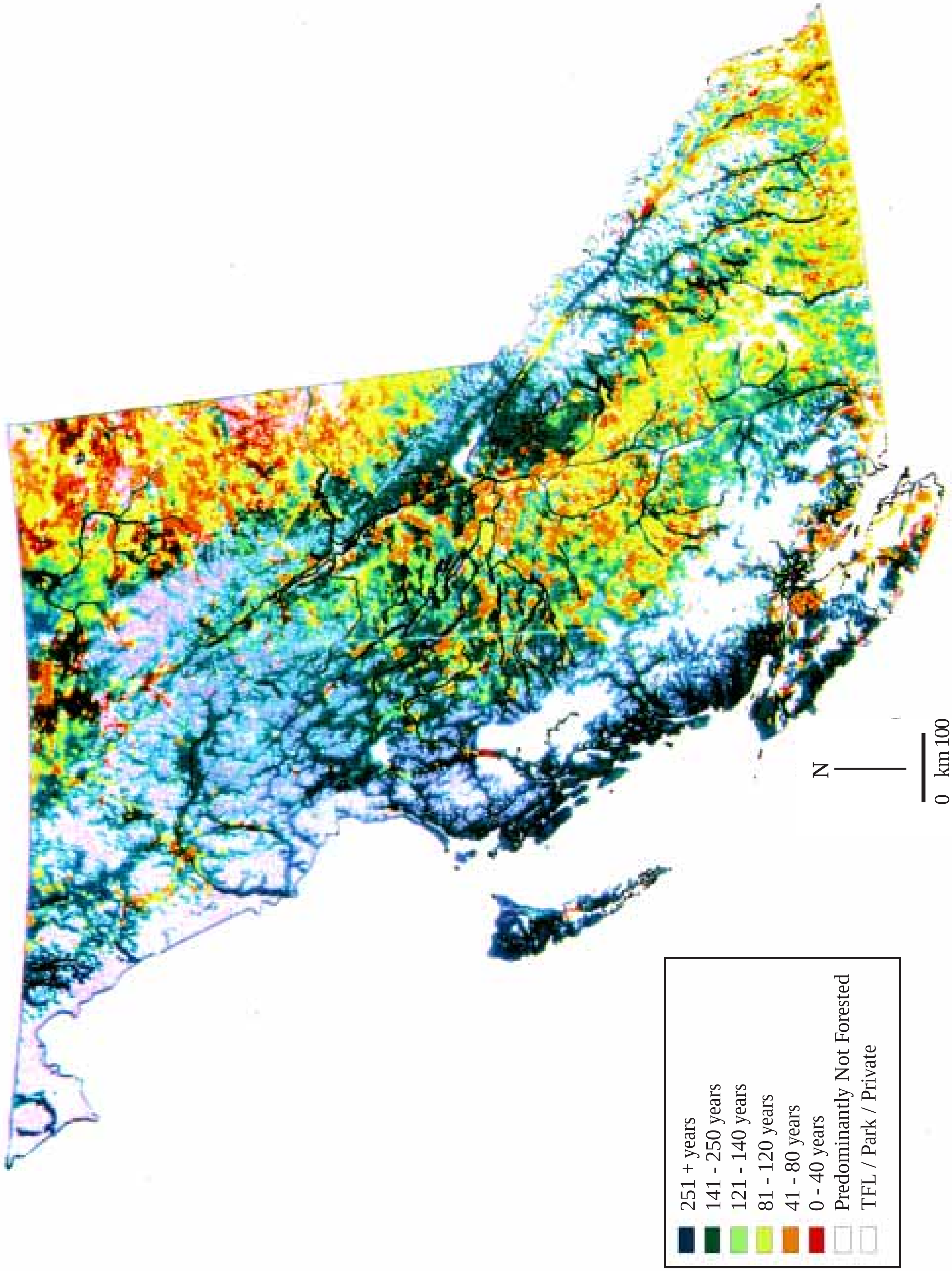


Figure 2. Leading tree species groups in British Columbia

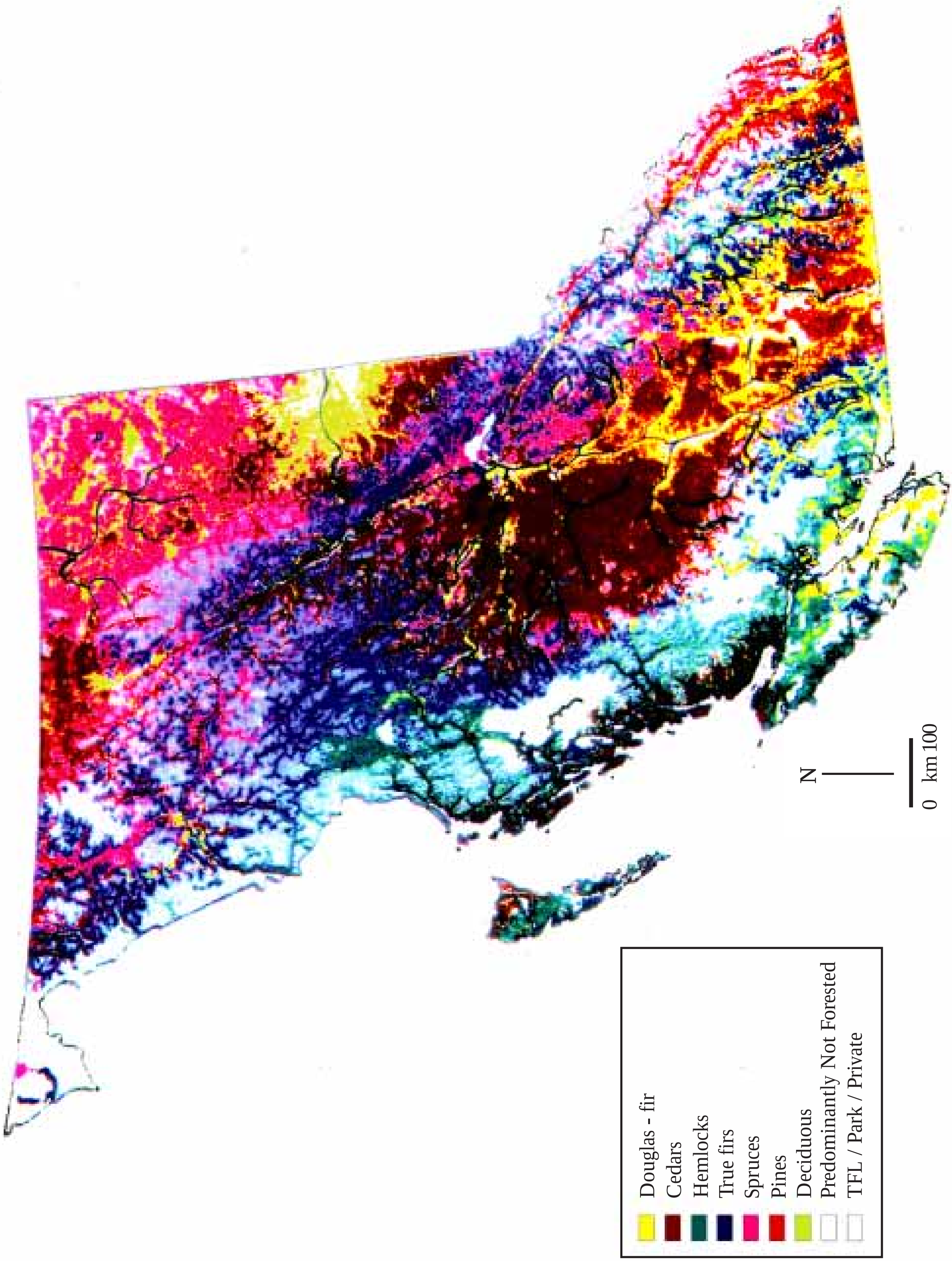


Figure 3a.
Undeveloped watersheds over 5000 ha in the Columbia/Kootenay watersheds of British Columbia (numbers refer to BCMOF 1992).

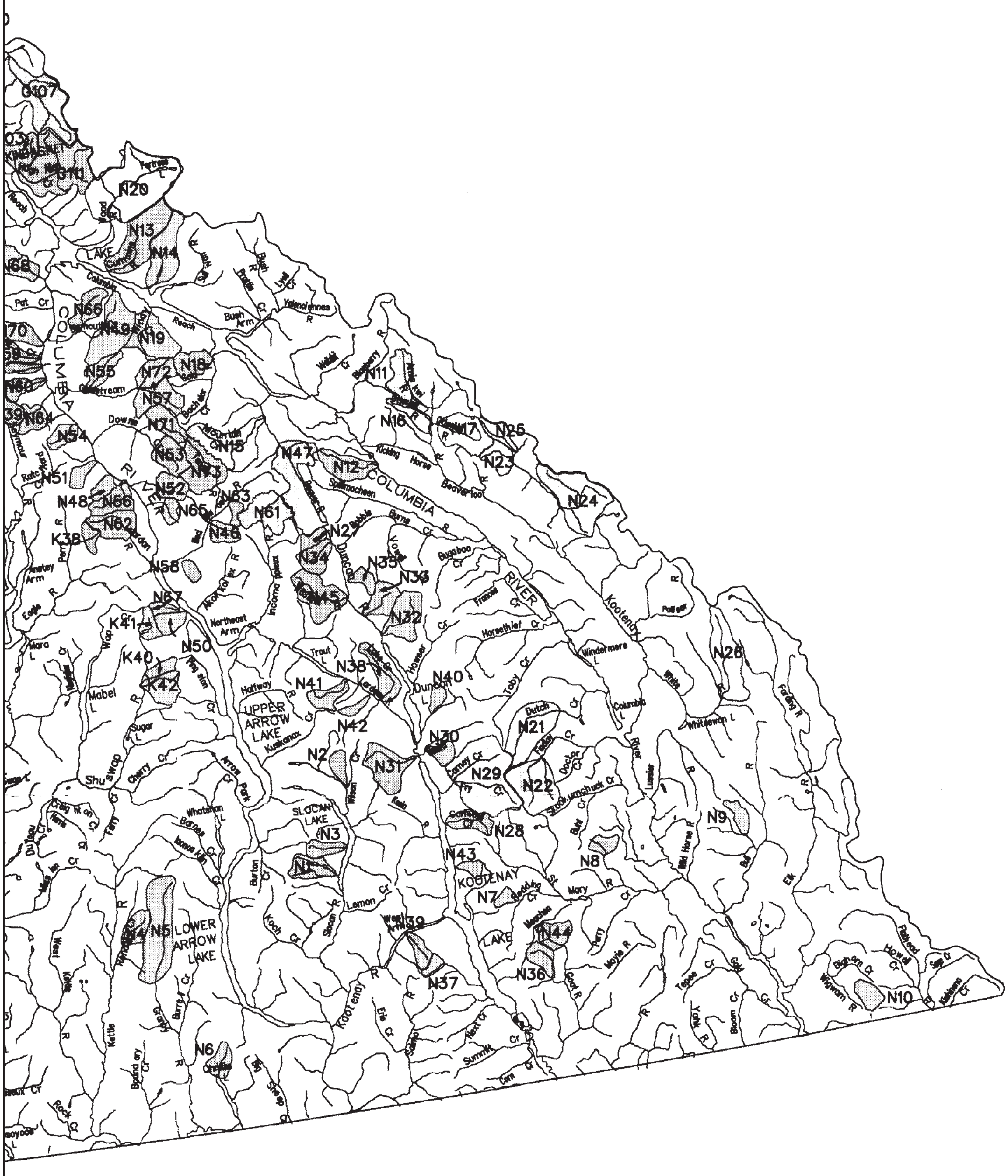


Figure 3b.
Undeveloped watersheds over 5000 ha in the Peace/Fraser/Thompson
watersheds of British Columbia (numbers refer to BCMOF 1992).

Figure 3c.
Undeveloped watersheds over 5000 ha in the Ft. Nelson/Muskwa watersheds of British Columbia (numbers refer to BCMOF 1992).

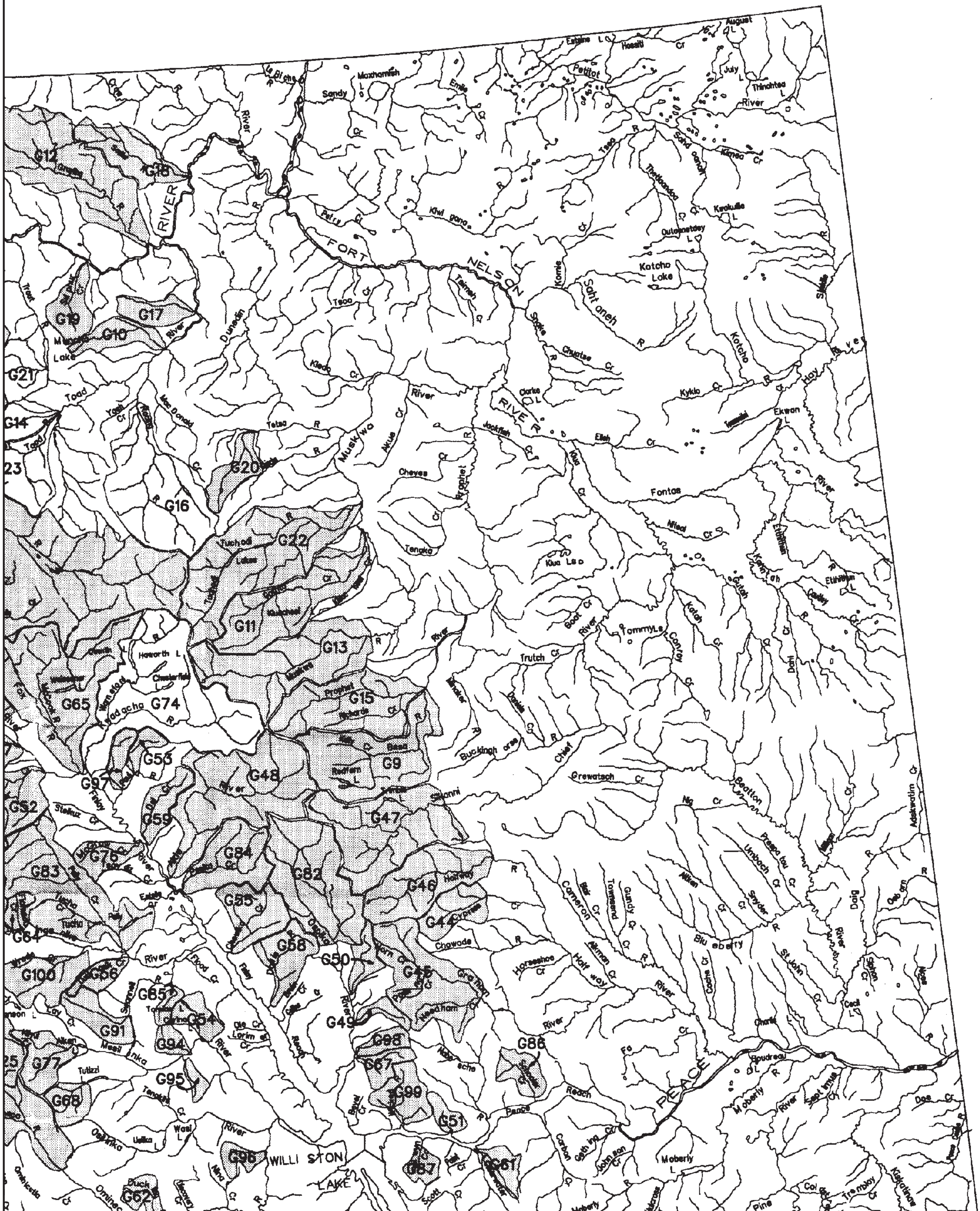


Figure 3d.
Undeveloped watersheds over 5000 ha in the Liard/Dease/Nass watersheds of British Columbia (numbers refer to BCMOF 1992).

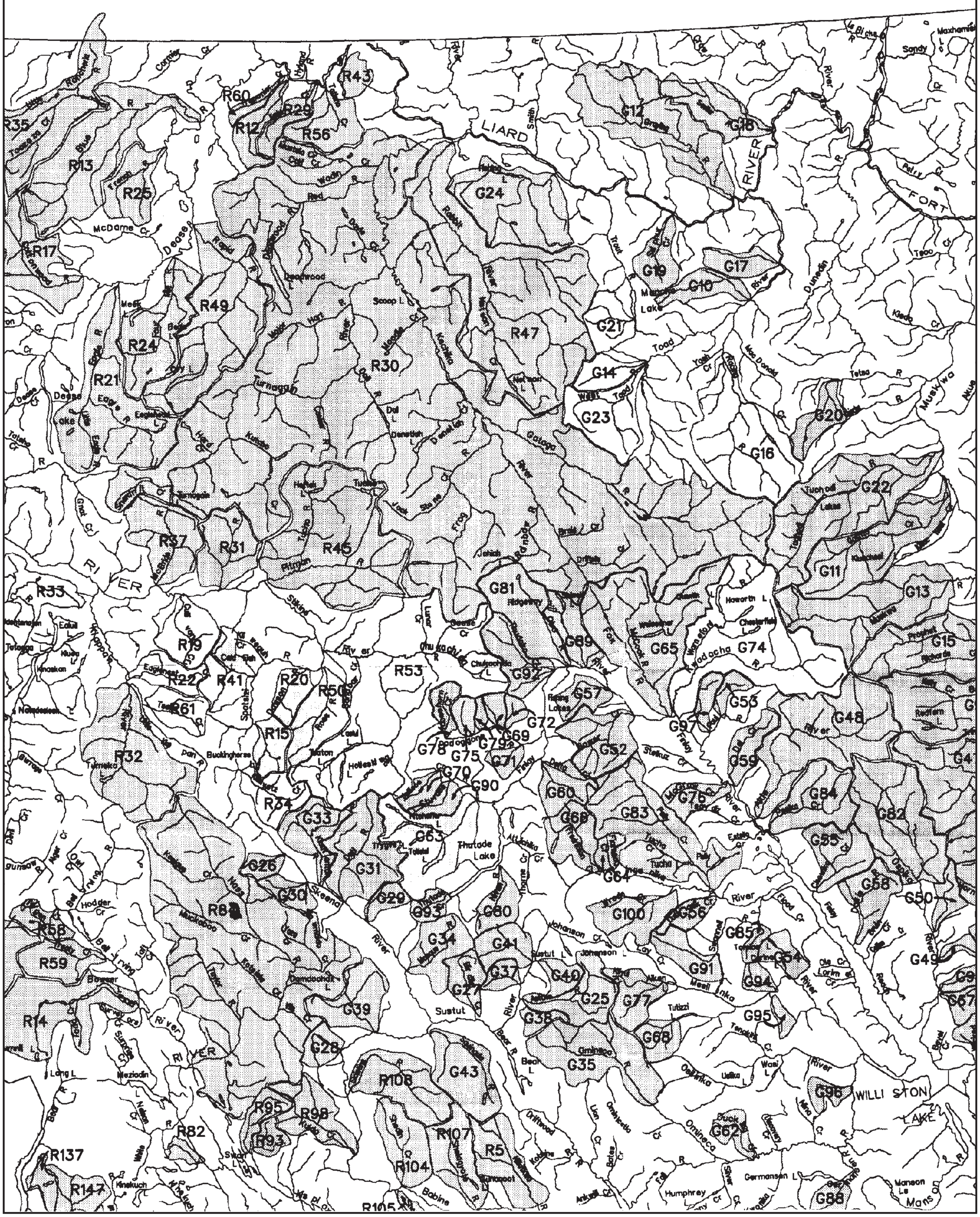
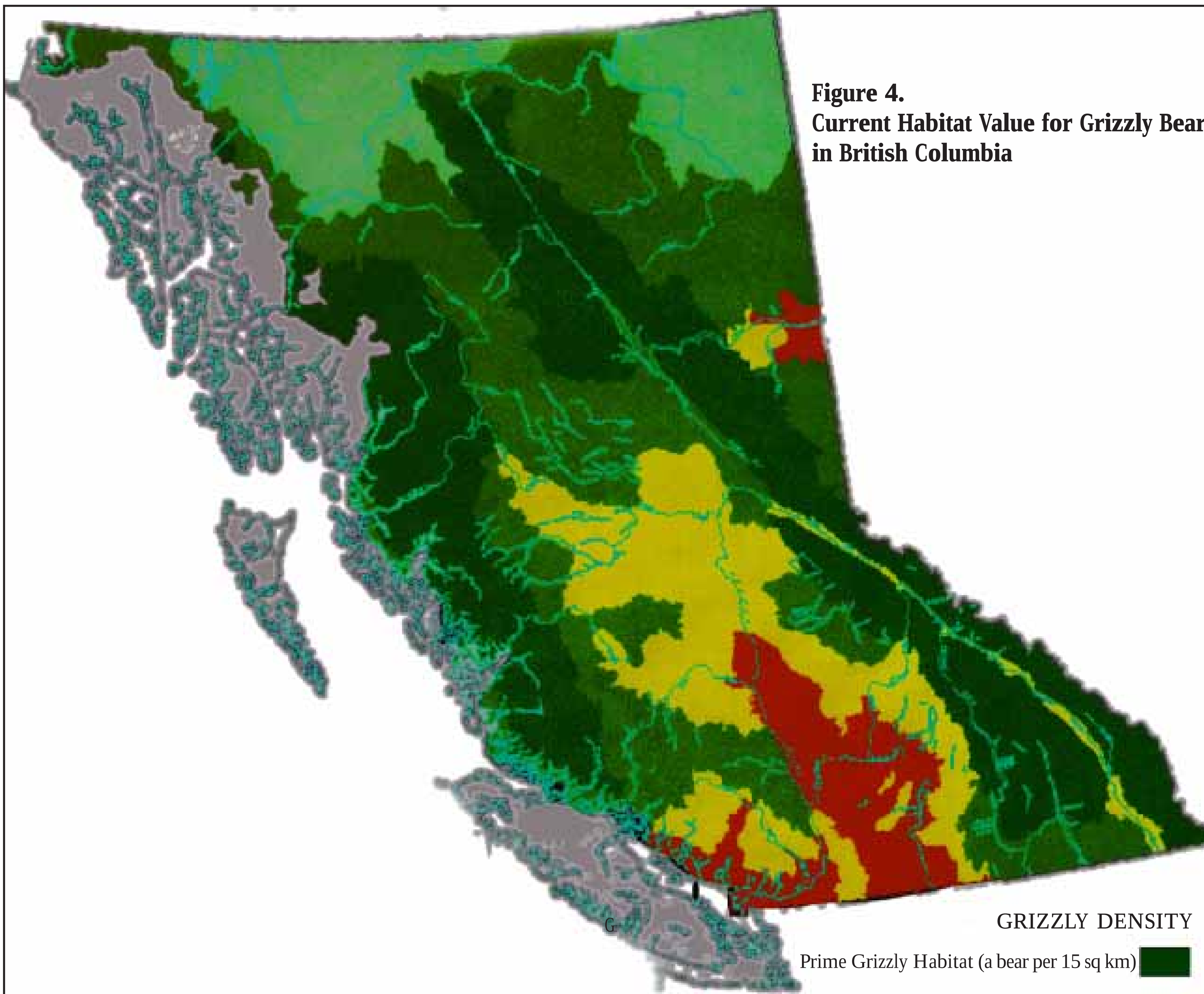


Figure 4.
Current Habitat Value for Grizzly Bear in British Columbia



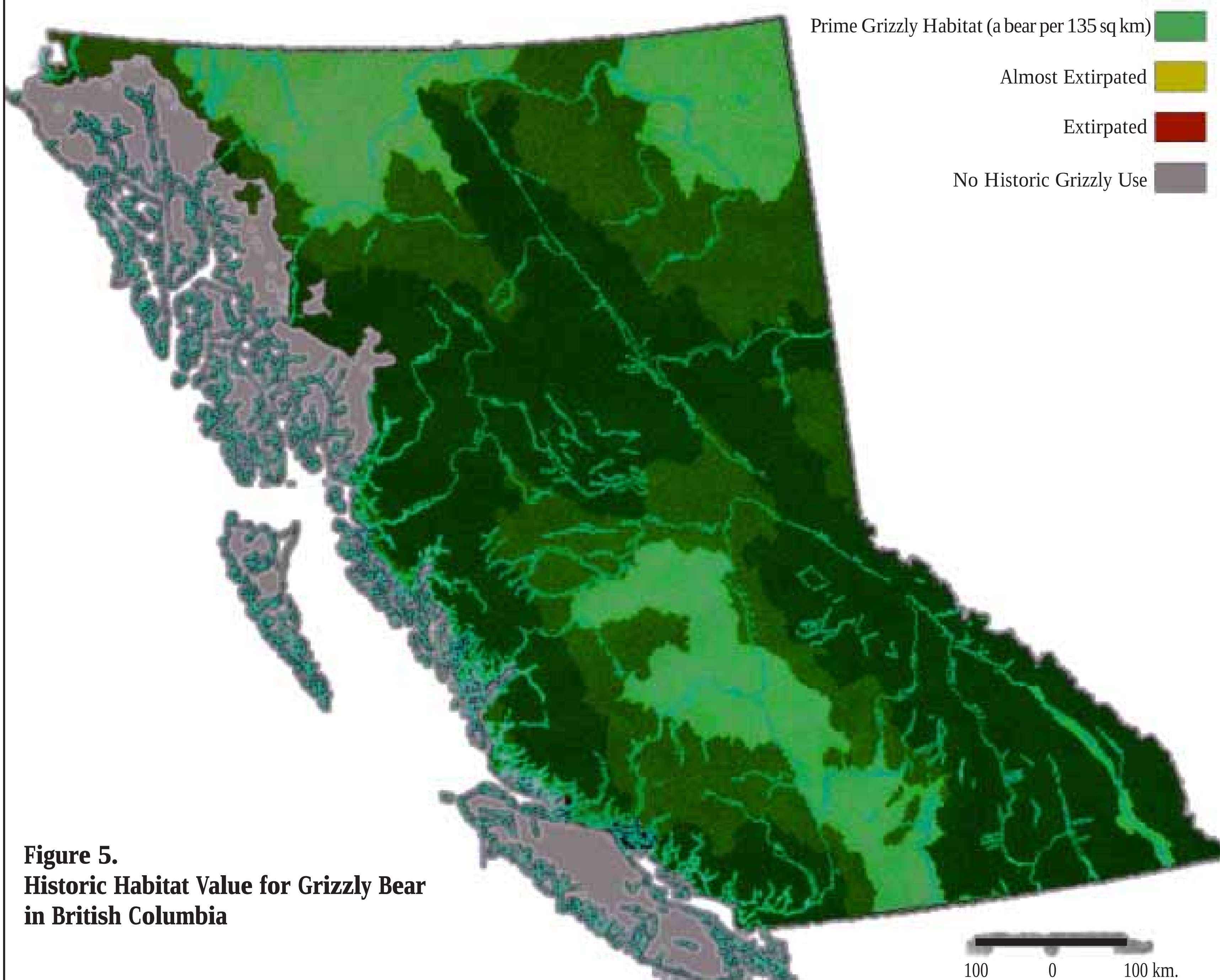


Figure 5.
Historic Habitat Value for Grizzly Bear in British Columbia

Literature cited

British Columbia Ministry of Environment. 1991. Managing wildlife to 2001. B.C. Min. Env. Disc. Pap. 150pp.

British Columbia Ministry of Environment, Lands, & Parks. 1995. Conservation of grizzly bears in British Columbia–Background Report. 70pp.

British Columbia Ministry of Forests. 1992. An inventory of undeveloped watersheds in British Columbia. B.C. Min. For. Rec. Br. Tech. Rep. 1992:2. 80pp.

Bunnell, F., and L. Kremsater. 1990. Sustaining wildlife in managed forests. N.W. Env. J. 6:243–270.

Franklin, J. F. 1993. Preserving biodiversity: species, ecosystems, or landscapes. Ecol. Applic. 3:202–205.

Fuhr, B., and D. Demarchi. 1990. A methodology for grizzly bear habitat assessment in British Columbia. B.C. Min. Env. Wildl. Bull. No. B-67.

Goward, T. 1994. Notes on old-growth-dependent epiphytic macrolichens in inland British Columbia, Canada. Acta Bot. Fenn. 150:31–38.

Goward, T. 1995. Macrolichens of the old-growth forests of the Robson Valley. B.C. Min. For. report. 19pp.

Goward, T. 1996a. The "antique" rainforests of the Robson Valley. Unpubl. ms. 1 p.

Goward, T. 1996b. Lichens of British Columbia: rare species and priorities for inventory. Res. Br., B.C. Min. For. and Hab. Protect. Br., B.C. Min. Env., Lands, and Parks. Victoria, B.C. Working Pap. 08/1996. 34pp.

Ketcheson, M., T. Braumandl, D. Meidinger, G. Utzig, D. Demarchi, and B. Wikeem. 1991. Interior cedar-hemlock zone. Page 168 in D. Meidinger and J. Pojar, eds. Ecosystems of British Columbia. B.C. Min. For. Spec. Rep. No. 6. 330pp.

Lattin, J. D. 1993. Arthropod diversity and conservation in old-growth Northwest forests. Amer. Zool. 33:578–587.

MacKinnon, A. 1996. The status of old-growth forests in British Columbia. Unpubl. ms. 50pp.

MacKinnon, A. and T. Vold. 1997. Old growth forests in British Columbia II: Inventory. Unpubl. ms. 33pp.

Morrison, P. 1988. Old growth in the Pacific Northwest: a status report. The Wilderness Society, Alexandria, Virginia. 46pp.

Noss, R.F., H.B. Quigley, M.G. Hornocker, T. Merrill, and P.C. Paquet. 1996. Conservation biology and carnivore conservation in the Rocky Mountains. Cons. Biol. 10:949–963.

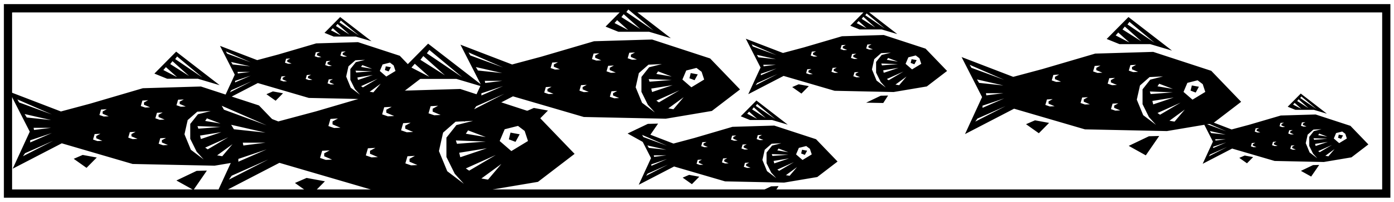
Shaffer, M.L. 1992. Keeping the grizzly bear in the American West: a strategy for real recovery. The Wilderness Society, Washington, D.C.

Stevenson, S. K., and D. F. Hatler. 1985. Woodland caribou and their habitat in southern and central British Columbia. B.C. Min. For. Land Manage. Rep. No. 23, Vol. 2. 112pp.

Weaver, J.L., P.C. Paquet, and L.F. Ruggiero. 1996. Resilience and conservation of large carnivores in the Rocky Mountains. Cons. Biol. 10:964–976.

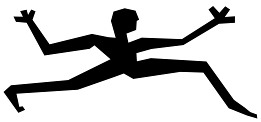
Zammuto, R. 1993. Inventory and management plans, Robson Valley wildlife habitat management areas. B.C. Min. Env., Lands and Parks reports, Prince George, B.C. 411pp.

Zammuto, R., and R. Howard. 1994. Wildlife enhancement plan development project for Robson Valley. B.C. Min. Env, Lands & Parks report, Prince George, B.C. 35pp.



CONCLUSIONS

A Summary of Issues Facing the Yellowstone to Yukon



Louisa Willcox

The authors of papers in A Sense of Place discuss in detail the threats to the biodiversity in the Yellowstone to Yukon ecoregion. Summaries of these problems are listed below.

- A critical limiting factor in maintaining large and mid-size carnivores such as grizzlies, wolves, wolverines, and lynx, as well as native fisheries, is the extent of habitat security. The ongoing loss of secure habitat due to logging, oil and gas development and associated roadbuilding, and other kinds of developments is an issue of vital concern. Loss of connectivity between patches of secure habitat also has serious implications for carnivore conservation.
- Roads and human access, including motorized vehicle use, are primary agents of environmental damage in the region. Roads and inappropriate motorized vehicle use adversely affect wildlife through displacement, increased mortality, fragmentation of habitat, and habituation. Similarly, watersheds and fish can be harmed by roads through increased sedimentation in streams, soil erosion, and change in water temperature and chemistry. In Y2Y, roads and access impacts have been found to be more pronounced where oil and gas development, including seismic lines, overlaps with logging, such as occurs on the eastern slopes of the Rockies in Alberta.
- Over-exploitation of certain natural resources, such as native fish, has contributed to a decline of some species in recent years (e.g. cutthroat trout and arctic grayling).
- Introduced species, including non-native fish, are out-competing native species in some areas; this problem is expected to worsen in the region in the future.
- Expansion of aggressive species adapted to disturbed habitats, such as cowbirds and raccoons, is causing a decline in native species in some areas as a result of competition and parasitism.
- Change in vegetation structure, including the simplification of formerly complex forests and grassland systems through logging, grazing, and fire suppression (especially at low elevations), has serious implications for plant and animal communities and ecological processes region-wide.
- Toxic pollution resulting from industrial activities, such as natural gas development and hardrock mining, is causing damage to plant, animal, and human communities in some areas.
- Damming and diversion of rivers is reducing wetland and riparian habitats for birds and other species, as well as available habitat for fish and other aquatic species.

Particularly vulnerable to human impacts are species that require large expanses of contiguous roadless country to survive, such as wide-ranging carnivores. Maintaining and restoring native fisheries also depends on the protection of roadless "headwaters" country. Other species, such as interior forest birds and native fish, are especially vulnerable to competition from non-native species. Some of the highest quality remaining habitat for disturbance-sensitive species occurs within the Yellowstone to Yukon region.

As indicated in the accompanying papers, signs of ecological trouble in Yellowstone to Yukon are already apparent: declines have been documented in forest and grassland birds, native cutthroat trout and arctic grayling, some amphibians, and large carnivores—especially in the southern

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half of the region where human impacts are most pronounced. These species serve as "coal mine canaries" for the larger ecosystem, and indicate larger and deeper problems for the protection of biodiversity in Y2Y.

Those involved in the Y2Y Conservation Initiative hope to use this information to develop a plan to reverse these declining trends, to prevent a wave of future species extinctions, and to maintain the region's biodiversity and ecological health. Important first steps identified by authors of this report for the development of such a plan include better synthesis of existing data and collection of new information to fill in critical gaps. (Data on natural resources in Y2Y gets sketchier as one travels north.) Particularly important are information and analytic techniques to evaluate cumulative effects of human activities on various resources. Broader dissemination of existing information, such as data on the trends in the region's economy, is also mentioned as a priority need.

The Next Steps

The pressure to extract natural resources, combined with the rapid increase in human settlement in the region, shows no signs of abating. Indeed, the pace of the change is accelerating. Given such forces, maintaining Yellowstone to Yukon as a healthy place for wildlife and human communities will be an enormous challenge. In taking the next steps to respond to this challenge, there will be no silver bullets, no magic formula, no single action that will prevent the disappearance of yet more species and their habitats, or the further pollution of clean air and mountain water. The problems are complex, and although there are many who offer simple and simplistic answers, true solutions will not come easily.

What solutions there are will evolve in various arenas: in resource law, agency administration and policy, economic and tax policies, science and education. They will grow out of the efforts, expertise and imaginations of many people: hunting outfitters and mountain guides, kayakers and cross-country skiers, retired school teachers, sympathetic ranchers, doctors, fruit farmers, summer visitors to Yellowstone and Nahanni and other wild places, and business people who realize that healthy ecosystems are ultimately the *sine qua non* of healthy economies. Solutions will come too at different scales: families, clubs, local community governments, land managing agencies, state and federal governments, First Nations. They will inevitably reflect the enormous diversity of political perspective, philosophy, and ideology that mirror the diversity of the individuals and communities within the region.

Solutions to the challenges facing Yellowstone to Yukon's future must also address the following issues, identified in *A Sense of Place* and in other publications about management of ecosystems:

- Conflicting and uncoordinated management practices and directions do not reflect ecological realities and often result in contradictory and piecemeal approaches to managing the landscape, wildlife, and fisheries.
- There is a lack of common understanding among the general public, managing agencies, and resource users about the status and trends of the regional economy and ecology—or how human actions affect the health of the land.
- There are insufficient data on and monitoring of many of the ecological, economic, and other important parameters of the region, as well as an inability to use effectively much existing information.
- The lands set aside as protected areas in the Y2Y region are only a small fraction of the area. Some lands important to maintaining the region's biodiversity are not included in protected areas.
- With the rapid pace of in-migration, the memory of indigenous relationships with the land is being lost, as is the knowledge of the region's long-term residents and caretakers about how to live here without destroying its essential nature.
- Dramatic differences in law, economic policies, management approaches, and political arrangements between Canada and the U.S. exacerbate problems of managing the integrity of the region across an international border.

Obviously, there is much to be done, and a well-grounded sense of urgency about doing it. The Rockies offer perhaps the best chance left on earth to keep intact a fully functional mountain ecosystem. *A Sense of Place* gives those who love these mountains—the wild heart of North America—a rudimentary map for looking at a fascinating, complex, and critically important part of the planet, and a starting place to chart its conservation.

The actual charting of the course will require new creativity and a new, diverse kind of community—a community of conservation biologists, economists, activists, First Nations, visitors, residents, and others bound together by a common concern for the future of this region. Tapping new talents and new ideas, and working along a new axis (north-south), such a community may yet succeed in developing and implementing a comprehensive plan of complementary actions to ensure that future generations will enjoy the biological riches and superb wilderness that defines Yellowstone to Yukon.