Muskwa-Kechika Management Area Biodiversity Conservation & Climate Change Assessment

Prepared by the Yellowstone to Yukon Conservation Initiative
for the
Muskwa-Kechika Management Area Advisory Board
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YELLOWSTONE TO YUKON CONSERVATION INITIATIVE:

The Yellowstone to Yukon Conservation Initiative (Y2Y) works to create and maintain an interconnected series of parks and wildlife corridors that allow both people and animals to thrive across an international landscape.

MUSKWA-KECHIKA ADVISORY BOARD:

Appointed by the Premier of British Columbia, the Muskwa-Kechika Advisory Board (M-KAB) is mandated with advising government on natural resource management in the Muskwa-Kechika Management Area (M-KMA) to ensure that activities within the area are consistent with the objectives of the Muskwa-Kechika Management Plan.

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A guided party of horseback riders relaxes in the Muskwa-Kechika high country. Wayne Sawchuk

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Acknowledgements

The Yellowstone to Yukon Conservation Initiative (Y2Y) appreciates the foresight and support of the Muskwa-Kechika Management Area Advisory Board to undertake this far-reaching conservation and climate change assessment for the greater Muskwa-Kechika ecosystem.

We also acknowledge the financial contributions of the Wilburforce Foundation and the BC Chapter of the Canadian Parks and Wilderness Society who helped make this work possible.

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Yellowstone to Yukon Conservation Initiative

The Yellowstone to Yukon Conservation Initiative (Y2Y) is a bi-national non-profit organization that promotes the conservation of biodiversity and sustainable human activities within a 1.2M square kilometre area stretching from Yellowstone National Park to the Arctic Circle. This vision is being achieved through the establishment of a network of core protected areas and the maintenance of functional ecological connectivity between them. Y2Y works with a myriad of partners including other environmental organizations, independent scientists, academic institutions, government agencies, aboriginal communities, private land conservancies, and progressive businesses.

The primary means through which Y2Y and its partners work toward their shared vision for the Yellowstone to Yukon region are: promoting new protected areas in large, intact landscapes; ensuring existing protected areas are managed primarily to maintain their ecological integrity; decreasing wildlife mortality due to motor vehicles, trains and conflict with humans; reducing linear disturbances and motorized access on multiple-use public lands; preventing subdivision and development of private lands within wildlife corridors; and creating the conditions that will provide ecosystems and human communities with the greatest capacity to resist or adapt to climate disruption.

Executive Summary

This conservation assessment and outreach project was conceived to help face challenges in the future management of the Muskwa-Kechika Management Area (M-KMA). The assessment contains a variety of tools to assess the existing network of conservation lands, strengthen conservation measures in light of climate change, plan and evaluate land and resource use proposals within this shifting environment, and gain further public and community understanding of and appreciation for the biodiversity values of the M-KMA.

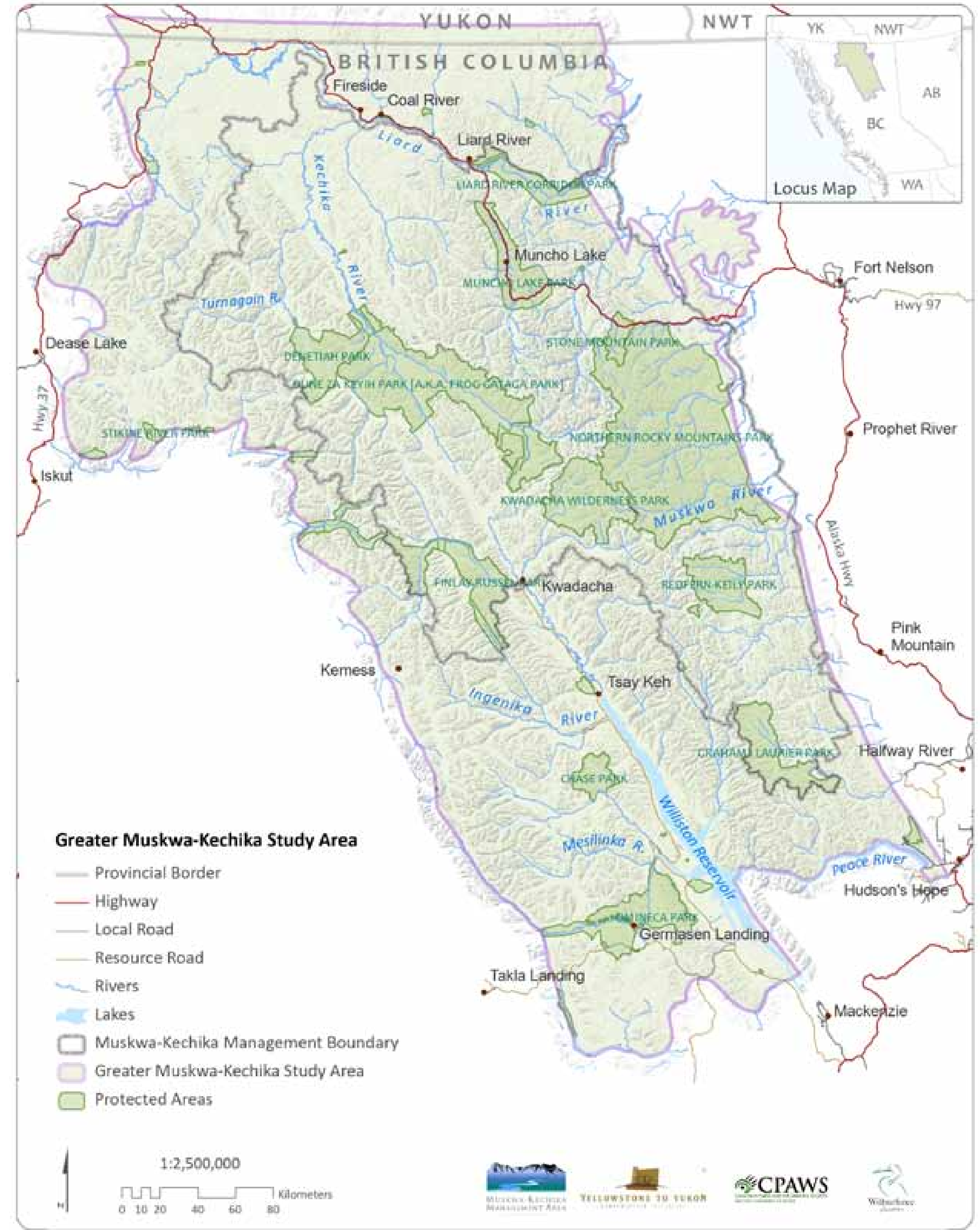
The Yellowstone to Yukon Conservation Initiative (Y2Y) proposed this project because of the important role that the M-KMA plays within the Yellowstone to Yukon region. The wild and natural landscapes that once covered most of the North American continent have disappeared completely or been highly fragmented by human settlement, agricultural activity, transportation and transmission networks, and resource exploration and development. The northern reaches of the Yellowstone to Yukon region contain some of the only and best remaining large-scale natural habitats on the continent. The participants in land use planning in northern BC and the BC government of the day had the foresight to create the M-KMA with the legislative mandate of protecting its wilderness and wildlife. The management model for the M-KMA is a globally-leading example of large landscape conservation, in which core protected areas are embedded in a landscape available for limited and sustainable commercial and industrial uses. The M-KMA now acts as one of the northern anchors of the Y2Y region, whose future management will determine the success or failure of the Y2Y vision for biodiversity conservation.

1. Project Objectives

The biodiversity conservation and climate change assessment objectives are:

1. To help ensure that the wilderness and wildlife goals of the Muskwa-Kechika Management Area are met;
2. To identify how well the existing protected areas and special management zones achieve broad conservation goals and, if necessary, recommend improvements in land use plans to increase the likelihood of meeting those goals;
3. To enable land managers within the greater M-KMA ecosystem to employ precautionary strategies to maintain wildlife and ecosystems in the face of climate change;
4. To provide conservation planners and managers with additional information against which to assess the potential impacts of developments proposed within the greater M-KMA ecosystem;
5. To identify key wildlife habitat linkages within and outside the M-KMA;
6. To contribute to First Nations' land use planning efforts in northern B.C. on lands in and adjacent to the M-KMA;
7. To inform any future review of existing land use plans in the greater MKMA ecosystem.

MAP 1 Muskwa-Kechika Study Area & Location Map [1]



1 See page 11 for a description of how the study area boundary was determined.
Note that a new protected area has been established by the Kaska Nation and the BC Government in the Horseranch Range, northeast of Dease Lake, outside the M-KMA.

2. Facing the Challenge

Over the past few decades, biodiversity conservation plans generally have focused on protecting a variety of habitats as a means of ensuring the persistence of a variety of species. However, as the climate changes, ecosystems will dissemble and species increasingly will move across the landscape and reassemble elsewhere, sometimes in novel combinations. Habitat types (ecosystems or natural communities) based largely on contemporary land cover no longer provide a reliable basis for long-term conservation planning. Another approach is to plan based on "enduring features" rather than habitat types. Enduring physical features will remain unchanged over time even if the living layers are removed or altered. As one key planning tool, we recommend using the enduring features approach, basing conservation on the physical environment rather than on highly uncertain, projected distributions of individual species and ecological communities. This long term approach will be more effective in conserving biodiversity, including wildlife species, in the "Serengeti of the North" over the coming centuries.

However, identifying and creating plans to conserve only enduring features is not sufficient. Over the coming decades, merely conserving the ecological stage will not necessarily sustain the actors; neither will it prevent local extinctions of individual species nor guarantee the survival of focal species like caribou, grizzly bears or Stone's sheep. We also need to continue with focal species management, protecting critical habitat for threatened species, and maintaining habitat connectivity based on focal species biology, today's land cover and patterns of productivity. In a climate-changing world, landscape connectivity will provide mobile species with the best chance of adapting to changing conditions. In this report we recommend a variety of approaches and tactics, especially to get as much biodiversity as possible through the "big squeeze" of climate change to the end of this century.

Pristine waters and intact boreal ecosystems characterize the mountain landscapes of the Muskwa-Kechika region.

Wayne Sawchuk

Fundamental to management for the conservation of biodiversity and focal species is the question of appropriate scale, i.e., the relative scope of interest, such as local, watershed, regional or landscape. Scale is important to decisions on the size and distribution of protected areas and other conservation lands, but also to assessing the pace, scope and intensity of proposed resource developments. While the regional assessment of enduring features, areas of high physical variety and rarity, productivity and focal species connectivity in this report are useful for longer term landscape conservation planning, the maps also can assist watershed-scale planning. For example, the location of lands with high values for physical variety or rare features can help guide specific improvements to the existing protected areas network. The maps can also show, at an operational scale, which areas should be avoided for development or roads. Similarly, wildlife connectivity pathways mapped for this report can be applied at a watershed scale, both to validate the data with local information, and to support local land use planning.

3. Study Area Boundary

For the purposes of this analysis, the project team sought to identify a study area that is defensible given the project's objectives. Our goal was to define the "Greater M-K Ecosystem". We started with the legislated M-KMA boundary. We then looked at the larger physiographic landscapes, i.e., different geographic areas having landforms that are unique from each other, of which the M-KMA is a part. The basic unit of analysis and mapping for this conservation assessment is the physiographic sub-province (after Holland, 1964: Landforms of British Columbia). The project study area of 132,558 square kilometres includes all or some[2] of the physiographic sub-provinces, portions of which are found within the M-KMA

4. Enduring Features Assessment

The rich variety of life in the greater M-KMA ecosystem is shaped in large part by the variety of the physical landscape. The physical landscape includes topography (elevation, slope, and aspect), bedrock and surface geology, macro landforms, and major aquatic elements—collectively called "enduring features". It is the template upon which Earth's living skin develops, and upon which organisms grow, diversify and combine, creating different ecosystems.

Regardless of how species and ecosystems may change as a result of climate disruption, all species and all future ecosystems will continue to need a physical landscape on which to live. The more diverse a physical landscape is today, the more biodiversity is likely to be found there in the future. In order to support future biodiversity and focal species in the greater M-KMA, two precautionary strategies are to protect the variety of enduring features, and maintain connectivity between areas of suitable wildlife habitat today and in the future.

a. Enduring Features – Areas with Concentrations of High Variety

Each enduring feature has a unique combination of physical characteristics such as geology, elevation or land form—kind of like a bar code. Each combination is expressed in different growing conditions that define a different habitat and support species adapted to the local conditions. Therefore, places with a high variety of enduring features should also have high biodiversity. We mapped the locations of concentrations of physical diversity as essential information to underpin this assessment's recommendations on land use management.

2 The Rocky Mountain Trench, Rocky Mountain and Rocky Mountain Foothill physiographic provinces extend well south of the M-KMA region into southern BC and Alberta. For practical purposes, the study area boundary was set where these provinces meet the Peace River.

b. Enduring Features – Areas with Concentrations of High Rarity

Also important is the location of rare enduring features—those unique combinations of elevation, substrate and macro landforms not common in the study area. These rare physical combinations can produce rare ecosystems or habitat for rare species, which in both cases could warrant special management consideration. For example, rare enduring features include certain types of uncommon bedrock formations (like types of volcanic rock known as ultramafic or serpentine rock), which in turn can provide unique habitat for uncommon plant species. We mapped the areas with high concentrations of rare enduring features to assist land managers in making conservation decisions.

5. Primary Productivity

Concentrations of physical variety based on enduring features depict many, but not all, of the inherent high biodiversity areas in the M-KMA study area. Also important in conservation planning is an understanding of areas of high biological productivity, for example wetlands, lakes and riparian areas, that support many focal species. Areas such as large, low-elevation areas of gentle relief, supporting productive forest, dotted with myriad wetlands, and drained by major streams and rivers must be important simply in terms of biomass, primary productivity and connectivity. These areas are often key wildlife habitat, sometimes are biological hotspots with an abundance and diversity of species, or serve as important wildlife connectivity corridors. Some areas of high primary productivity exist in large expanses of fairly uniform landscapes, and thus are missed by assessments identifying areas of high physical variety. To fill this gap, we identified those areas of high primary productivity in the study area.

6. Why Wilderness Matters in This Conservation Assessment

One of the legislative imperatives of the M-KMA is to maintain its wilderness characteristics over the long term. From the biodiversity conservation perspective, one of the most important attributes of the M-KMA area is its wilderness, i.e., its naturalness or intactness. For the most part, it is a landscape substantially unaffected by human activity and for that reason it stands apart from much of the southern two-thirds of BC, large parts of northeast BC, and the southern third of the Yellowstone to Yukon region. Most of the study area has little "human footprint".

For these reasons, the conservation of wilderness in the M-KMA complements and supports the enduring features representation and wildlife connectivity goals assessed in this study. Wilderness areas serve as benchmarks of intact ecosystems, and they are natural reservoirs of biodiversity, including wide-ranging focal species. Within the greater M-KMA ecosystem, and within the Yellowstone to Yukon Conservation Initiative context, wilderness has an important role to play in meeting conservation goals, in serving as climate change sanctuaries, and for control areas in monitoring the impacts of land use and climate change.

7. Wildlife and Connectivity

Maintaining biodiversity and healthy wildlife populations depends not only on the existence of core habitats but also on the maintenance of connectivity among them. Connectivity contributes in many ways, including: maintaining healthy genetic exchange; helping sustain predator-prey systems; enabling migration, both seasonal and long term; and even allowing movement of wildlife from less accessible, less hunted areas into those more used by hunters. We assessed habitat suitability for four focal species

This study assessed habitat suitability and connectivity for four focal species: caribou, moose, mountain goat and Stone's sheep.

CPAWS-BC

(caribou, moose, mountain goat and sheep), and applied a recently developed connectivity modelling tool to show the location of the most important wildlife linkages in the greater M-KMA. We selected four example focal species for mapping purposes, based on the availability of consistent and validated habitat suitability maps and the interests of local stakeholders.[3] The wildlife connectivity maps for the four focal species we selected, and other species that could be mapped in the future, will help land managers to assess gaps in managing for wildlife connectivity, and will help in the review of development proposals that may affect wildlife linkages.

8. Climate Change Adaptation

The future climate in the M-KMA region is projected to be warmer and wetter, with the Mean Annual Temperature (MAT) increasing 3 degrees C. These changes will have widespread but variable ecological effects. For example, in an alpine or boreal area where MAT increases but remains below 0 degrees C, ecological change will not be as significant. In places where the MAT increases to above 0 degrees C, soils will start to warm up, permafrost (if present) will slowly melt, nutrient cycling and decomposition will speed up, biological productivity will increase, the vegetation will respond accordingly, and ecological change will be significant.

a. Projected Ecological Upheaval From Climate Change

As climate changes in northern BC, there will be changes in land cover and vegetation type. For example, some alpine ecosystems will be taken over by subalpine scrub and forest. There will be less change where the increased warmth and moisture are still insufficient to transform the land cover to a dramatically different condition; e.g., from grassland to forest. In general, forests will persist over much of the area, but they will be different kinds of forest. Most alpine areas will shrink; grasslands could be threatened by a takeover by woody plants; large lakes and streams should persist while small shallow ones could dry up or fill in; riparian zones should persist; and wetlands will change, perhaps becoming less acid and more productive.

3 The study team recognizes the importance of carnivores as focal species, but the available data and resources limited the number of focal species we were able to model for connectivity in this project.

Areas with a projected high degree of upheaval call for management strategies that maintain wildlife connectivity between areas of suitable habitat, to allow for species to move or adapt to the new conditions. Areas with low projected upheaval can be viewed as potential climate change refugia for species that use this habitat today. We modeled these scenarios using projected climate change data, resulting in maps that could provide broad guidance to land managers in assessing and responding to the impacts of land use changes.

b. Projected Persistent Habitat Elements – Alpine

As the climate warms, trees on the mountains begin to colonize the shrub belt, and shrubs begin to colonize the alpine tundra. The start of this rise in tree-line and loss of alpine can be noticed already in some places. Where the mountains are sufficiently high that the climate will still be intolerable for trees and erect shrubs, alpine tundra ecosystems will persist, although they will be smaller in area. Given enough time and high enough terrain, alpine could expand upward, recouping some of the losses. Where the high country is not high enough, over time the alpine will disappear. The report provides maps and tables showing a projected 43% decline in alpine areas by the year 2050, which is equivalent to an 8% decline in the overall proportion of alpine zones relative to other vegetation zones within the greater M-KMA.

9. Protected Areas

About 27% of the M-KMA is fully protected today, while further protected lands are located outside the M-KMA, within the greater study area. The conservation biology literature cites a range of protection targets to help ensure adequate representation of biodiversity and connectivity within a protected areas system. Meta-analyses of land use planning for conservation have found that the proportion of a region's land base that must be managed primarily to meet conservation objectives lies between 25 and 75%. The median protected area recommendation lies above 50%.

Therefore, in order to ensure that the network of protected areas and other conservation lands within the greater M-K ecosystem contains sufficient land to ensure the future conservation of biodiversity, especially in the face of an uncertain climate future, it must adequately represent each of the ecosystem's physiographic sub-provinces and special elements, and should contain approximately 50% of the land base within its boundaries.

Our assessment of existing conservation status for the study area as a whole provides a picture of where the most significant conservation gaps are located. The assessment points to focussing special land use management on areas with concentrations of high enduring feature variety or rarity, and in areas with little or no representation of typical enduring features. The study team also completed a more detailed conservation gap analysis of each physiographic province in the study area. This assessment allows land managers to review conservation status and needs at a more manageable scale, and to set conservation priorities on lands outside existing protected areas.

10. Recommendations

a. Management Context

Planning for long term biodiversity conservation and climate change adaptation calls for a holistic approach to land management. The scope of these recommendations encompasses the entire Muskwa-Kechika Management Area, plus adjacent lands within the greater M-KMA ecosystem. The recommendations, primarily based on scientific analysis of enduring features and climate change data, are provided as advice to the M-KMA Advisory Board, which in turn may make recommendations to the BC government on implementing the proposed actions.

However, these recommendations are also pertinent to other land managers and levels of government, such as First Nations and communities, who may be developing or implementing land, watershed or resource use plans in the M-KMA region. Resource and tourism businesses also have a role to play in considering and supporting these recommendations, as do non-government organizations and the general public. Ensuring the ecological integrity of the M-KMA now and through projected long term climate-induced changes is the responsibility of all of these entities.

In fact, over time, decisions about roads or resource development at a watershed scale, rather than the greater ecosystem scale, will play a significant role in achieving conservation goals, such as conserving the variety of wildlife and maintaining ecosystem integrity. However, the tools for evaluating the cumulative effects of development at a watershed or larger scale are limited.

The environmental impacts of proposed developments in the greater ecosystem of the M-KMA should be assessed and addressed at a site, watershed, and landscape scale.

b. Importance of the Precautionary Principle

The Preamble to the International Convention on Biological Diversity defines the "biodiversity precautionary principle" as:

> *"…where there is a threat of significant reduction or loss of biological diversity, lack of full scientific certainty should not be used as a reason for postponing measures to avoid or minimize such a threat."*

Given the finality of extinction, biodiversity conservation planning should incorporate wide margins of safety against the potential loss of organisms, populations or ecological processes. In particular, biodiversity conservation plans must carefully consider the consequences of further human impact and loss of natural habitat, even when no obvious role or effect on the ecosystem has been empirically described. In other words, the absence of ecological data does not equate with the absence of ecological importance (from the M-K *Conservation Area Design*, 2004).

4 *Cumulative Effects: From Assessment Towards Management.* (2011) BC Forest Practices Board Special Report, FPB/SR/39.

c. General Recommendations

This report's recommendations are organized into four broad categories based on these principles:

- Maintain the ecological integrity of high conservation value lands that are not represented in protected areas;
- Conserve existing wilderness;
- Implement an M-KMA climate change adaptation strategy to meet long term conservation goals;
- Enhance communications and public awareness about the M-KMA and the report recommendations.

The report also provides numerous specific recommendations about conservation and land management.

i. Maintain the Ecological Integrity of High Conservation Value Lands

What are the recommended priorities for long term conservation in the M-KMA?

- As a management priority, maintain the ecological integrity of high conservation value lands identified in this assessment. These areas are mapped as having concentrations of high enduring variety, rarity, productivity, or wildlife connectivity values. Focus special attention on high conservation value lands that are not represented in existing protected areas.
- Enhance the configuration of existing protected areas and special management zones within the M-KMA to meet current and future conservation goals, including the maintenance of wildlife connectivity, given the projected ecological upheaval from climate change.
- Complete the network of representative protected areas to include the full spectrum of enduring features (physical environments) in the greater M-KMA region. Focus first on those physiographic regions that have no representation or less than 1% represented in protected areas, such as the Rabbit Plateau.
- Seek ways to incorporate traditional and indigenous ecological knowledge (TIEK) to add to and validate the findings of this study. Support the use of TIEK in management and land use decisions to improve the information presented in this report by identifying unique, rare, or key habitats and features, as well as occurrences of species, biological hotspots and areas of key wildlife connectivity. For example, test the accuracy of wildlife connectivity maps by asking local people to compare the maps of focal species pathways with their knowledge of familiar watersheds.
- Provide the means for different resource sectors, such as mining, oil and gas, forestry and renewable energy, to compare updated resource value maps with the conservation maps in this report. Identify areas of high and low conflict between biodiversity conservation and resource development values. Work with industry to focus development in areas having lower conservation value. Provide GIS-based conservation data to industry to support this work.

ii. Conserve Wilderness

How can wilderness contribute to long term ecosystem conservation goals?

- Maintain wilderness in the greater M-KMA ecosystem as part of a climate change adaptation strategy, and as a way to ensure the ecological integrity of areas with high physical variety, rare features, wildlife connectivity and high primary productivity.
- Implement the *existing approved management recommendations* to maintain wilderness in the M-KMA, as they also apply broadly to the maintenance and protection of areas of high physical variety, primary productivity, connectivity and rarity as part of a larger regional climate change sanctuary.

iii. Implement a Climate Change Adaptation Strategy

What actions will help achieve effective conservation in the M-KMA in a time of rapid and uncertain climate change?

- Manage the M-KMA for its important role as part of a climate change adaptation strategy for the greater Yellowstone to Yukon region.[5] Manage the intact landscapes and wildlife linkages in the M-KMA as a climate change sanctuary.

An M-KMA climate change adaptation strategy will help to bring plants and animals successfully through the projected ecological upheaval due to a changing climate. Within the context of the greater Yellowstone to Yukon region within which the M-KMA sits, the M-KMA offers an increasingly rare example of a very large, intact ecosystem with fully-functioning ecological processes and inherent resilience to climate disruption. The precautionary approach is to manage the greater M-KMA region as a climate-change sanctuary, i.e., a theatre large enough for the ecological drama to unfold, where species can react and interact as best they can without excessive human-caused disturbances and habitat loss. We recommend these general principles as a climate change adaptation framework for determining how to direct long term conservation efforts in the greater M-KMA ecosystem:

- Reduce adverse human impacts on species and ecosystems from sources other than climate change.
- Maintain and enhance connectivity in the M-KMA and greater ecosystem to enable wildlife and other organisms to adjust (as best they can) to changes in land use and climate.
- Focus management attention on areas with the best habitat suitability for species vulnerable to ecological upheaval.
- Consider the long term needs of focal wildlife species such as caribou, moose, grizzly bears, mountain goats and sheep.
- Increase the extent and effectiveness of conservation lands.
- Apply the best available science and support or create effective monitoring systems.
- Manage to maintain key ecosystem functions rather than status quo distributions of species and ecosystems.
- Engage communities to understand and discuss new challenges and create solutions.
- Collaborate at appropriate scales.

iv. Enhance Communications and Public Awareness

How can we increase support for achieving long term conservation goals in the M-KMA region?

- Engage First Nations, industry associations, user groups, non-government organizations and other interested parties in a dialogue about the findings of this assessment and how they could apply to future biodiversity conservation challenges and opportunities in the greater M-KMA study area.
- Improve public and local community awareness of, and support for, achieving long term conservation goals in the M-KMA, particularly as they relate to climate change. Distribute and make this report and its maps available through multiple sources, including the M-KMA Board, government agencies, First Nations, public libraries, non-government organizations, industry, communities, and universities.

5 For example, see: Graumlich, L. and W.L. Francis. (2010) *Moving Toward Climate Change Adaptation: The Promise of the Yellowstone to Yukon Conservation Initiative for Addressing the Region's Vulnerability to Climate Disruption.* Yellowstone to Yukon Conservation Initiative, Canmore, AB.

Introduction

1. Purpose and Scope of the Conservation Assessment

This conservation assessment and outreach project was conceived to help face challenges in the future management of the Muskwa-Kechika Management Area (M-KMA). The assessment provides a variety of tools to assess the existing network of conservation lands, strengthen conservation measures in light of climate change, plan and evaluate land and resource use proposals within this shifting environment, and gain further public and community understanding of and appreciation for the biodiversity values of the M-KMA. This study builds upon previous work such as the Conservation Area Design for the M-KMA, completed in 2004.

The Yellowstone to Yukon Conservation Initiative (Y2Y) proposed this project because of the important role that the M-KMA plays within the Yellowstone to Yukon region. The wild and natural landscapes that once covered most of the North American continent have disappeared completely or been highly fragmented by human settlement, agricultural activity, transportation and transmission networks, and resource exploration and development. The northern reaches of the Yellowstone to Yukon region contain some of the only and best remaining natural habitats on the continent. The participants in land use planning in northern BC and the BC government of the day had the foresight to create the M-KMA with the legislative mandate of protecting its wilderness and wildlife. The management model for the M-KMA is a globally-leading example of large landscape conservation, in which core protected areas are embedded in a landscape available for limited and sustainable commercial and industrial uses. The M-KMA now acts as one of the northern anchors of the Y2Y region, whose future management will determine the success or failure of the Y2Y vision for biodiversity conservation.

With the assistance of scientific advisors, including Dr. Jim Pojar, Dr. Katherine Parker, Gregory Kehm Associates, Dr. Carlos Carroll, and the BC Chapter of the Canadian Parks and Wilderness Society (CPAWS), Y2Y prepared this biodiversity conservation and climate change assessment for the Muskwa-Kechika Advisory Board (M-KAB).

A Project Advisory Committee, convened by Y2Y, provided advice on project implementation, and a Technical Advisory Committee assisted with scientific review and advice to the project team. Community visits and participation, for example at the 2010 Moose Valley Gathering, provided opportunities for First Nations to learn about the project and provide their advice, a process that is ongoing. The study findings and preliminary recommendations were presented to the M-KAB and invited stakeholders in May, 2011.

2. Project Objectives

The conservation assessment objectives are:

1. To help ensure that the wilderness and wildlife goals of the Muskwa-Kechika Management Area are met;
2. To identify how well the existing protected areas and special management zones achieve broad conservation goals and, if necessary, recommend improvements in land use plans to increase the likelihood of meeting those goals;
3. To enable land managers within the greater M-KMA ecosystem to employ precautionary strategies to maintain wildlife and ecosystems in the face of climate change;
4. To provide conservation planners and managers with additional information against which to assess the potential impacts of developments proposed within the greater M-KMA ecosystem;
5. To identify key wildlife habitat linkages within and outside the M-KMA;
6. To contribute to First Nations' land use planning efforts in northern B.C. on lands in and adjacent to the M-KMA;
7. To inform any future review of existing land use plans in the greater MKMA ecosystem.

3. Muskwa-Kechika Management Area: Summary of Conservation and Heritage Values

The Muskwa-Kechika Management Area (M-KMA), together with the greater ecosystem assessed in this report, is one of the largest, most diverse wilderness areas in North America, with expansive forests, spectacular geological formations, lakes, rivers, waterfalls, hot springs, sub-alpine and alpine areas and major wetlands. The M-KMA is part of the great Canadian Cordillera, lying within the Rocky Mountain (eastern system) and Northern and Central Plateaus and Mountains (interior system) physiographic regions.

Located where the boreal plains and muskeg ecoregions of the east meet the rugged Northern Rocky Mountains and Cassiar Mountains of the west, the greater M-KMA region has been described as Canada's "Serengeti of the North" where extensive predator-prey systems remain largely undisturbed by human industrial development pressures. These robust ecosystems support large mammals such as black and grizzly bears, moose, caribou, elk, mountain goats and Stone's sheep in densities of global importance. Wildlife found in the M-KMA is supported by a variety of habitats from high elevation subalpine and alpine to low lying meadows and wetlands. The low density of roads, limited motorized access and industrial development, has enabled ecosystems to remain in an essentially intact and natural state. Untrammelled wilderness is one of the outstanding values and reasons behind the establishment of the M-KMA.

First Nations have inhabited the region for thousands of years, living, hunting, gathering and practicing traditional land uses throughout what is now known as the Muskwa-Kechika Management Area. In addition to these activities, First Nations whose traditional territories include the M-KMA developed distinct cultural and spiritual beliefs and customs. There are many archaeological sites in the area, an historic fur trading route with related trapper cabin sites, the remains of a Hudson's Bay Trading Post, an historic commercial fishery site, a native village abandoned after World War Two, native pack trails, and an old wagon trail.

Part of the Muskwa-Kechika Management Area is within the traditional territory of the Kaska Dena First Nation. The Kaska Dena call the area Dena Kéyih (pronounced den-ah key-ah), which means "people's land" in their traditional language. Parts of the traditional territories of the Tsay Kay Dena and Treaty 8 Nations, including the Halfway River, Prophet River, and Fort Nelson First Nations, also encompass portions of the M-KMA (adapted from M-KMA information posted on www.muskwa-kechhika.com).

4. Management Context for the Conservation Assessment

The *M-KMA Act* and the M-KMA Management Plan adopted through Order-in-Council, provide guidance to managers in government agencies and non-government organisations, communities, and industry groups while conducting their activities in the M-KMA. As well, a public advisory board was appointed by the Premier to provide advice to government on planning and land use management. A trust fund was established to fund projects.

The Muskwa-Kechika Management Area includes a mosaic of protected areas encompassing approximately 1.7 million hectares (ha) or 27% of the area. About 4.6 million ha, or 73% is in Special Management Zones (SMZ) and Wildland Zones, where various forms of resource development are permitted. Inside the parks, wilderness will remain unimpaired by industrial activities such as forestry, logging, oil and gas development, or hydro development. However, within the SMZ's industrial activities may occur according to special rules. Access to the area is managed under a special permitting arrangement.

To ensure that land use and other human activities in the M-KMA are managed to a higher standard than elsewhere in the province, the *M-KMA Act* and M-KMA Management Plan required the development of 5 "local strategic plans". These plans are intended to provide direction to ensure appropriate management of activities and intensities of development for:

- Wildlife (M-KMA Wildlife Management Plan)
- Oil and Gas (Pre-tenure Plans)
- Recreation (Recreation Management Plan)
- Forestry (Landscape Unit Objectives)
- Provincial Parks (Park Management Plans)

A variety of environmental concepts, approaches, models and tools influence current planning and management in the M-KMA. Some of these, which are further described in the report recommendations, include:

- Ecosystem-Based Management and Ecological Integrity
- Integrated Resource Management
- Cumulative Effects Assessment and Management
- Monitoring
- Adaptive Management

This conservation and climate change assessment builds upon and is consistent with the *M-KMA Act* and Management Plan and the goals of these environmental planning tools.

Fundamental to management for the conservation of biodiversity and focal species is the question of appropriate scale, i.e., the relative scope of interest, such as local, watershed, regional or landscape. Scale is important to decisions on the size and distribution of protected areas and other conservation lands, but also to assessing the pace, scope and intensity of proposed resource developments. While the regional assessment of enduring features, areas of high physical variety and rarity, productivity and focal species connectivity in this report are useful for long term landscape conservation planning, the maps also can assist watershed-scale planning. For example the spatial pattern of lands with high values for physical variety or rare features can help guide specific improvements to the existing protected areas network. The maps can also show at an operational scale, which areas should be avoided for development or roads. Similarly, wildlife connectivity pathways mapped for this report can be studied at a watershed scale, both to validate the data, and to support local planning.

5. Facing the Challenge

Over the past few decades, biodiversity conservation plans generally have focused on protecting a variety of habitats as a means of ensuring the persistence of a variety of species. However, as the climate changes, ecosystems will dissemble and species increasingly will move across the landscape and reassemble elsewhere, sometimes in novel combinations. Habitat types (or natural communities) based largely on contemporary land cover no longer provide a reliable basis for long-term conservation planning. Another approach, one that was pioneered by the World Wildlife Fund of Canada in the 1980s and is regaining currency as a consequence of rapid climate change, is to plan based on "enduring features" rather than habitat types. Enduring physical features will remain unchanged over time even if the living layers are removed or altered. As one key planning tool, we recommend using the enduring features approach, basing conservation on the physical environment rather than on highly uncertain, projected distributions of individual species and ecological communities. This long term approach will be more effective in conserving biodiversity over the coming centuries. (See more on the scientific rationale for using the enduring features approach, in Appendix 1: *A Scientific Framework for Using the Enduring Features Approach to Support the Conservation Assessment* by Dr. Jim Pojar, 2011)

However, identifying and creating plans to conserve just enduring features is not sufficient. Over the coming decades, merely conserving the ecological stage will not necessarily sustain the actors; neither will it prevent local extinctions of individual species nor guarantee survival of focal species like caribou or Stone's sheep. We also need to continue with focal species management, protecting critical habitat for threatened species, and maintaining habitat connectivity based on focal species biology and today's land cover and patterns of productivity. In a climate-changing world, landscape connectivity will provide mobile species with the best chance of adapting to changing conditions. Biodiversity conservation is a complicated endeavour; in this report we recommend a variety of approaches and tactics, especially to get as much biodiversity as possible through the "big squeeze" of climate change to the end of this century.

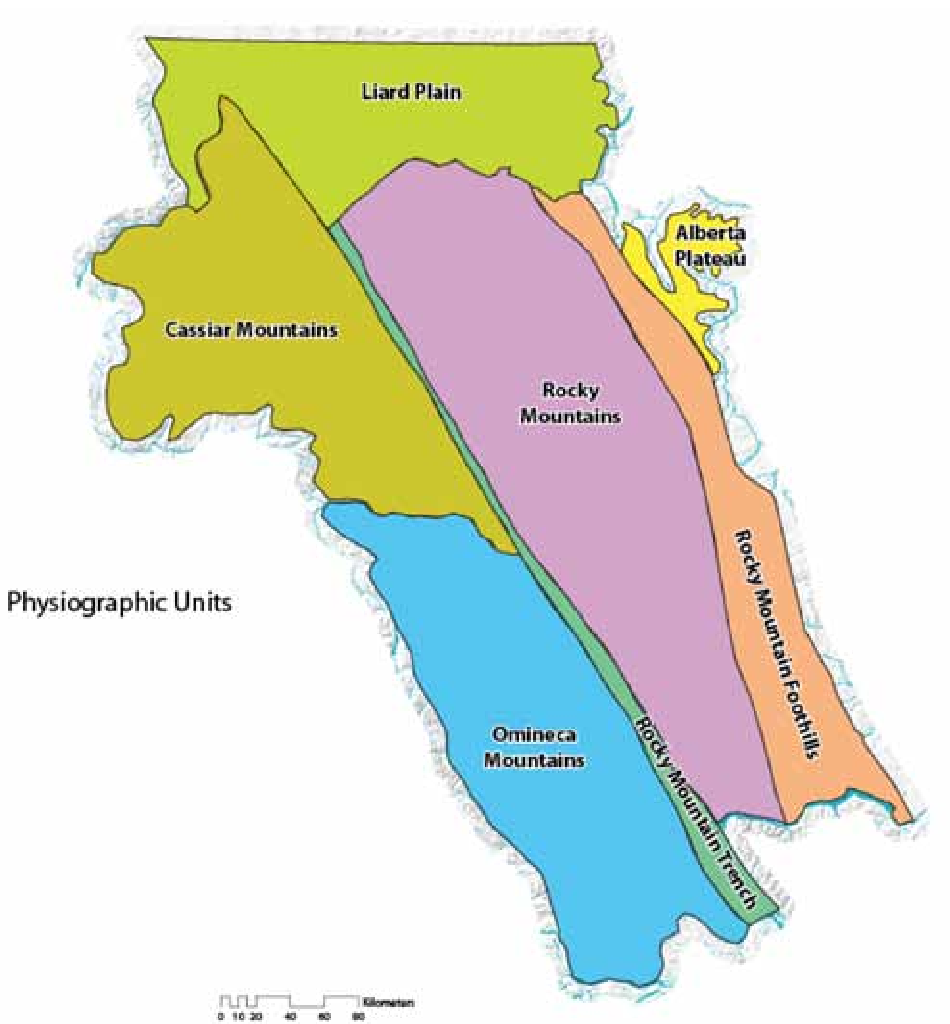
6. Study Area Boundary

For the purposes of this analysis, the project team sought to identify a study area that is defensible given the project's objectives. Our goal was to define the "Greater M-K Ecosystem". We started with the legislated M-KMA boundary. We then looked at the larger physiographic landscapes – i.e., different geographic areas having landforms that are unique from each other – of which the M-KMA is a part. The basic unit of analysis and mapping for this conservation assessment is the physiographic sub-province (after Holland, 1964: Landforms of British Columbia). The 132,558 square kilometre study area includes all or some[6] of the physiographic sub-provinces portions of which are found within the M-KMA. In the greater M-KMA ecosystem (i.e., the study area for this assessment) there are seven physiographic provinces and fourteen sub-provinces.

Each physiographic unit has a unique physical landscape. For example, the Muskwa Ranges sub-province falls within the Rocky Mountains physiographic province. The Muskwa Ranges extend northward from the Peace River to the Liard River. The western edge is bounded by the Rocky Mountain Trench with an eastward width of between 32 km in the south and 112 km in the north. Those summits having the highest elevations in the northern part of this sub-province are comprised of thick limestone bedrock, whose resistance to erosion gives these mountains their rocky and rugged character. Mt. Churchill is the highest peak at 3,200 meters. This sub-province's valleys are markedly long and wide and are a distinguishing land form in the Ranges. (For a summary description of each physiographic unit in the study area, see Appendix 3). Map 2 outlines the seven physiographic provinces within the greater M-K study area.

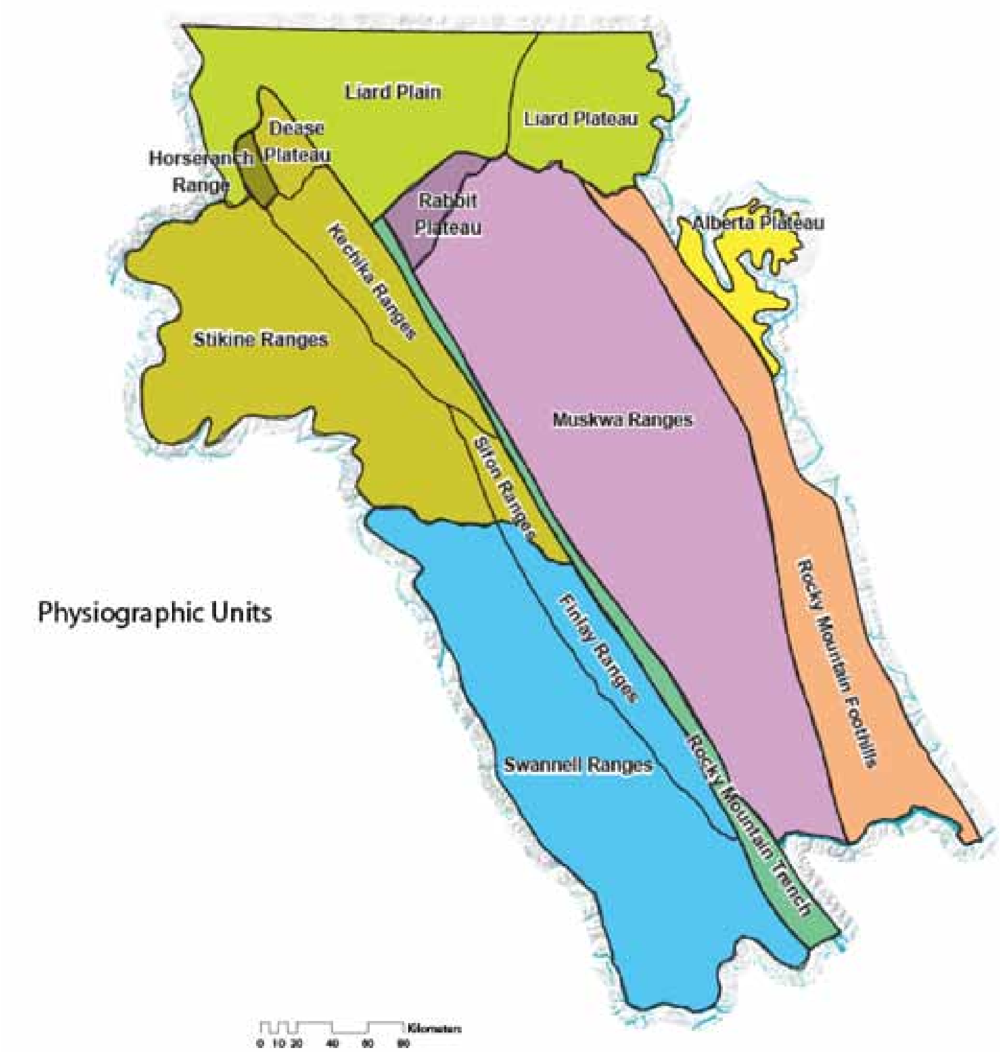
6 The Rocky Mountain Trench, Rocky Mountain and Rocky Mountain Foothill physiographic provinces extend well south of the M-KMA region into southern BC and Alberta. For practical purposes, the study area boundary was set where these provinces meet the Peace River.

MAP 2
Physiographic Units of the Study Area



Map 3 shows more detail than Map 2, with the combined fourteen physiographic provinces and sub-provinces in the study area.

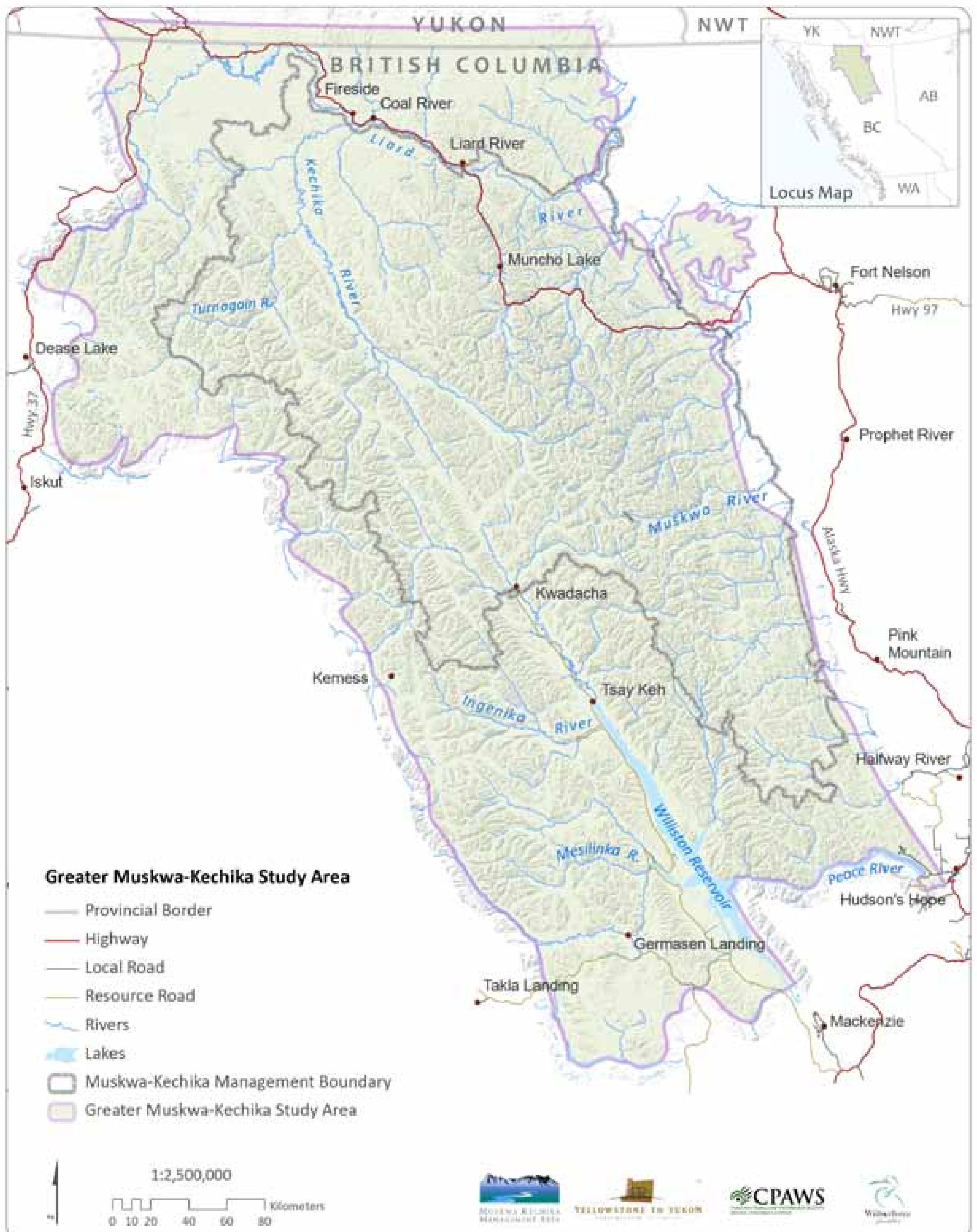
MAP 3
Physiographic Provinces, Sub-provinces and Subdivisions in the Study Area



Map 3 shows all the physiographic units that we used for mapping the enduring features and identifying areas with high conservation values as well as areas with gaps in existing protection.

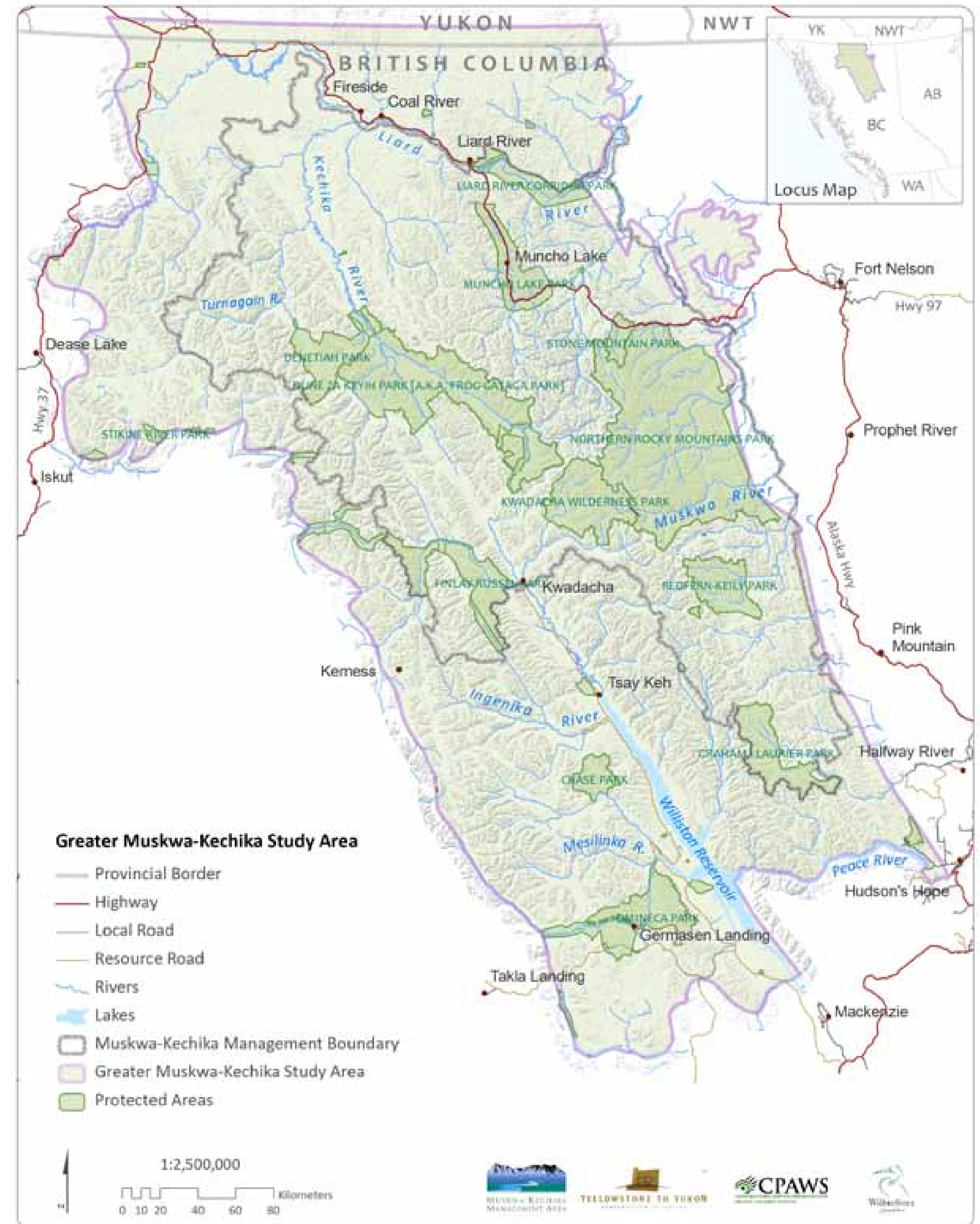
The final study area boundary derived from this process, the outer purple line on Map 4, is shown in relation to the M-KMA boundary, mapped as the dark grey interior line.

MAP 4
Study Area Boundary, Showing M-KMA Boundary



Map 5 shows the study area in relation to the network of existing protected areas in the M-KMA and adjacent lands. In January, 2012, The Kaska Nation and the BC Government agreed to a new protected area in the Horseranch Range, northeast of Dease Lake.

MAP 5
Greater Muskwa-Kechika Study Area with Protected Areas



II. Enduring Features Assessment for the Greater M-KMA Ecosystem

The rich variety of life in the greater M-KMA ecosystem is shaped in large part by the variety of the physical landscape. The physical landscape includes topography (elevation, slope, and aspect), bedrock and surface geology, macro landforms, and major aquatic elements—collectively called "enduring features". It is the template upon which Earth's living skin develops, and upon which organisms grow, diversify and combine, creating different ecosystems.

Because of the complex dynamics between multiple species and their habitats and the different ways they may be affected by changes in temperature and precipitation, it is not possible to predict how ecosystems with their many species of plants, mammals, birds, fish, and insects may pull apart or reassemble as a consequence of something as big and rapid as climate change. Yet, if one or two plant species are vital food sources for certain mammals, and climate change alters the abundance of this food, we can project a cascading effect not only on those mammals but throughout the entire ecosystem, affecting its composition, structure and function.

Regardless of how species and ecosystems may change as a result of climate disruption, all species and all future ecosystems will continue to need a physical landscape on which to live. The more diverse a physical landscape is today (e.g., having high and low elevations, wet and dry sites, and both north-facing and south-facing aspects) the more biodiversity is likely to be found there in the future.[7] In order to support future biodiversity, including a full suite of focal wildlife species in the greater M-KMA, one precautionary strategy is protect the variety of enduring features, and maintain connectivity between areas of suitable wildlife habitat today and in the future. (See Appendix 1 for a more detailed rationale for the enduring features approach to biodiversity conservation planning.)

1. Enduring Features Model for the Greater M-K Ecosystem

The enduring features map (Map 6) illustrates the remarkable diversity and distribution of more than 1600 unique combinations of physical features across the greater M-KMA landscape. Why is this map useful for land management? Some of the combinations of these physical features are captured in existing protected areas, while others are located outside the network of conservation lands. Understanding where the concentrations of physical diversity (that presumably will continue to support relatively high biodiversity) are located is essential information, which underpins this assessment's recommendations and is the key to developing appropriate land use management in those areas.

7 For background on this proposition, see: Anderson MG, Ferree CE. (2010) *Conserving the Stage: Climate Change and the Geophysical Underpinnings of Species Diversity*. PLoS ONE 5(7): e11554. doi:10.1371/journal.pone.0011554

Sifton Ranges and the Finlay River in the M-KMA.

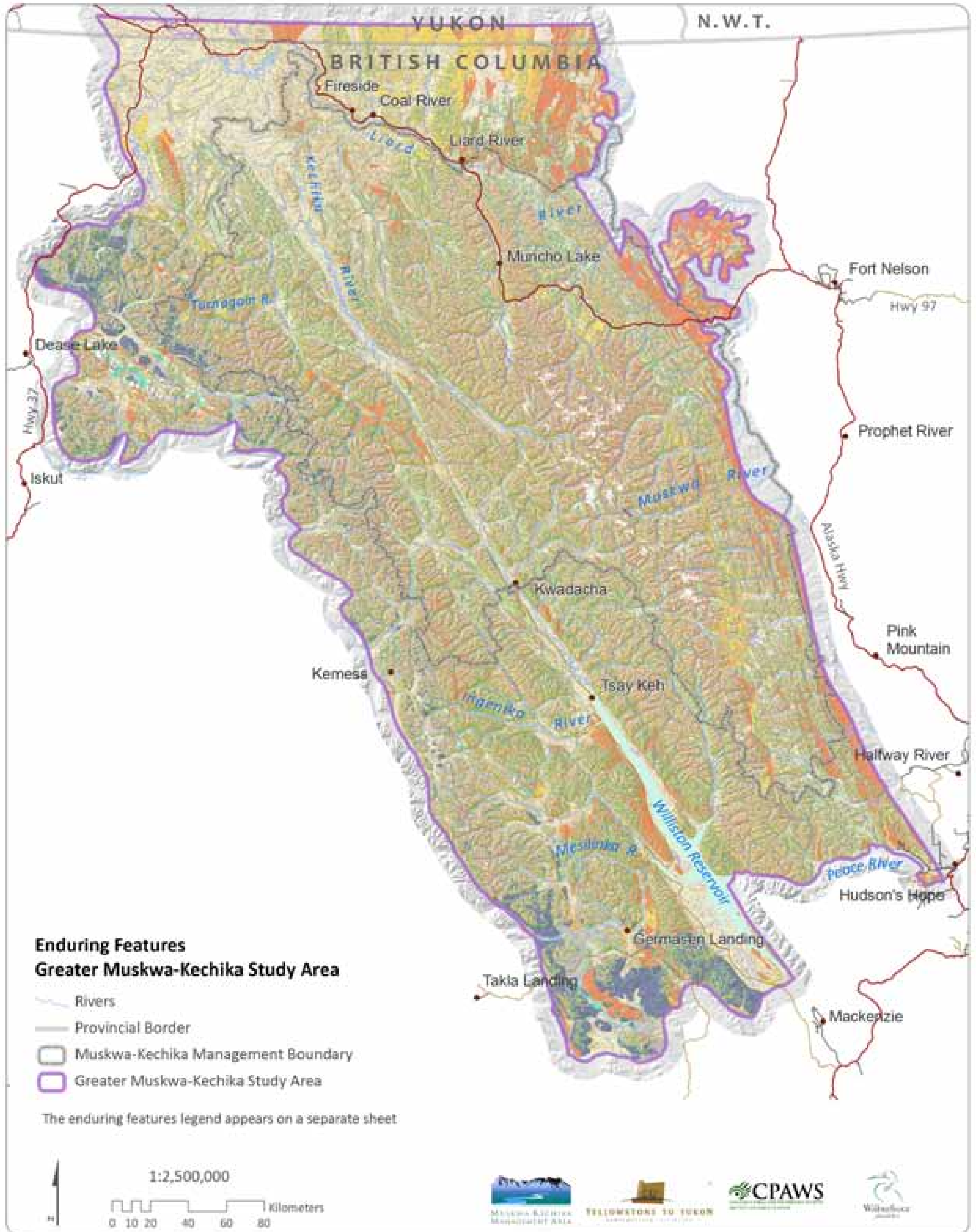
Johnny Mikes

Our methodology for modelling enduring features is based upon science and spatial modelling methods developed and applied by the Nature Conservancy (US).[8] The colours on the map represent the different enduring features mapped at a resolution of 90 X 90m squares on the ground. Each 90m cell contains a unique physical signature composed of elevation, substrate (bedrock and quaternary geology) and macro land forms (slope, aspect).

Refer to the legend (Table 1) for an insight into the diversity of enduring features characteristics, and see Map 7 for an example of what enduring features might look like in the Stone Mountain area.

8 Groves, Craig, L. Valutis, D. Vosick, B. Neely, K. Wheaton, J. Touval and B. Runnels. (2000) *Designing a Geography of Hope: A Practitioner's Handbook for Ecoregional Conservation Planning, Volume II*. The Nature Conservancy, pp. A6-1 to A6-4.

MAP 6 Enduring Features of the Greater M-K Ecosystem



(Note: Due to cartographic limitations, elevation is not displayed. See Map 7 to zoom in on an example enduring features map of the Stone Mountain area, southeast of Muncho Lake.)

TABLE 1 Enduring Features Map Legend

Enduring Features

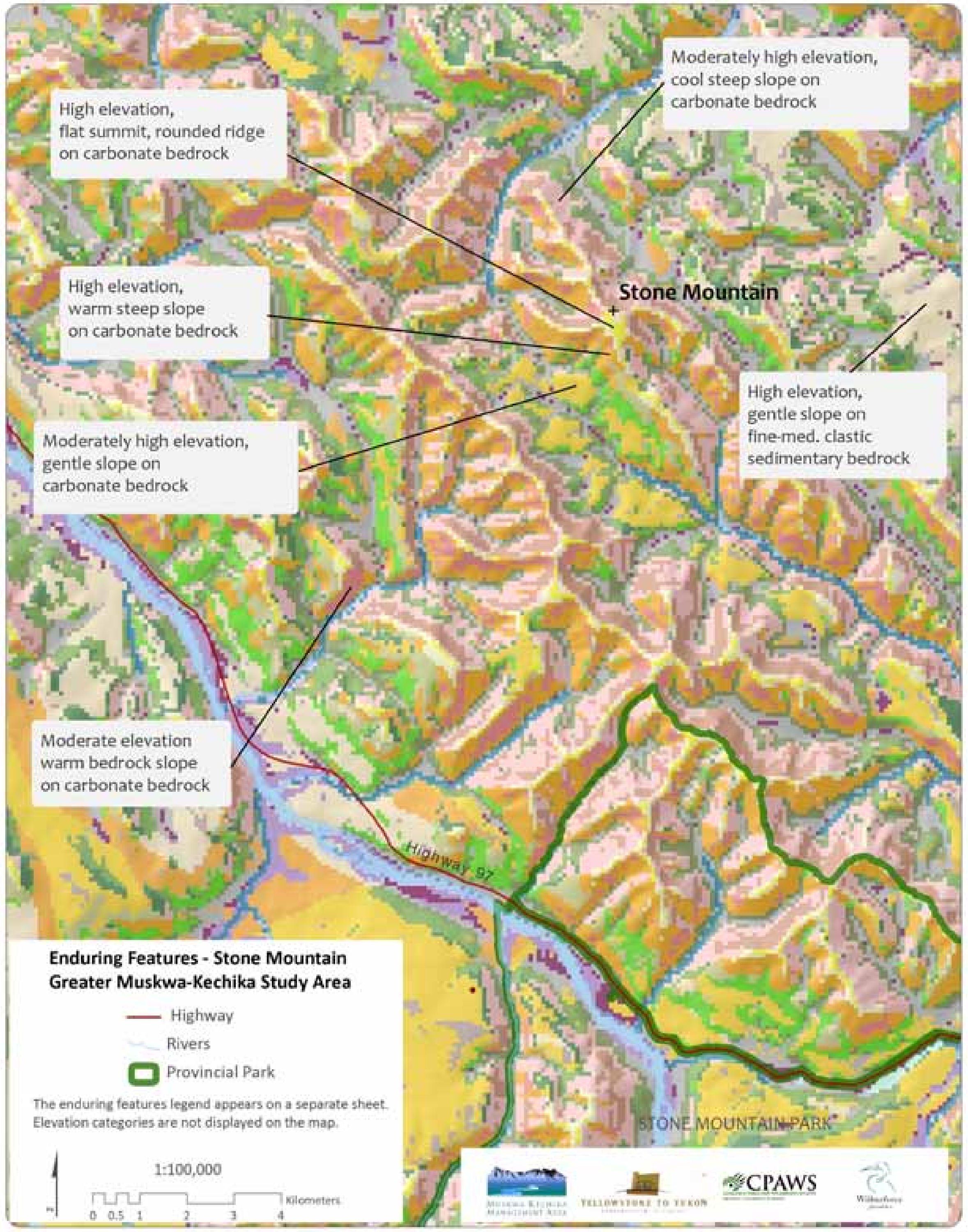
SIMPLIFIED DISPLAY LEGEND to MAP 1648 UNIQUE SIGNATURES

Primary Landform Influenced Combinations	Hydrography	Flats on Bedrock Influenced Combinations
4 - steep slope (cool)	50 - lake	122 - gntl slope, coarse clastic sedimentary rock
5 - steep slope (warm)	51 - river	131 - dry flat, coarse clastic sedimentary rock
6 - bedrock slope (cool)	52 - stream	222 - gntl slope, calcareous sedimentary (and metasedimentary)
7 - bedrock slope (warm)	53 - wetland	231 - dry flat, calcareous sedimentary (and metasedimentary)
8 - cliff (cool)	54 - glacier	322 - gntl slope, carbonate bedrock
9 - cliff (warm)		331 - dry flat, carbonate bedrock
11 - flat summit		422 - gntl slope, siliceous bedrock
12 - rounded ridge		431 - dry flat, siliceous bedrock
13 - crest		522 - gntl slope, fine-medium clastic sedimentary & metamorphic
21 - low hill top flat		531 - dry flat, fine-medium clastic sedimentary & metamorphic
22 - gentle slope on quaternary sediments		622 - gntl slope, soft volcanics
23 - upper sideslope (cool)		631 - dry flat, soft volcanics
24 - upper sideslope (warm)		722 - gntl slope, hard volcanics
31 - dry flat on quaternary sediment		731 - dry flat, hard volcanics
33 - mid sideslope (cool)		822 - gntl slope, granitics and similar crystalline bedrock
34 - mid sideslope (warm)		831 - dry flat, granitics and similar crystalline bedrock
41 - valley bottom flat		922 - gntl slope, ultramafic bedrock
42 - cove/toe slope		931 - dry flat, ultramafic bedrock
43 - lower sideslope		

Note: Elevation is not displayed due to cartographic constraints

This legend in Table 1 explains the colour coding used in Map 6, but refer to Map 7, a close-up of the Stone Mountain area, for an illustration of how each colour relates to specific enduring features on the land.

MAP 7 Enduring Features of the Stone Mountain Area



Box 1: How the enduring features map was produced

The study team constructed an enduring features model of the greater M-KMA landscape, and then completed an in-depth analysis and cataloguing of enduring features. First, the physical variety of the M-KMA was described and quantified. Three information themes are recognized by ecologists as primary influences for the types and distributions of ecological communities in the study area.

1) **Elevation** was grouped into nine classes to delineate altitude gradations in current ecological communities for each physiographic sub-province, for example the Rocky Mountain Foothills, Liard Plateau and Muskwa Ranges.

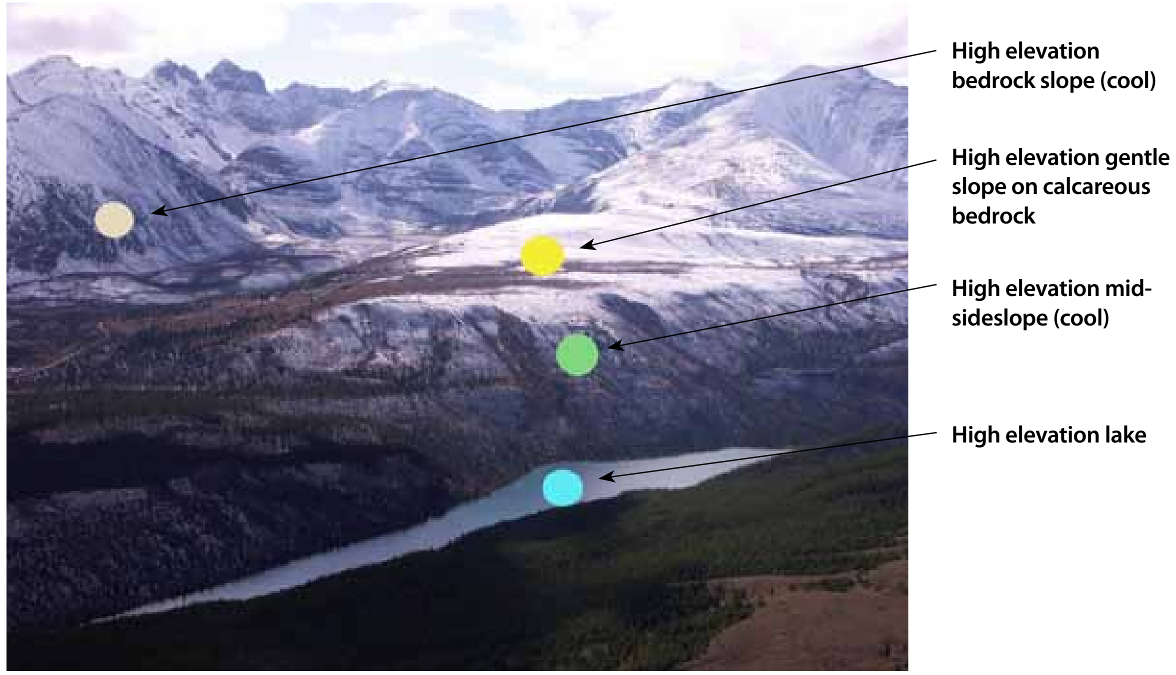
2) **Substrate Groups** (bedrock geology types and thick quaternary sedimentary geology deposits) were categorized into ten groups. The groupings recognize the role of both the chemical (e.g., mineralogical, pH) and physical (e.g., fine or coarse texture, and resistance to erosion) properties of bedrock in influencing ecosystem type and pattern. The ten groupings include: deep surficial glacial deposits; coarse clastic sedimentary bedrock; calcareous clastic sedimentary bedrock; carbonates; siliceous metamorphic; fine-medium grained clastic sedimentary/metamorphic; granitics and similar crystalline bedrock (batholiths, plutons, gneiss); soft volcanic; and hard volcanic or ultramafic.

3) **Macro land forms** characterize the land surface in an ecologically meaningful way, and are derived from a digital elevation model (DEM). Twenty-three macro land forms were defined by combining slope and land position and, when appropriate, specific land forms were further divided by aspect. Example macro land forms include rounded ridges, bedrock slopes (cool and warm), three side slopes (low, middle, and high), toe slopes, dry flats and valley bottoms. Glaciers, wet flats and major lakes, rivers and streams are also included.

The nine elevation groups, ten substrate groups, and twenty-three macro land forms were integrated, resulting in an enduring features model that locates 1648 unique combinations of enduring features with 90m by 90m polygons, classified into 5 categories according to variety and rarity. This high degree of physical diversity is represented on Map 6.

The visual complexity of the enduring features model makes it difficult to display completely and clearly on a single two-dimensional map (for example, the enduring features model map does not display elevation). The variety and rarity maps that follow in this section synthesize the data to help more clearly visualize, understand and analyze the physical landscape of the area.

9 Bostock, H.S. (1948) *Physiography of the Canadian cordillera, with special reference to the area north of the fifty-fifth parallel.* Geological Survey Memoir 247. Canada Department of Mines and Resources, Ottawa, ON. 106 p.
10 Holland, S.S. (1964) *Landforms of British Columbia: A physiographic outline.* Bulletin No. 48, British Columbia Department of Mines and Petroleum Resources, Victoria, B.C. 138p.



This photo in the Summit Lake area illustrates the variety of enduring features that are present in this typical landscape in the Muskwa Ranges sub-province. The colour of the dots matches the colours of the legend in Table 1 to show different types of enduring features based on slope and landforms. *Juri Peepre*

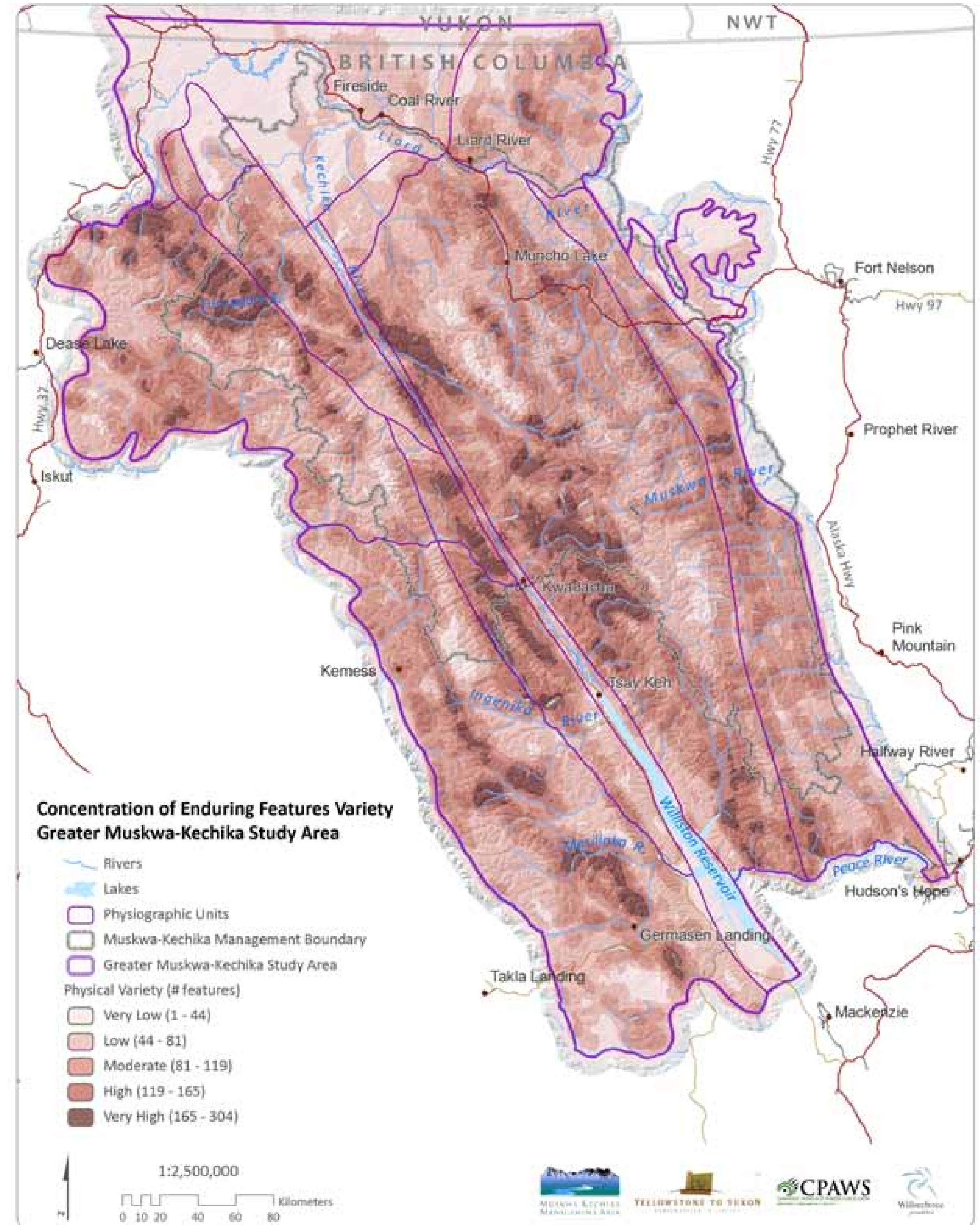
a. Enduring Features – Areas with Concentrations of High Variety

Each enduring feature has a unique combination of physical characteristics such as geology, elevation or land form —kind of like a bar code. Each combination is expressed in different growing conditions that define a different habitat and support species adapted to the local conditions. Therefore, places with a high variety of enduring features should also have high biodiversity. Understanding the locations of concentrations of physical diversity is essential information that underpins this assessment's recommendations and is a key to developing appropriate land use management approaches in those areas.

Map 8 shows concentrations of high enduring variety. The entire study area is mapped according to the classes of physical variety, from very low to very high. The areas with the darker red tones have the highest physical variety and should support inherently high biodiversity. These areas warrant special conservation attention.

The context for greatest "enduring variety" is the study area. For example, the Liard Plain has relatively low enduring features variety compared to most of the other physiographic units in the study area. Nonetheless, a precautionary approach would dictate protection of features within the Liard Plain to ensure that all physical characteristics are represented.

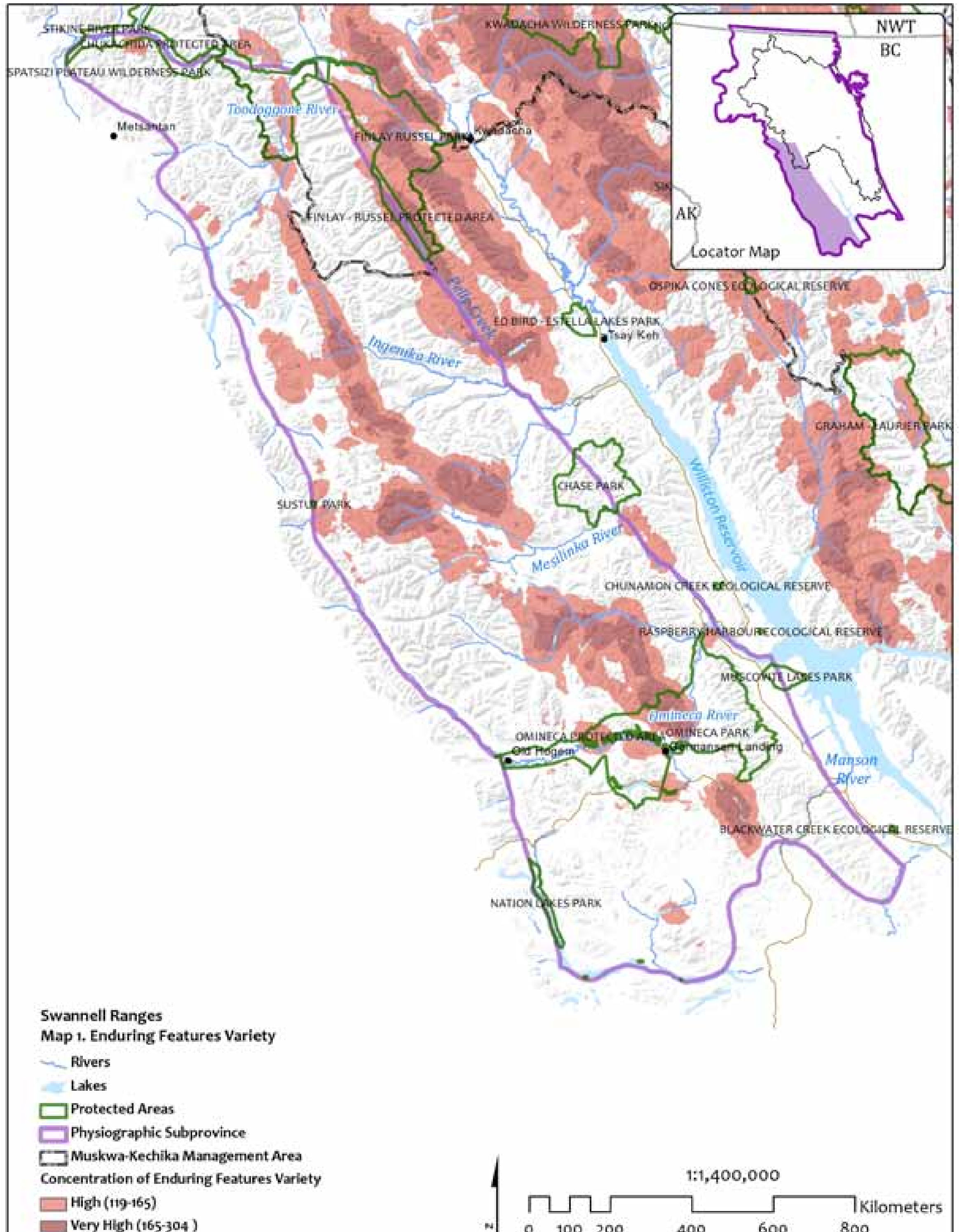
MAP 8 Concentration of Enduring Features Variety



Map 9 on page 34 zooms in on the southwest corner of the study area, in the Swannell Ranges (see the inset locator map). It shows the areas classified as having the two highest rankings (i.e., very high and high) of physical variety (shown in dark and light pink). Existing protected areas are outlined in dark green. Note the areas of high enduring feature variety in Omineca Park near the southern edge of the study area boundary, as well as to the north and south of the Park, and north towards the Mesilinka and

Ingenika Rivers. This shows how the park captures some of the high physical variety in the Swannell Ranges physiographic sub-province, but leaves many other areas of high variety unprotected. For detailed information on the extent of physical variety represented in protected areas in each of the physiographic sub-provinces, see Appendix 3, the Conservation Gap Analysis.

MAP 9 Concentrations of Enduring Features Variety in SW Part of Study Area



Box 2: How the enduring features variety map was produced

A computer-based spatial analysis determined where enduring features variety is concentrated. A focal analysis was performed by comparing each 90 metre by 90 metre data cell in the M-KMA study area with its surrounding neighbour cells across a 5000 metre radius. This search distance was the maximum allowed by the computer. The result was a new value for each 90 metre by 90 metre data cell representing the number of unique enduring features combinations. The values ranged from 1 to 448 and the mean was grouped into five classes using thresholds where large breaks exist in the range of data. The top two classes (173 to 249 and 250 to 448) were re-classed into two values (numbered 4 and 5) and named "High" and Very High". A new map was created: Concentration of Enduring Features Variety (Map 8).

b. Enduring Features – Areas with Concentrations of High Rarity

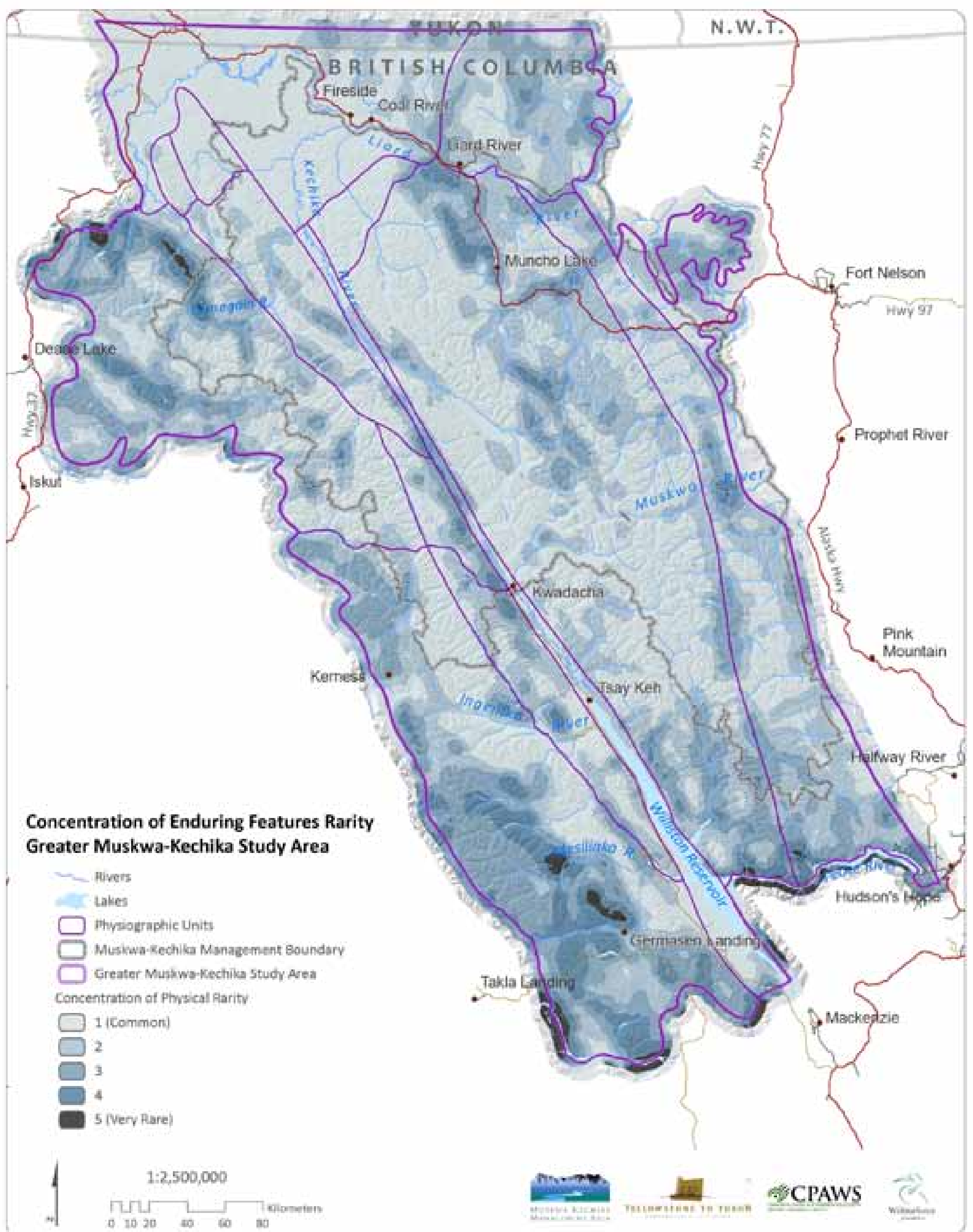
Also important is the location of rare enduring features—those unique combinations of elevation, substrate and macro landforms not common in the study area. These rare physical combinations can produce rare ecosystems or habitat for rare species, which in both cases could warrant special management consideration. For example, rare enduring features include certain types of uncommon bedrock formations (like types of volcanic rock known as ultramafic or serpentine rock), which in turn can provide unique habitat for uncommon plant species (like rare ferns).

This mineral lick is an enduring feature with a high rarity value.

Wayne Sawchuk

Map 10 shows in the darker grey colours concentrations of rare enduring features, i.e., those places classified as having the two highest rankings (i.e., extra rare and very rare) of physical rarity within the greater M-KMA. Some of the rare physical features in the greater M-KMA study areas are captured in the existing protected areas network, and other concentrations of high rarity lie outside protected areas. Note the areas with very high rarity values in the southwest and northwest parts of the ecosystem, outside the M-KMA, but within the greater ecosystem. Areas of high physical rarity outside existing protected areas may warrant special management attention, i.e., habitat and connectivity conservation to maintain the stage upon which the greatest diversity of species will be dissembling and reassembling.

MAP 10
Areas with Concentrations of Rare Enduring Features



Box 3: How the enduring features rarity maps were produced

The study area's 1648 unique combinations of enduring features were categorized from most common to most rare based on the cumulative percent area covered by each combination. The top rarity category is found within only 1% of the greater M-KMA area and was assigned a score of 5. The next rarity category is found within only 2% of the total area and was assigned a score of 4. The third rarity category covers 4% of the total area and was assigned a score of 3; the fourth category covers 8% of the total area, with a score of 2; and the final category of rarity, which covers 16% or more of the greater study area, was assigned a score of 1.

We identified the places with high concentrations of rare or unique combinations of enduring features. We calculated a rarity score for each 90 metre by 90 metre data cell based on the mean rarity of features in cells located within a circular search radius of 5000 metres. This was the maximum search distance allowed by the computer. The Concentrations of Enduring Features Rarity (Map 10) displays the mean focal rarity grouped by thresholds defined by natural breaks in the data.

c) Areas With Concentrations of Both High Enduring Feature Variety and Rarity

Map 11 combines the areas with concentrations of high enduring feature variety and rarity. Areas with overlapping high variety and rarity are shown in yellow, orange and red tones. These are distributed in four main areas of the greater MKMA ecosystem, and point to locations where we expect high physical diversity values and rare physical features to endure over time. These locations, several of which are outside the MKMA boundary, merit close attention for their biodiversity conservation values, both as potential future protected areas and as important connectivity habitat.

The key areas (numbered 1-4 on Map 11) with combined high variety and rarity, mostly outside existing protected areas, are:

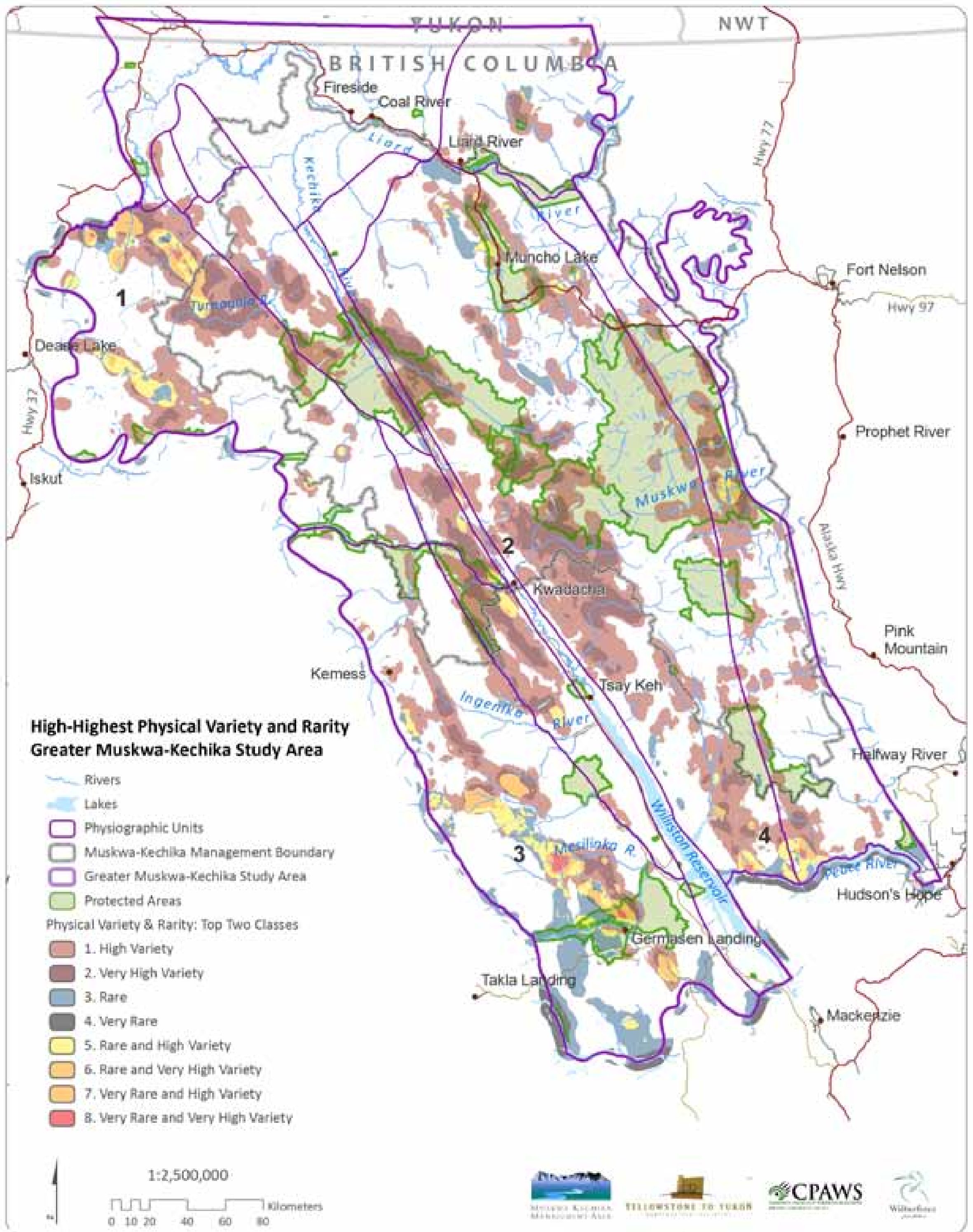
1. Stikine Ranges, East and Northeast of Dease Lake
There are two main areas of special interest, one east of Dease Lake, and the other northeast of Dease Lake and north of the Turnagain River. Both are outside or partially outside the MKMA boundary.

2. Finlay Ranges and Sifton Ranges, West of Kwadacha
Several nodes of combined high variety and rare features occur north of the Ingenika River, and immediately west of the Rocky Mountain Trench.

3. Swannell Ranges in Omineca Park Vicinity
A large concentration of high variety and rarity occurs to the northwest of Omineca Park in the Mesilinka and nearby watersheds.

4. Rocky Mountain Foothills and Muskwa Ranges
Two large concentrations of high variety and rarity occur at the southwest end of the study area, east of Williston Reservoir and north of the Peace River. Other smaller concentrations occur in the northern part of these ranges, for example just outside of Muncho Lake Provincial Park.

MAP 11
Areas with Overlapping High Enduring Feature Variety and Rarity

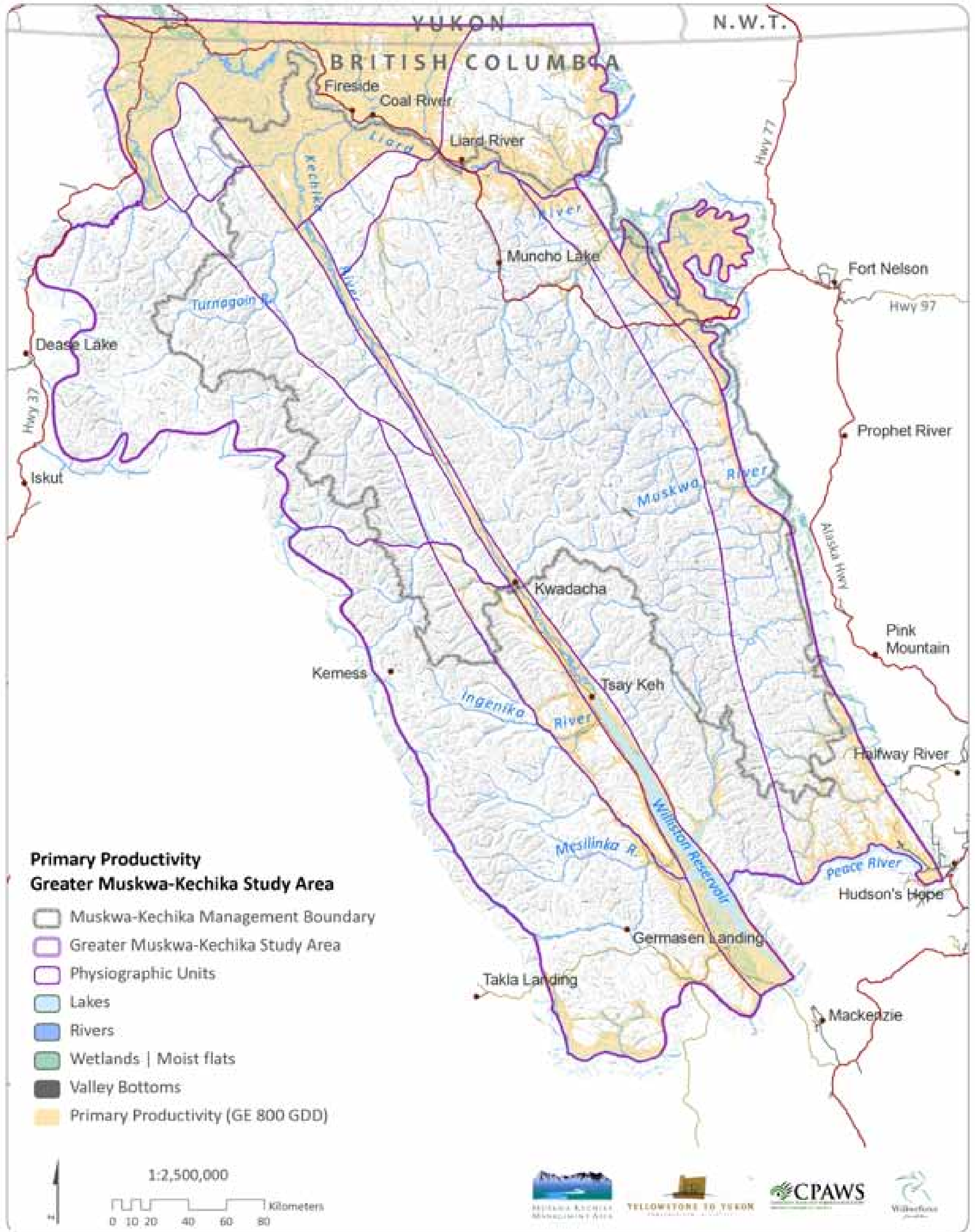


d. Enduring Features – Primary Productivity

Concentrations of physical variety based on enduring features depict many, but not all, of the inherent high biodiversity areas in the M-KMA study area. Also important in conservation planning is an understanding of areas of high biological productivity, for example wetlands, lakes and riparian areas, many of which support focal wildlife species. Areas such as large, low-elevation areas of gentle relief, supporting productive forest, dotted with myriad wetlands, drained by major streams and rivers must be important simply in terms of biomass, primary productivity and connectivity. This is especially significant in a largely mountainous, boreal region such as the M-KMA, and in terms of trans-boundary connectivity such as north from the M-KMA through the Liard Plain to the Mackenzie Mountains—the northern continuation of the Rockies. (For key connectivity corridors in the study area, see Maps 17-27.) These areas are often key wildlife habitat, sometimes are biological hotspots with an abundance and diversity of species, or serve as important wildlife connectivity corridors. Some areas of high primary productivity exist in large expanses of fairly uniform landscapes, and thus are missed by assessments identifying areas of high physical variety. To fill this gap, we identified those areas of high primary productivity in the study area (Map 12).

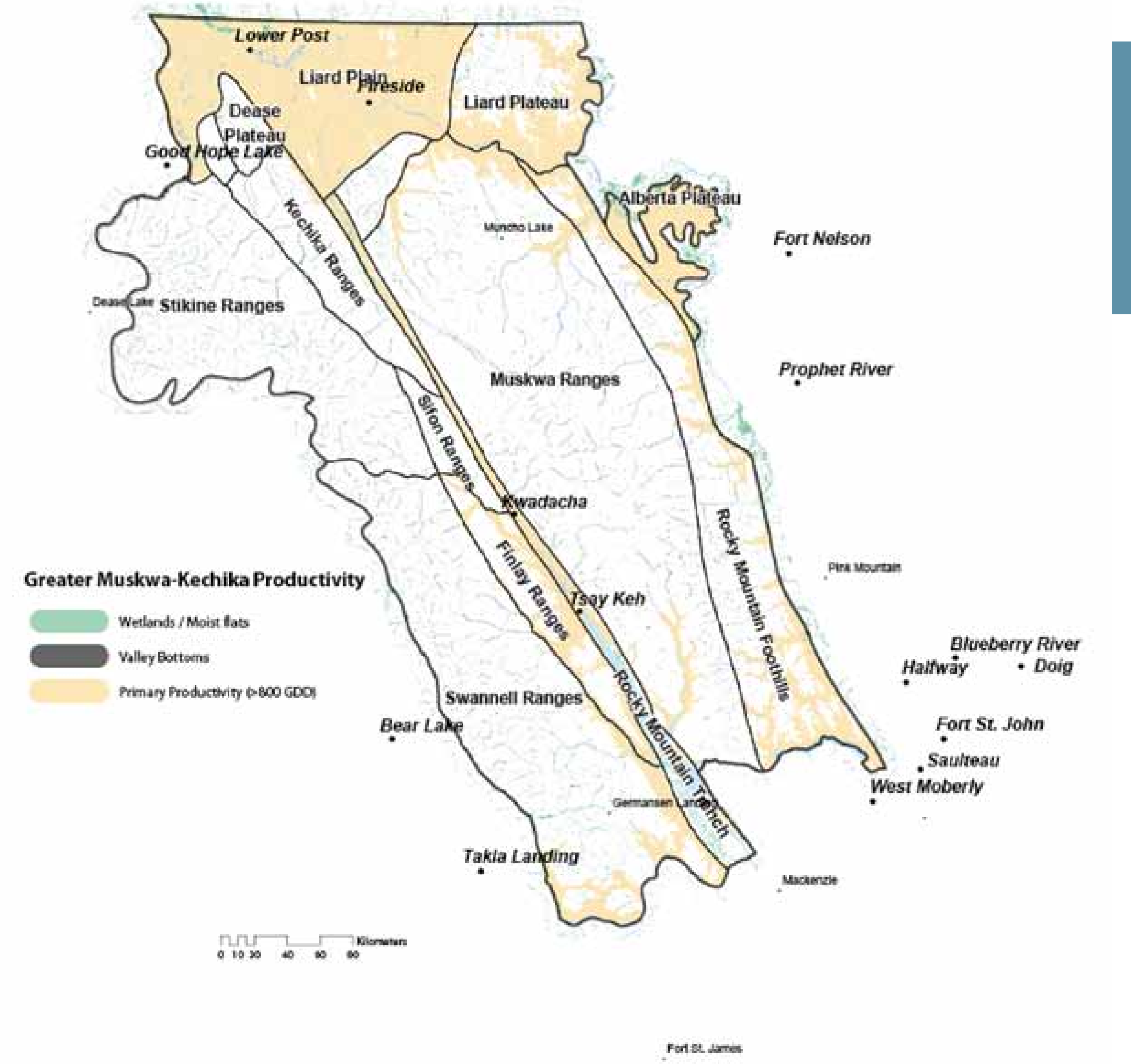
The Liard River valley bottom and riparian forests have high primary productivity. Juri Peepre

MAP 12
Areas of High Primary Productivity



Map 13 overlays the physiographic sub-provinces on the primary productivity map. The Liard Plain has high primary productivity but relatively low enduring variety compared to most of the other physiographic units in the study area. However on first principles of conservation (including representativeness) *all* major physiographic units or parts of the landscape that make up the greater Muskwa-Kechika system are ecologically important—not just those areas that have high physical variety or rarity.

MAP 13
Areas of High Primary Productivity by Physiographic Unit



Box 4: How the primary productivity map was produced

The primary productivity map is based on a compilation of wetlands greater than 5ha, large lakes, valley bottoms and areas having a high number of Growing Degree Days (GDD). GDD are an indicator of total heat available for plants in the growing season. Growing degrees are defined as the total number of degrees above a certain base temperature (below which plant growth is zero). Growing degrees each day are the average temperature for the day minus the base temperature. (For example, if the base temperature is 5°C and the day's average temperature is 10°C, that day had five growing degrees.) For GDD we used analytical data from the Pacific Climate Impacts Consortium, University of Victoria, 2009, which was based on data from recording stations accumulated between 1961 and 1990.

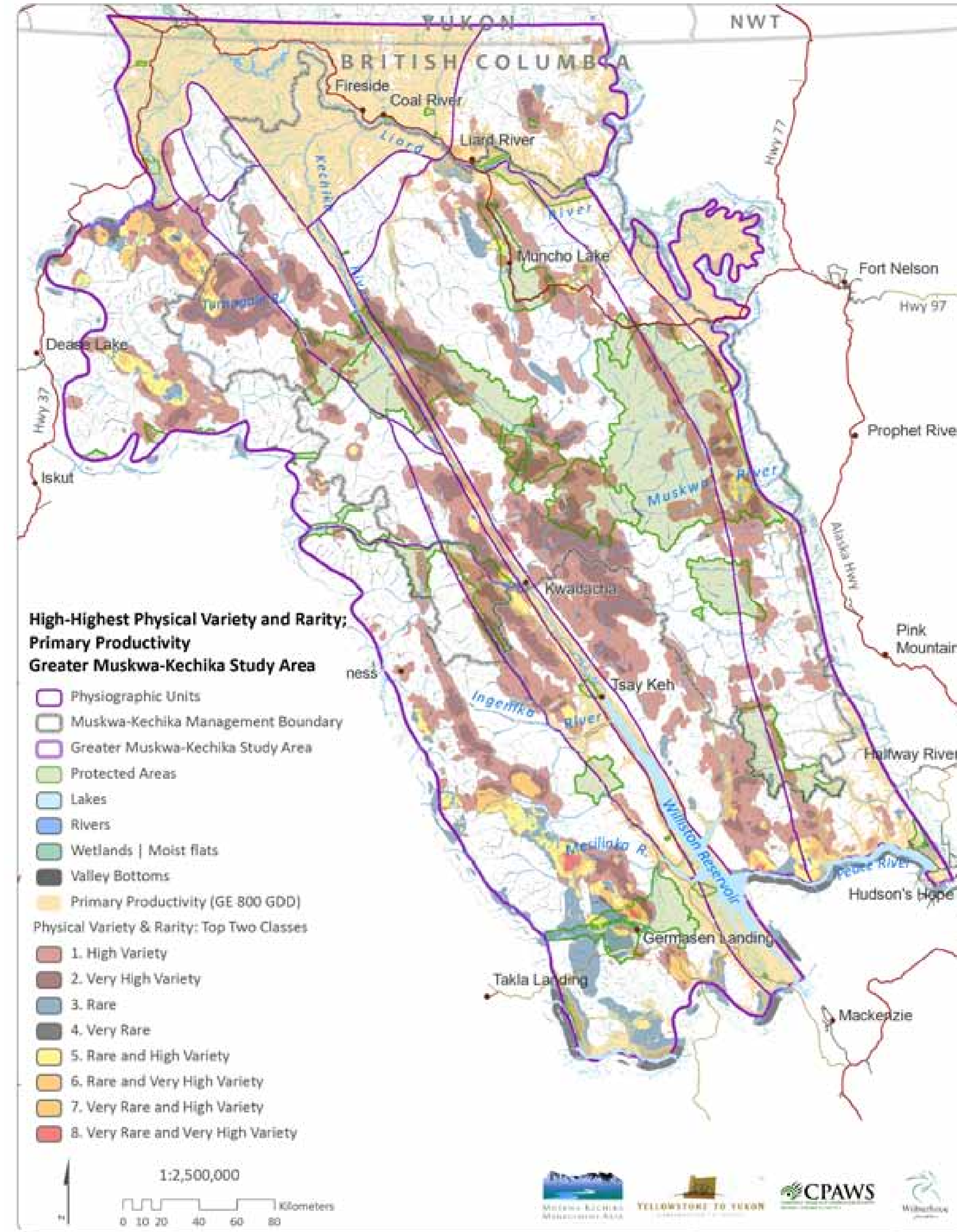
For this assessment, areas outside wetlands, riparian areas or valley bottoms with annual GDD above 800 were used as the basis for determining locations of high productivity. Although GDD are a reasonable proxy for primary productivity, the use of GDD is not completely reliable because of confounding factors. For example, Ft. Nelson has fairly high annual GDD (because of low elevation and long summer days) but much of the land in the area supports low productivity muskeg—because it's flat and poorly drained, thus peat-covered with cold wet soils underlain by permafrost in places. But on freely drained uplands and river terraces there is very productive boreal forest. A similar situation occurs around the northern part of the study area in the Liard Plain. The potential for relatively high primary productivity exists here but is often realized only in patches.

Most of the Muskwa-Kechika ecosystem is wilderness.

Wayne Sawchuk

Map 14 on page 43 shows the large areas of high primary productivity that occur mostly outside the existing protected areas network, for example in the Liard Plain, Liard Plateau, Alberta Plateau and parts of the Rocky Mountain Trench. The map also shows how the concentrations of combined high physical variety and rarity, in bright yellow, red, and orange, do not necessarily overlap with areas of high primary productivity, shown in dull yellow. This map draws attention to those areas outside the existing protected areas network that warrant further assessment and consideration for management and protection of biodiversity conservation values.

MAP 14
Areas With High Primary Productivity and Concentrations of High Enduring Feature Variety and Rarity



In January, 2012, the Kaska Nation and BC Government agreed to a new protected area in the Horseranch Range, northeast of Dease Lake. This significant new protected area will add to the representation of physical features protected in the Horseranch Range, Kechika Ranges, Stikine Ranges and Liard Plain.

III. Wilderness and Intact Ecosystems

... the Muskwa-Kechika Management Area is an area of unique wilderness in northeastern British Columbia that is endowed with a globally significant abundance and diversity of wildlife;

...and, the management intent for the Muskwa-Kechika Management Area is to maintain in perpetuity the wilderness quality, and the diversity and abundance of wildlife and the ecosystems on which it depends while allowing resource development and use in parts...

(from the Preamble of the Muskwa-Kechika Management Area Act)[11]

The Muskwa-Kechika Management Area Act states that *"the long-term maintenance of wilderness characteristics, wildlife and its habitat is critical to the social and cultural well-being of First Nations and other people in the area,"* and that *"the integration of management activities especially related to the planning, development and management of road accesses within the Muskwa-Kechika Management Area is central to achieving this intent and the long-term objective is to return lands to their natural state as development activities are completed."*

Amazay Lake and nearby alpine meadows display the wild beauty of the M-KMA region.

Johnny Mikes

11 Statutes of British Columbia, 1998, Chapter 38

Pursuant to the M-KMA Act, the Muskwa-Kechika Board has defined the terms "wilderness," "wilderness quality" and "wilderness characteristics." These clear definitions are intended to help manage land use activities in a manner that is consistent with the intention of the Muskwa-Kechika Management Area Act.

1. M-KMA Definitions of Wilderness, Wilderness Characteristics, and Wilderness Quality

These definitions and criteria are excerpts from the M-KMA Advisory Board approved Wilderness Definition, 2004: [12]

Wilderness Definition

Wilderness consists of two inter-related concepts,

I) an ecological system maintaining its ecological integrity, based on best scientific analysis, and
II) a large area perceived by humans to be natural or wild, based on anthropocentric criteria.
III) The terms "ecological system" "ecological integrity," "large area" "perceived by humans" "natural" and "wild" must be defined in order to ensure that this definition of wilderness is precise.

Wilderness Characteristics

Wilderness Characteristics are those elements that comprise Wilderness. If Wilderness is a large area perceived by humans as natural or wild, with an ecological system maintaining its ecological integrity, then Wilderness Characteristics include the following:

- an area greater than 5000 ha. that is perceived to be unaffected by humans, and is within the range of natural variation, where the landscape is perceived to be wild, or in a state similar to that which existed prior to European settlement, and where there is a high probability of encountering human solitude,
- a landscape where evidence of post-European-contact human activity including road access or linear corridors, industrial facilities or other infrastructure, lights, sounds, or smells, is not apparent to a neutral observer, and
- an ecosystem in a state or condition where the structures and functions of the system are unimpaired by human-caused disturbances, and where native species are present at population levels within the range of natural variation, with their processes (such as growth, evolution, and reproduction) intact.

Wilderness Quality

"Wilderness quality" is a measure of the degree to which the ecosystem and landscape retain "wilderness characteristics." It is the responsibility of the proponents of activities that would affect or alter the wilderness characteristics to measure wilderness quality on both a project-by-project and a cumulative basis.

12 Muskwa-Kechika Advisory Board, *An Operational Wilderness Definition for the M-KMA*, February 29, 2004, http://www.muskwa-kechika.com/pdf/m-kab_wilderness_definition.pdf, accessed June 17, 2011

2. Why Wilderness Matters in This Conservation Assessment

From the biodiversity conservation perspective, one of the most important attributes of the M-KMA area is its wilderness —it's naturalness or intactness. For the most part, it is a landscape substantially unaffected by human activity and for that reason it stands apart from much of the southern two-thirds of BC, and large parts of northeast BC. Most of study area has little "human footprint".

During the BC Protected Areas Strategy work of the early 1990s, the Prince Rupert Regional Protected Areas Team (RPAT) defined naturalness as "the extent to which the area is unaffected by human development or disturbance". Naturalness was a key consideration for recommending protected areas. For example, the RPAT process did not accept areas with a disturbance "greater than 25%" for consideration.

Naturalness is important to the conservation of biodiversity in many ways. Less developed/more natural areas:

- tend to maintain stronger wildlife populations,
- better support natural ecosystems and processes,
- optimize Nature's ability to be resilient and adaptable to climate change,
- are valuable to recreation in terms of wilderness feel and scenic quality,
- are less fragmented and are better able to connect various habitats and watersheds.

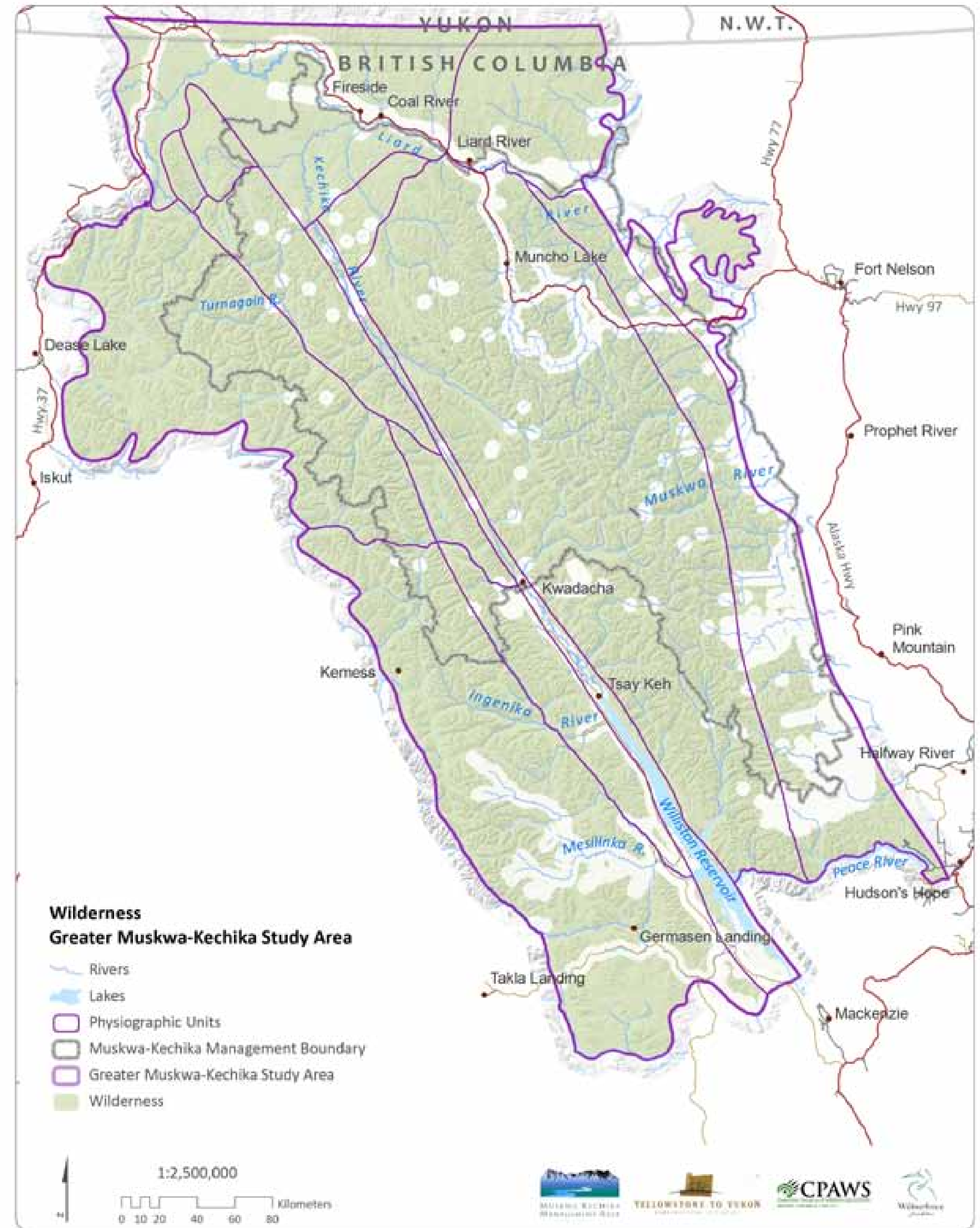
For these reasons, the conservation of wilderness in the M-KMA complements and supports the enduring features representation and wildlife connectivity goals assessed in this study. Wilderness areas serve as benchmarks of intact ecosystems, and they are natural reservoirs of biodiversity. Within the greater M-KMA ecosystem, and within the Yellowstone to Yukon Conservation Initiative context, wilderness has an important role to play in meeting conservation goals, in serving as climate change sanctuaries, and as control areas in monitoring the impacts of land use and climate change.

3. Interpreting the Wilderness Map

The wilderness maps prepared for this assessment (Map 15 &16) show that the core of the greater M-KMA ecosystem is still substantially intact, with the most disturbance resulting from the Alaska Highway and related access roads, the Williston Reservoir and Mesilinka River areas. The white buffered corridors and small circles on Maps 15 and 16 depict the existing disturbed areas. The scattered small circles, or point sources of human influence, may include resource exploration sites, mines, and lodge-based tourism sites. Since 2004, the last time this type of mapping exercise was conducted,[13] there has been little change in overall human influence in the Muskwa-Kechika study area. The most significant new disturbance is seen in the southwest of the greater Muskwa-Kechika study area, mostly related to forest harvest activities. However, current proposals for roads, resource exploration or wind energy production, if approved, would change the extent and configuration of wilderness within the M-KMA.

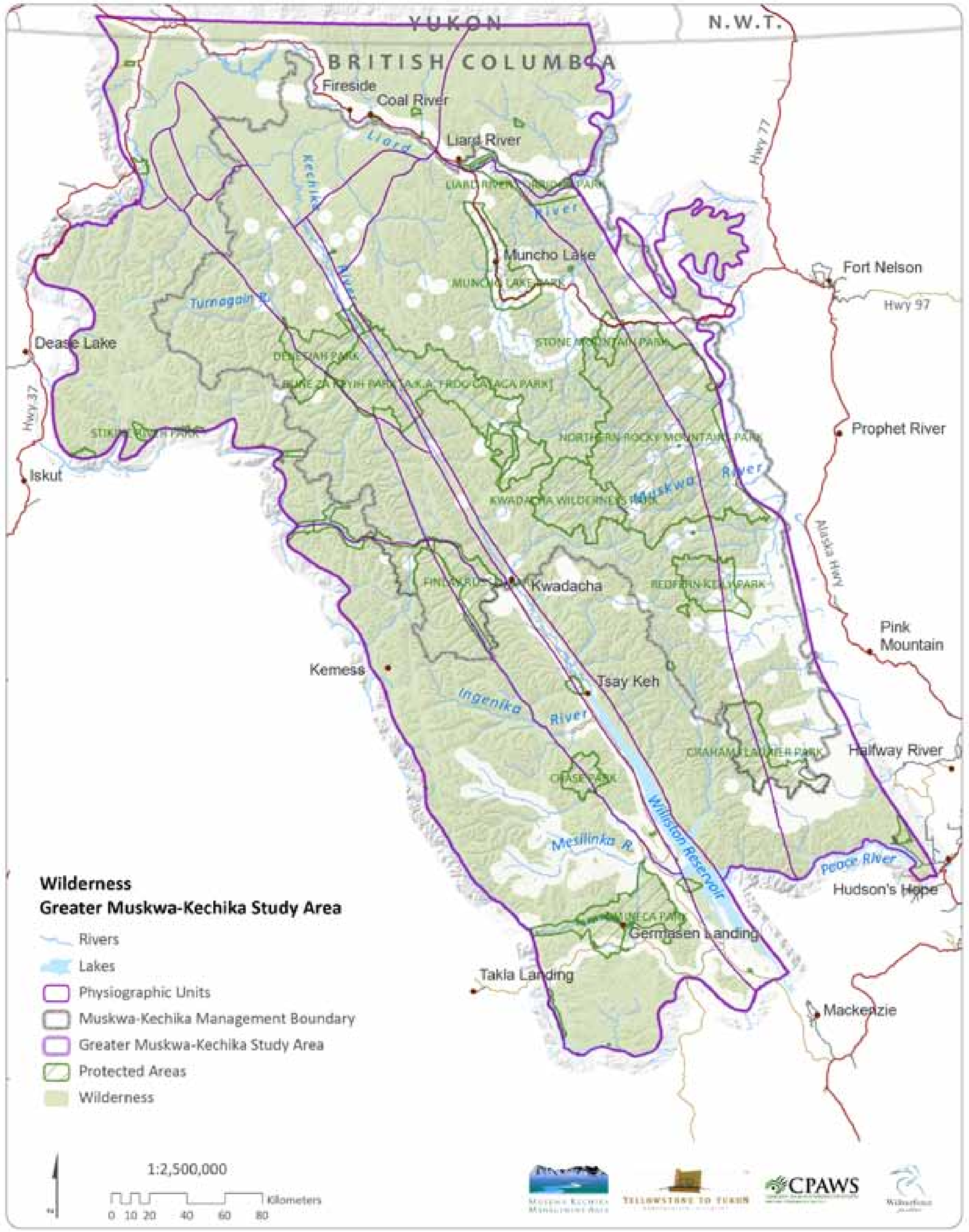
Map 16 shows where existing protected areas conserve wilderness in the greater M-KM ecosystem.

13 Heinemeyer, K., et al. (2004) *Conservation Area Design for the Muskwa-Kechika Management Area (MKMA).*



MAP 15
Wilderness in the Greater M-KMA Study Area

MAP 16 Wilderness and Existing Protected Areas



In January, 2012, the Kaska Nation and BC Government agreed to a new protected area in the Horseranch Range, northeast of Dease Lake. This significant protected area is located in existing intact wilderness, covering the entire Horseranch Range physiographic unit.

Box 5: How the wilderness map was produced

For the purposes of this assessment, we relied on data from Wildlife Infometrics, which evaluated the potential effects on caribou of wind power generation in the M-KMA region. They selected the following categories of features from three data sets (TRIM, Tantalis, and OGC): buildings, energy/transmission corridors; industrial areas; harvesting areas; transportation features (including airports, bridges, embankment/fill, and select roadways). These data were reviewed, selectively edited, and buffered by 3.83km. (While a specific rationale for the size of this buffer was not documented in the Wildlife Infometrics methods, the extent of the buffer is consistent with other studies measuring disturbance effects from linear features such as roads.)

These data were collected and updated using provincial transportation data and satellite images. The majority of new disturbances were related to harvesting forests attacked by the mountain pine beetle, new roads and power corridors. The Wildlife Infometrics method was applied to these updated data, and combined to create a single data set. As the Wildlife Infometrics data covered the 2004 Conservation Area Design study area only, parts of the greater M-KMA study area were omitted from the wilderness analysis, especially to the southwest.

The wild rivers of the greater Muskwa-Kechika ecosystem are highly valued for conservation and recreation. *Wayne Sawchuk*

IV. Wildlife and Connectivity

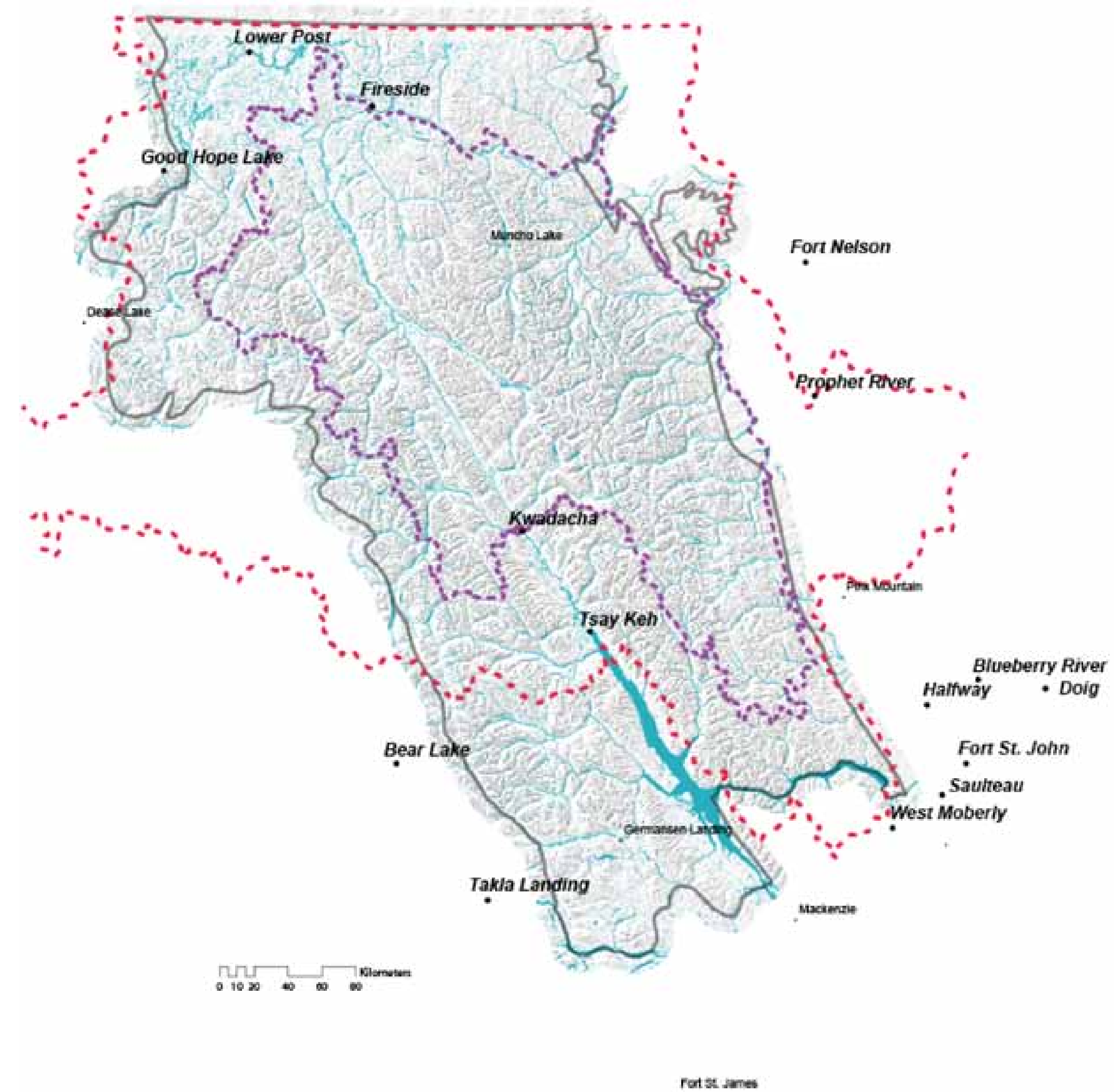
Maintaining biodiversity and healthy wildlife populations depends on the existence not just of core habitats but also on the connectivity among them. Connectivity contributes in many ways, including: maintaining healthy genetic exchange; helping sustain predator-prey systems; enabling seasonal and longer term migration, and even allowing movement of wildlife from less accessible, less hunted areas into those more used by hunters.

The wildlife connectivity maps in this report (Maps 17 through 23) are based on the summer growing season habitat suitability data for four focal species, as defined in the *Conservation Area Design for the M-KMA* (2004) (see footnote 13; hereafter 2004 CAD). Habitat suitability for each focal species defines the importance of each wildlife linkage between available high quality habitat areas. Habitat suitability was modelled on the basis of available landscape data, which in this case is circa 2004. Use of these data, while perhaps somewhat dated, was determined to be best available based on a survey of available focal species habitat models. We determined that none of the other data sets covered the same areal extent or range of focal species as that of the CAD habitat suitability data.

Moose feed in a wetland in the M-KMA. See the moose connectivity pattern on Map 26.

Wayne Sawchuk

Map 17 shows the area with available wildlife habitat suitability data from the 2004 CAD, indicated by the red dotted line. As noted above, the 2004 CAD study area boundary and the study area for this report (coloured grey in Map 17) are different. Map 17 illustrates why this meant that wildlife connectivity modelling was not possible for the SW corner of the study area, since habitat suitability data were not available. The purple dotted line outlines the M-KMA boundary.



MAP 17 Data Source For Wildlife Connectivity Maps: 2004 CAD (red dotted line)

The four focal species used by this report's authors for assessing wildlife connectivity are mountain goat, Stone's sheep, caribou, and moose. We selected these four focal species, based on the availability of consistent and validated habitat suitability maps and the interests of local stakeholders. The study team recognizes the importance of carnivores as focal species, but the available resources for this project limited the number of species for which we were able to model connectivity. For example, the available habitat suitability model for grizzly bears was based on conditions further to the south, in Yellowstone National Park. Without local validation, this data may not have been suitable for use in the connectivity mapping. Furthermore, since grizzly bears are habitat generalists, connectivity mapping for this species may not have been as instructive as that of the ungulates we chose to map.

On the maps that follow, the black lines show the shortest or "easiest" distance between areas of highest habitat suitability for that species. The darker the line, the higher the quality of the habitat.. The red colour highlights concentrations of connectivity for multiple species through high suitability habitat. The darker the red, the more important is the area as a hub for wildlife habitat linkages. These are habitat suitability "hotspots".

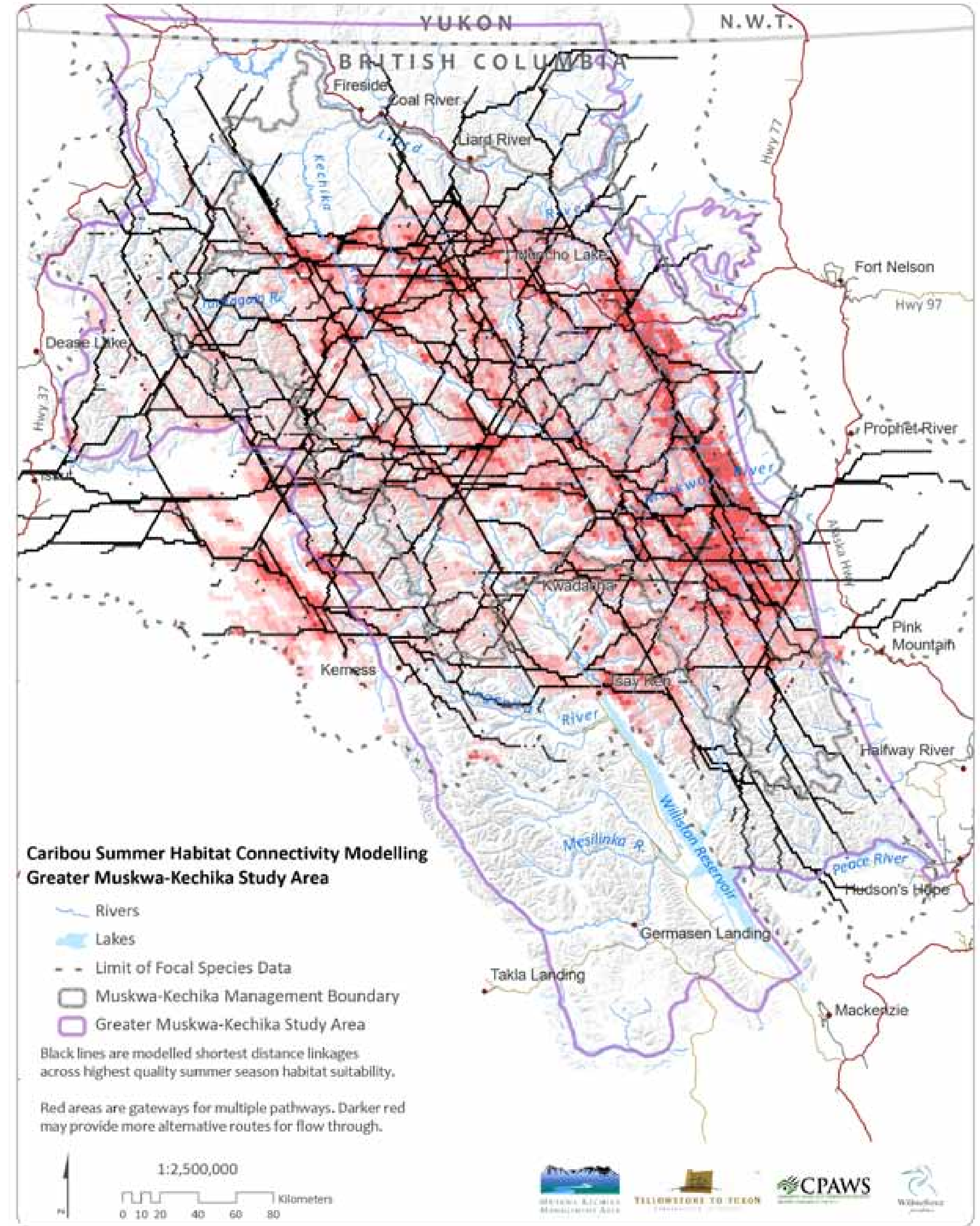
In a future where the climate has changed, species will likely persist wherever today's habitat (or something suitably similar) is still present in the future. We can also expect that species will persist wherever future habitat is within dispersal distance of current habitat. Species will face greater challenges where connectivity habitat that is used today is not available in the future and routes to future habitat are blocked.

In the M-KMA alpine habitats are projected to decline by 2050, especially in the Rocky Mountain Foothills, which will affect caribou, sheep and goats. The Rocky Mountain Trench is also an area of projected high ecological upheaval, so it will be important both to maintain north-south connectivity and to avoid development that could adversely affect wildlife movements along this productive valley corridor. See additional notes on wildlife and climate change in Appendix 2.

Woodland caribou on the move near Muncho Lake in the M-KMA.

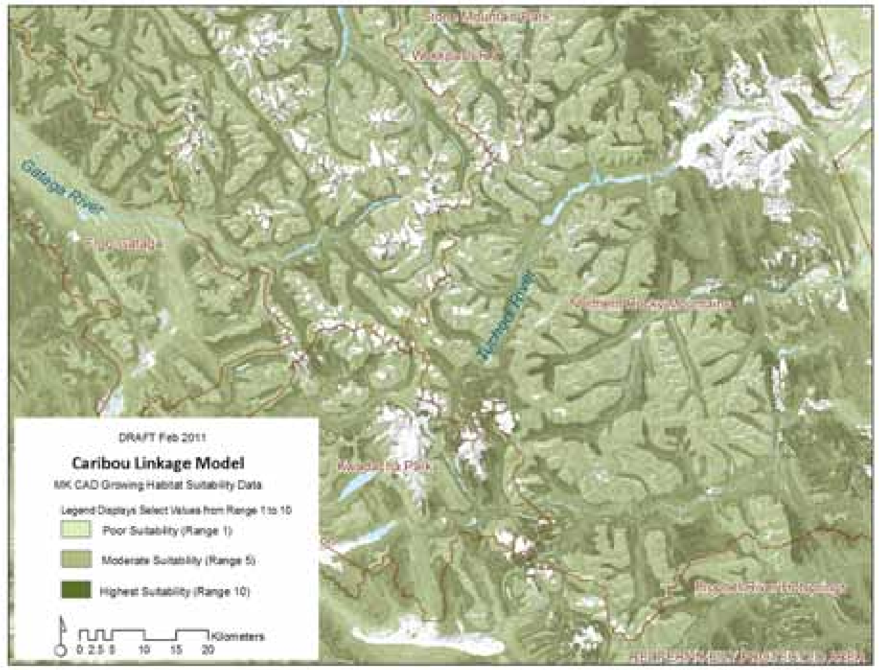
Juri Peepre

MAP 18
Caribou Summer Habitat Connectivity Model



The sample wildlife connectivity map for caribou in the Tuchodi and Gataga River areas, (Map 20 below), is based on growing season habitat suitability mapping from the 2004 CAD, (Map 19). The darkest green tones on Map 19 indicate highest habitat suitability for caribou during the growing season. The connectivity map for each focal species was based on habitat suitability data for that species. In comparison to caribou, sheep and goat habitat is more local with less seasonal variation likely.

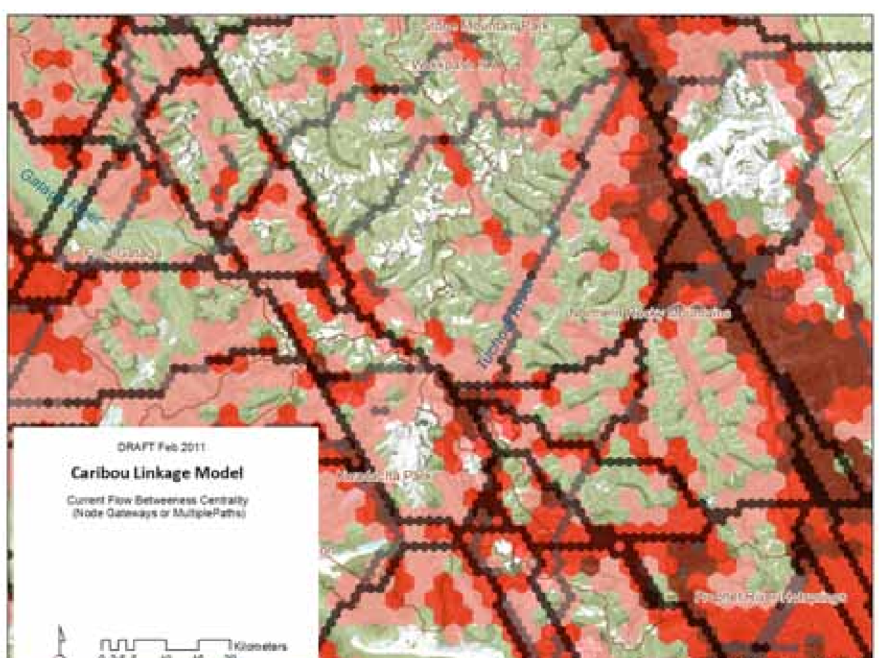
MAP 19
Growing season caribou habitat suitability map for the Tuchodi and Gataga River areas



Note: The habitat suitability data and map are adapted from the Muskwa-Kechika Conservation Design (CAD), 2004

The black lines in this sample connectivity model in the Tuchodi and Gataga River areas (Map 20) indicate key wildlife pathways. Red areas show wildlife gateways or nodes of high activity for caribou in the same area as the above habitat suitability map (Map 19).

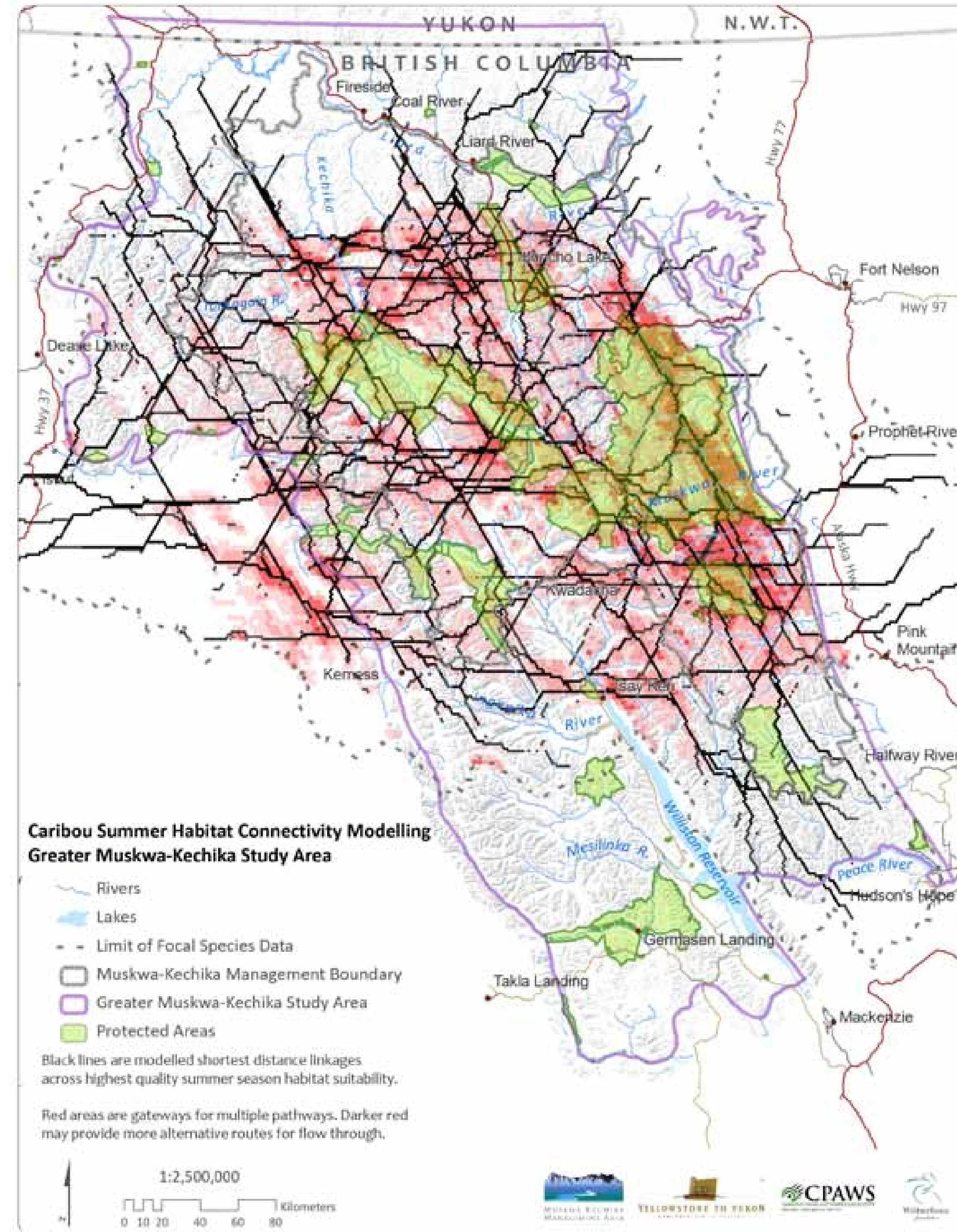
MAP 20
Wildlife linkage model for caribou in the Tuchodi and Gataga River areas



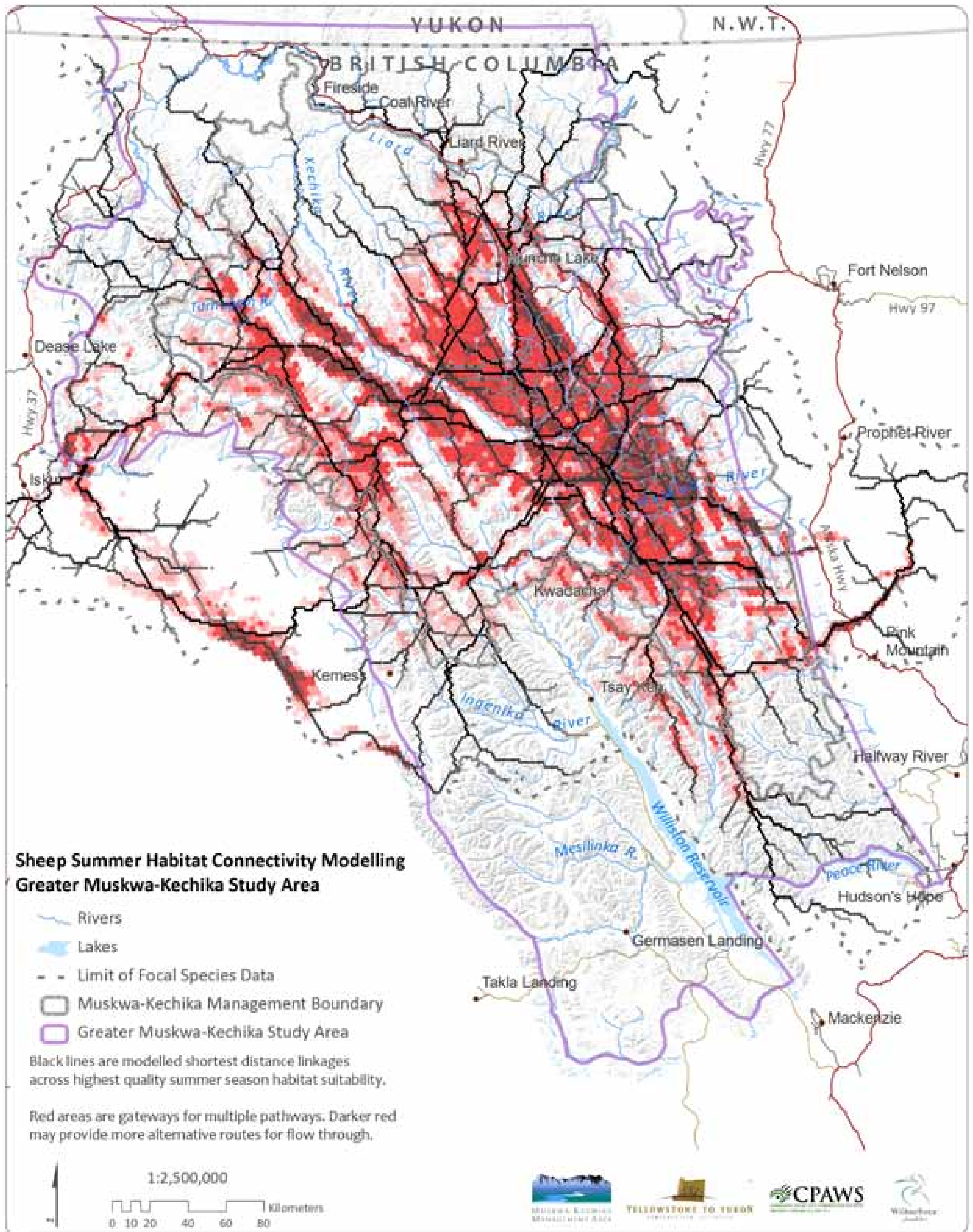
For three of the focal species connectivity maps, we overlaid the network of protected areas in the study area (e.g., Map 21 below). This information may help managers and policy-makers who wish to ensure that connectivity throughout the area is preserved.

Please refer to Map 29 to see the caribou connectivity map overlaid with radio telemetry data that show a possible validation method for the wildlife connectivity modelling.

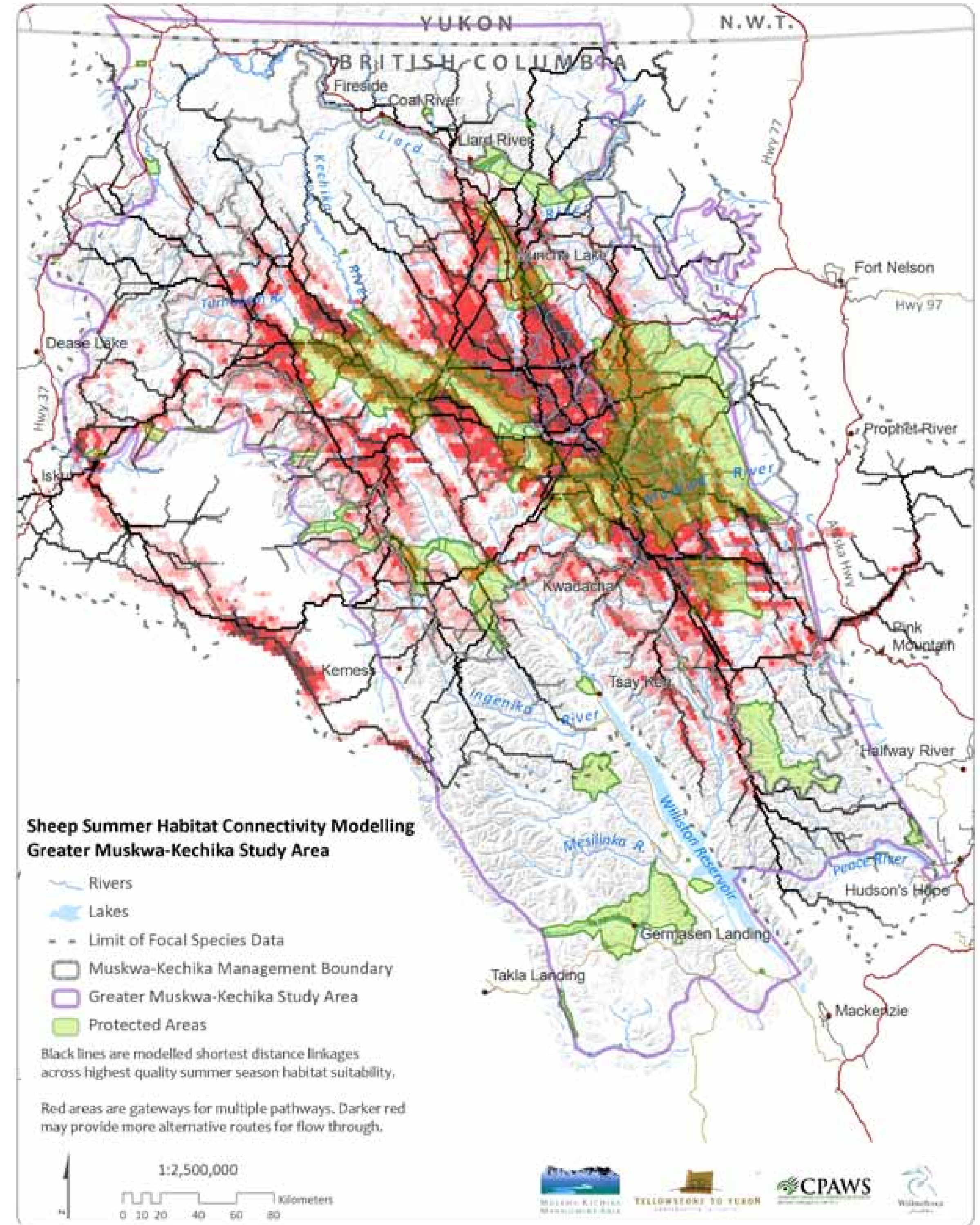
MAP 21
Caribou Connectivity Model with Existing Protected Areas



MAP 22
Stone's Sheep Summer Habitat Connectivity Model

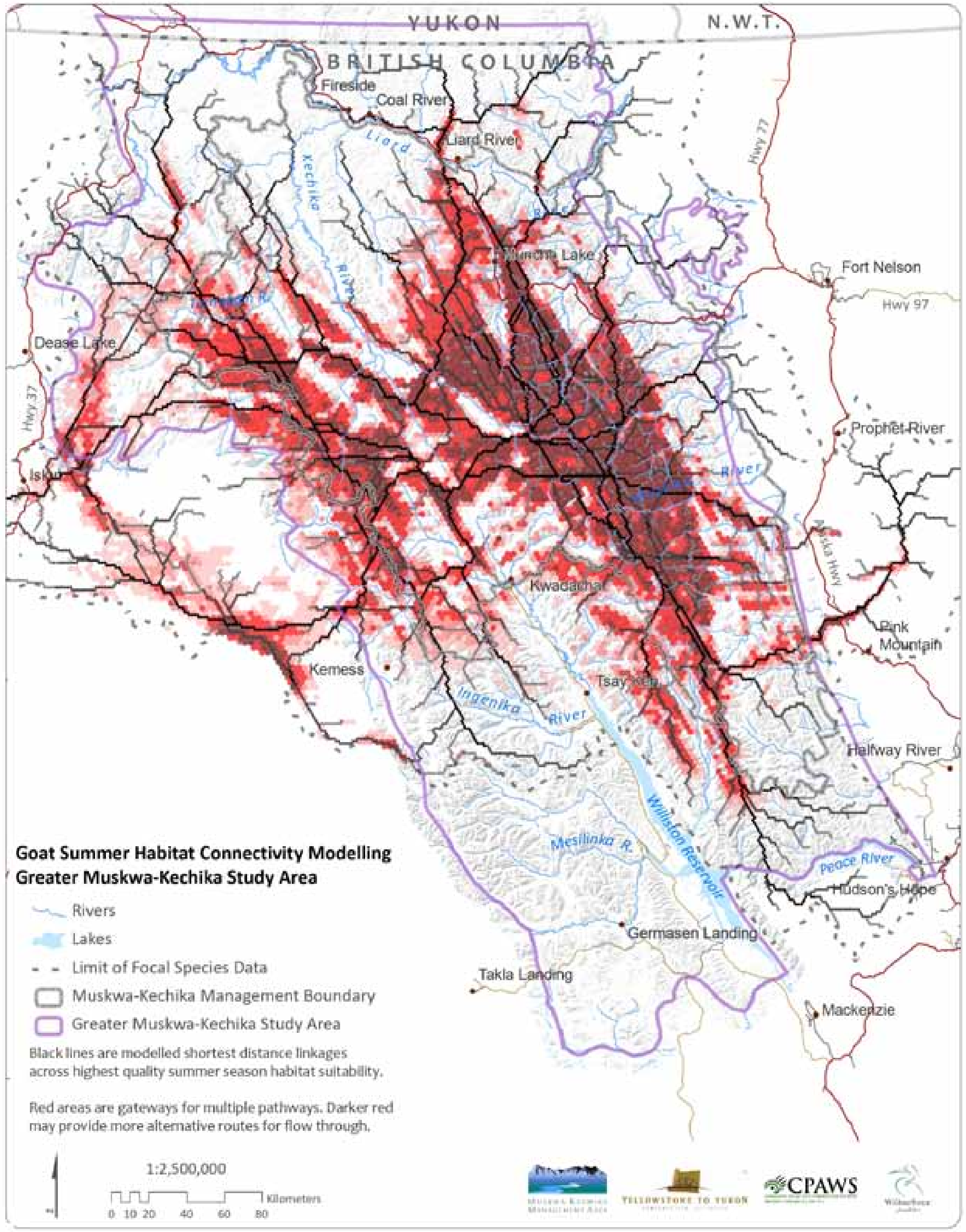


MAP 23
Stone's Sheep Connectivity Model with Protected Areas

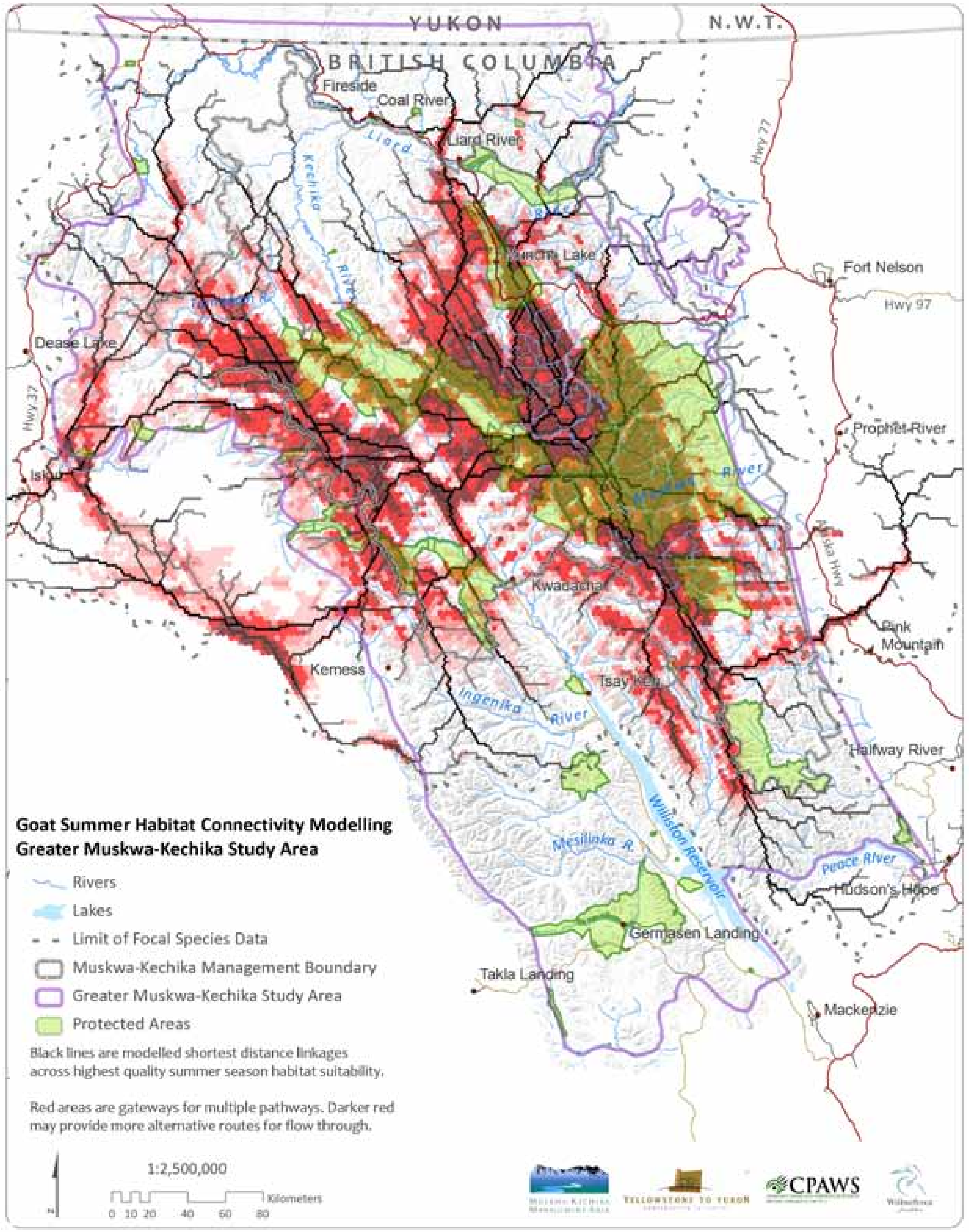


For the sheep habitat and pathways depicted in Map 23, there are significant areas of high connectivity located outside current protected area boundaries. These areas could be examined as candidates to fill some of the representation gaps, thus fulfilling two biodiversity conservation goals at once. Alternatively, areas of high connectivity value may require additional management considerations.

MAP 24
Mountain Goat Summer Habitat Connectivity Model



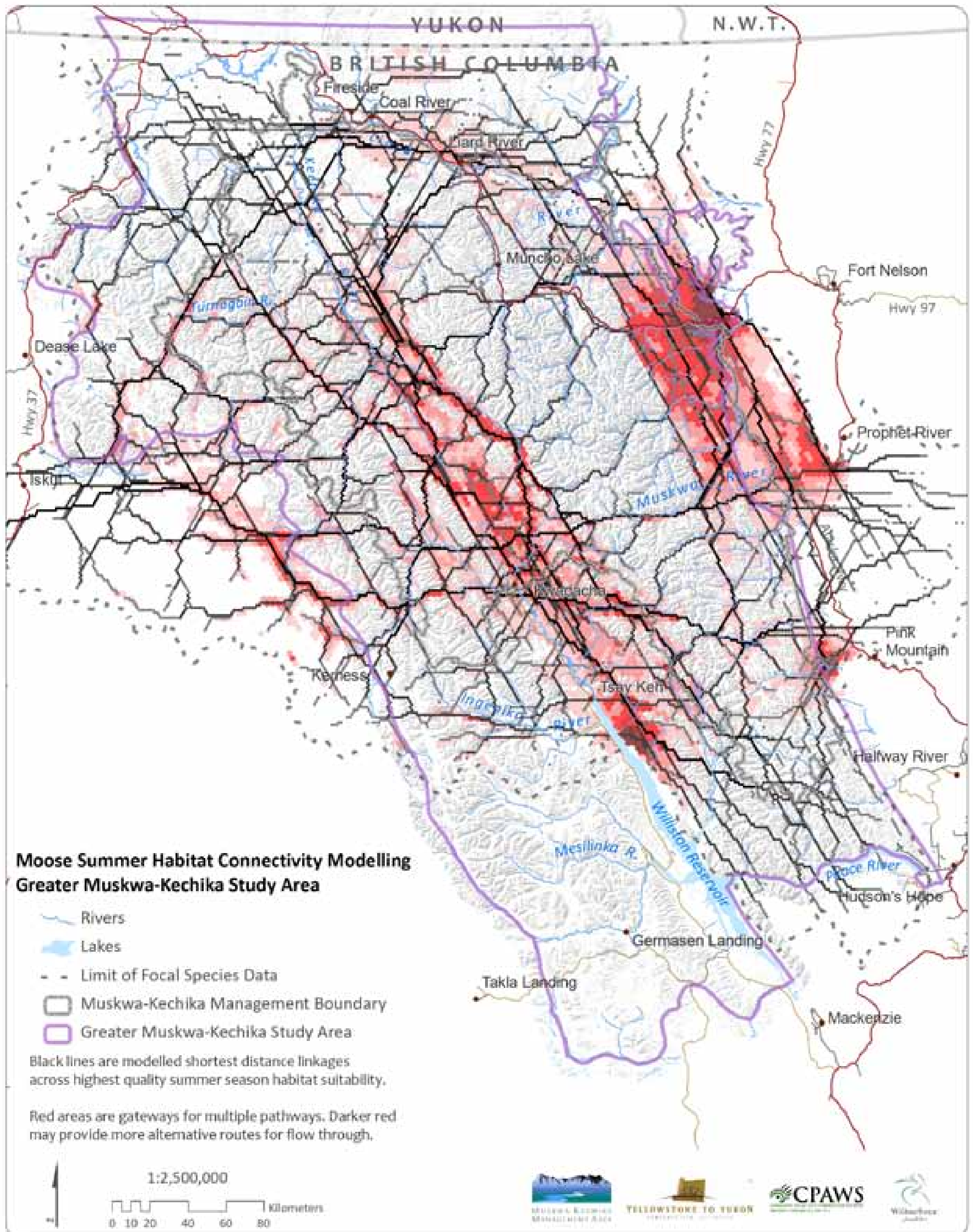
MAP 25
Mountain Goat Connectivity Model with Protected Areas



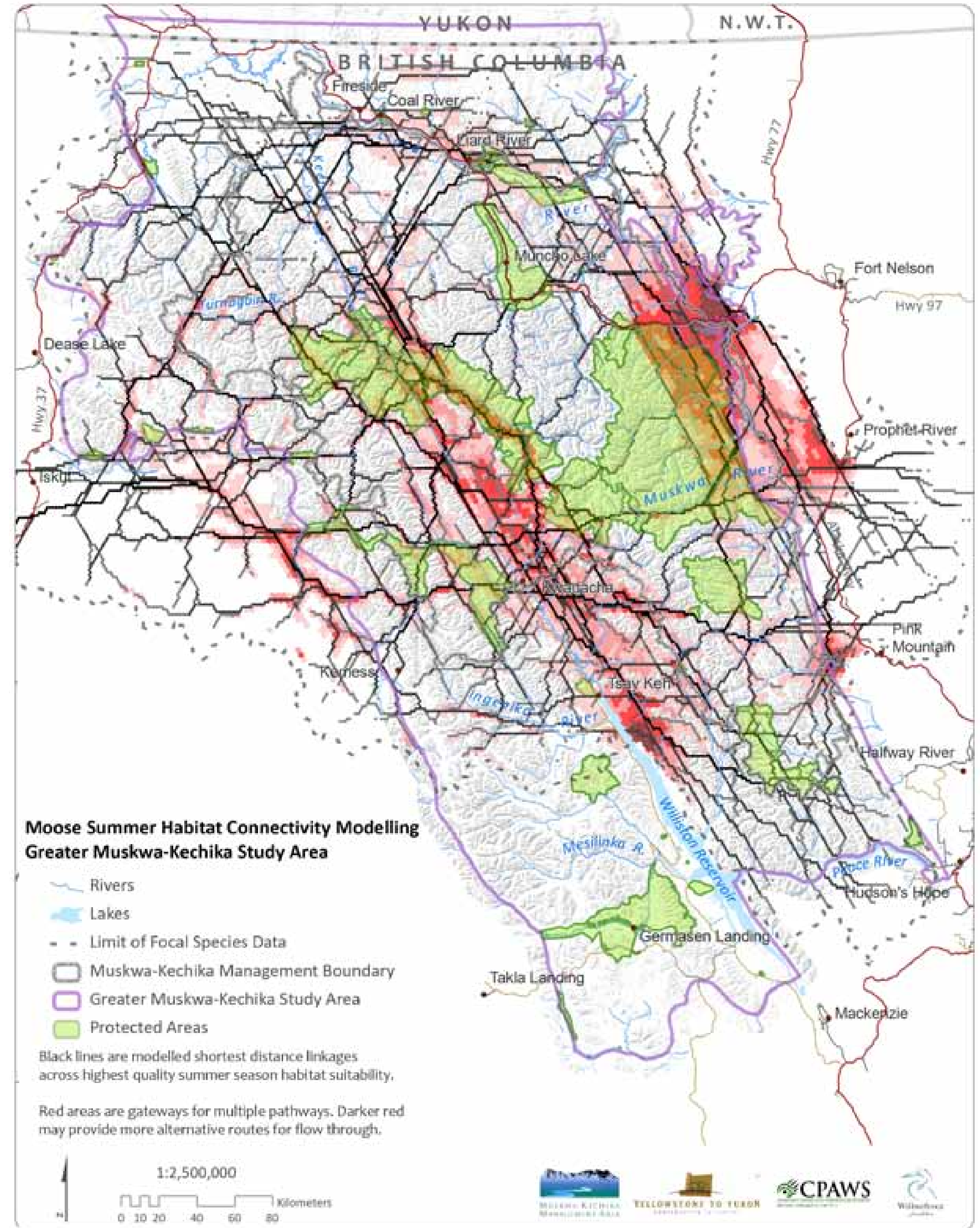
For the goat habitat and pathways depicted in Map 25, there are significant areas of high connectivity located outside current protected area boundaries. These areas could be examined as candidates to fill some of the representation gaps, thus fulfilling two biodiversity conservation goals at once. Alternatively, areas of high connectivity value may require additional management considerations.

MK

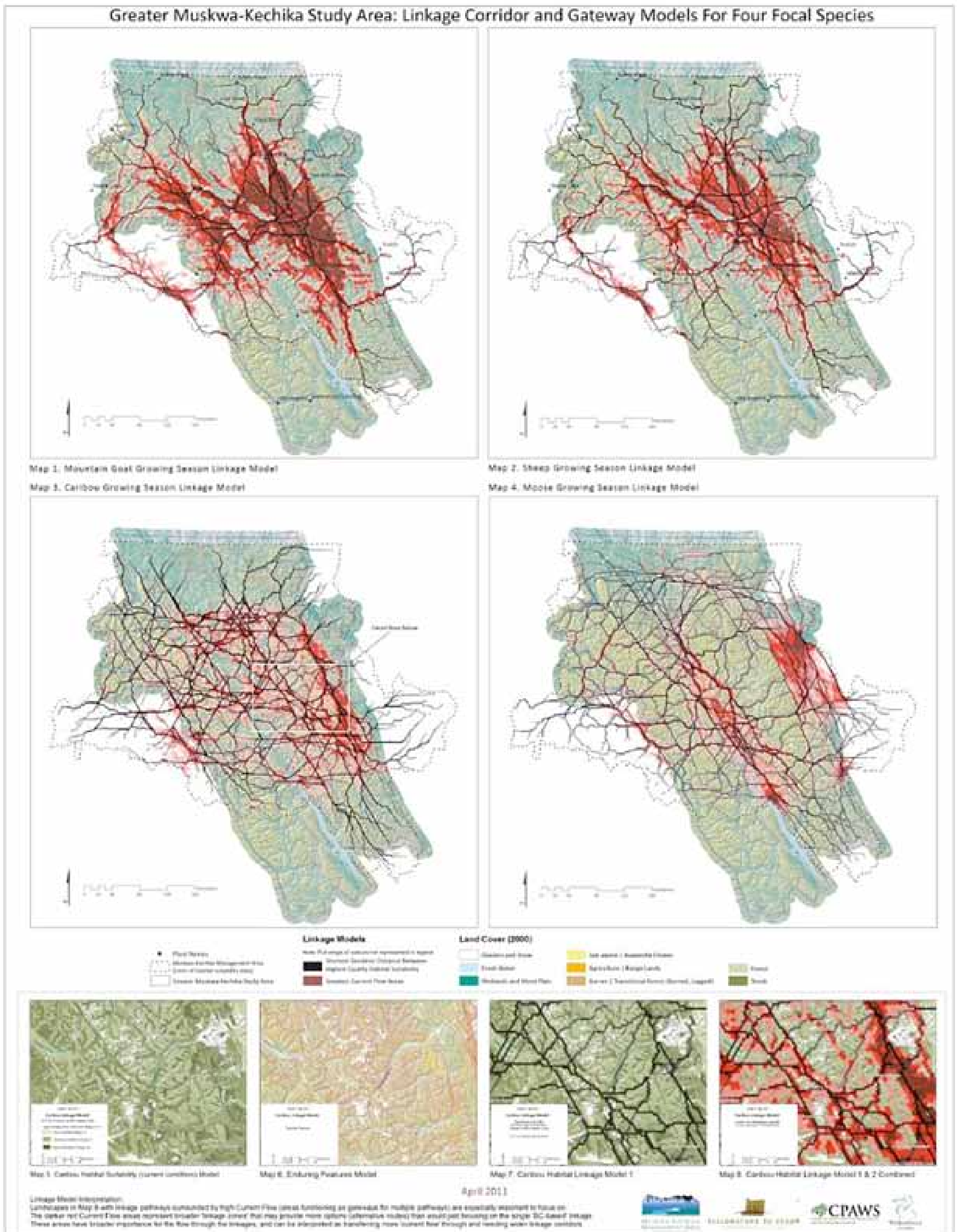
MAP 26
Moose Summer Habitat Connectivity Model



MAP 27
Moose Connectivity Model with Protected Areas



MAP 28
Composite Picture of Wildlife Connectivity for Four Focal Species



For each of the four species depicted in these maps, there are significant areas of high connectivity located outside current protected area boundaries. These areas could be examined as candidates to fill some of the representation gaps, thus fulfilling two biodiversity conservation goals at once. Alternatively, areas of high connectivity value may require additional management considerations.

Box 6: How the wildlife connectivity maps were produced

To model current wildlife connectivity for four example focal species, we consulted Dr. Carlos Carroll, conservation biologist, and applied his "Connectivity Analysis Toolkit" (Available for free download at www.connectivitytools.org) In the past, connectivity analysis often focused on the "least cost" connections between existing protected or managed areas, meaning the shortest distance through high quality species habitat.

Improvements in computational power and performance of algorithms (instructions directing a computer to solve a problem or produce a result) used to "spatially identify the importance of sites as gatekeepers for flow across a network" now enable analysis across continuous habitat gradients.[14] Said differently, we asked the computer to find the shortest distances and most frequent flow sites or gateways of "wildlife current" across the entire habitat of each of four focal species. Note that focal species habitat quality will include some indirect measure of elevation, for example the model limits how far uphill a "shortest distance path" can go.

Our first step was to scan existing data to fully understand and document all available habitat modelling and connectivity analysis for the Greater Muskwa-Kechika Study Area. While we found numerous potential information sources, particularly for habitat suitability and capability data, none of the data covered enough of the study area to provide a large picture, except for the original M-KMA CAD (2004) habitat suitability data.

We proceeded to model four example focal species using the MK CAD data: moose, caribou, goat and Rocky Mountain Bighorn sheep based on available habitat models (circa 2004). While the MK CAD collected information on additional species, we decided to focus on four due to project budget and time constraints. Please see Maps 29 and 30, below, for a possible approach to validating the wildlife connectivity modelling

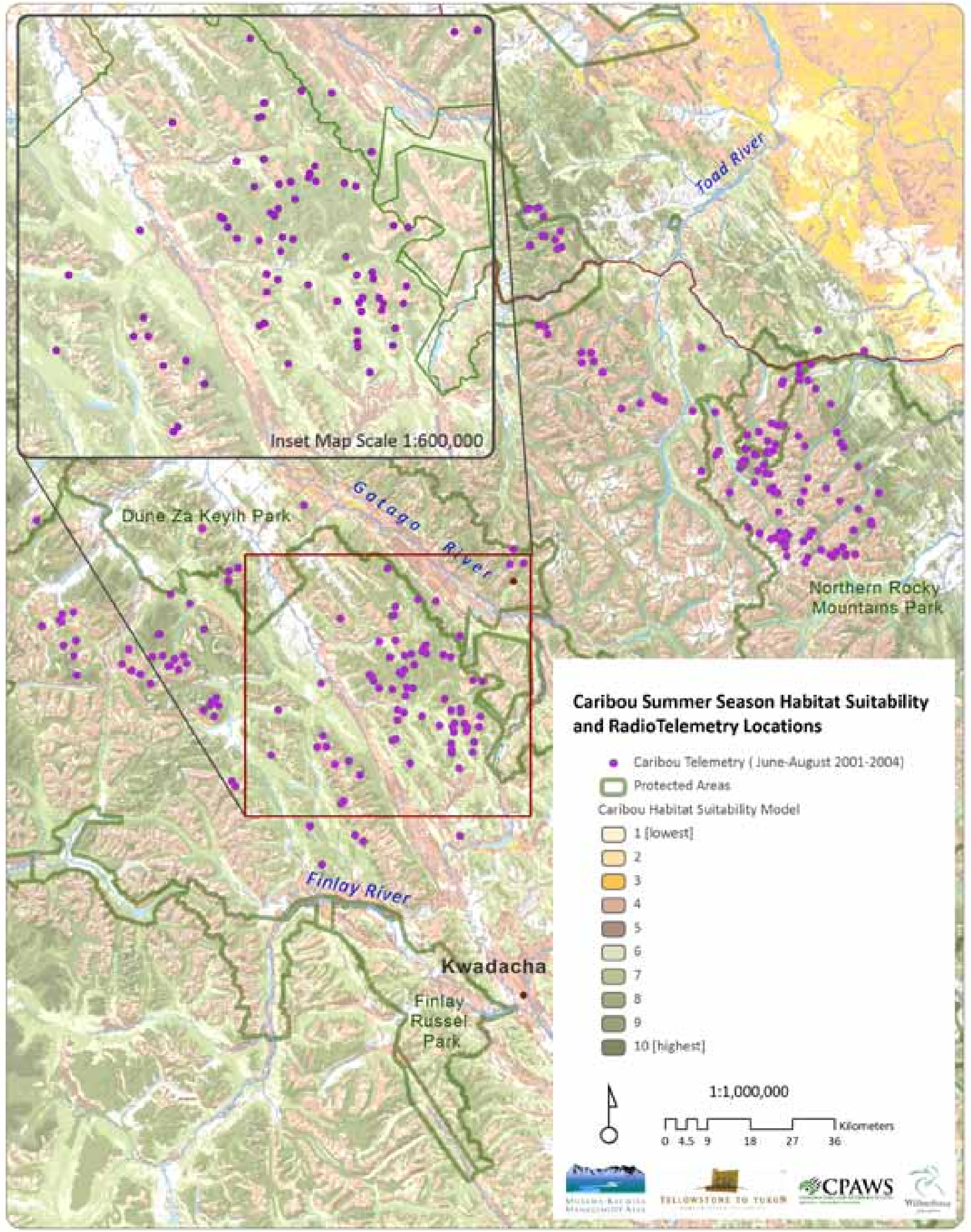
We did not run any models explicitly looking at how focal species habitat will shift in response to climate change, but such an assessment would be useful in projecting changes to wildlife connectivity patterns.

14 Carroll, C., B. McRae, and A. Brookes. (2011) Linkage mapping and centrality analysis across habitat gradients to conserve gray wolf population connectivity in western North America. Conservation Biology 26:78-87.

Kemess Mine exploration area in the alpine habitat zone.

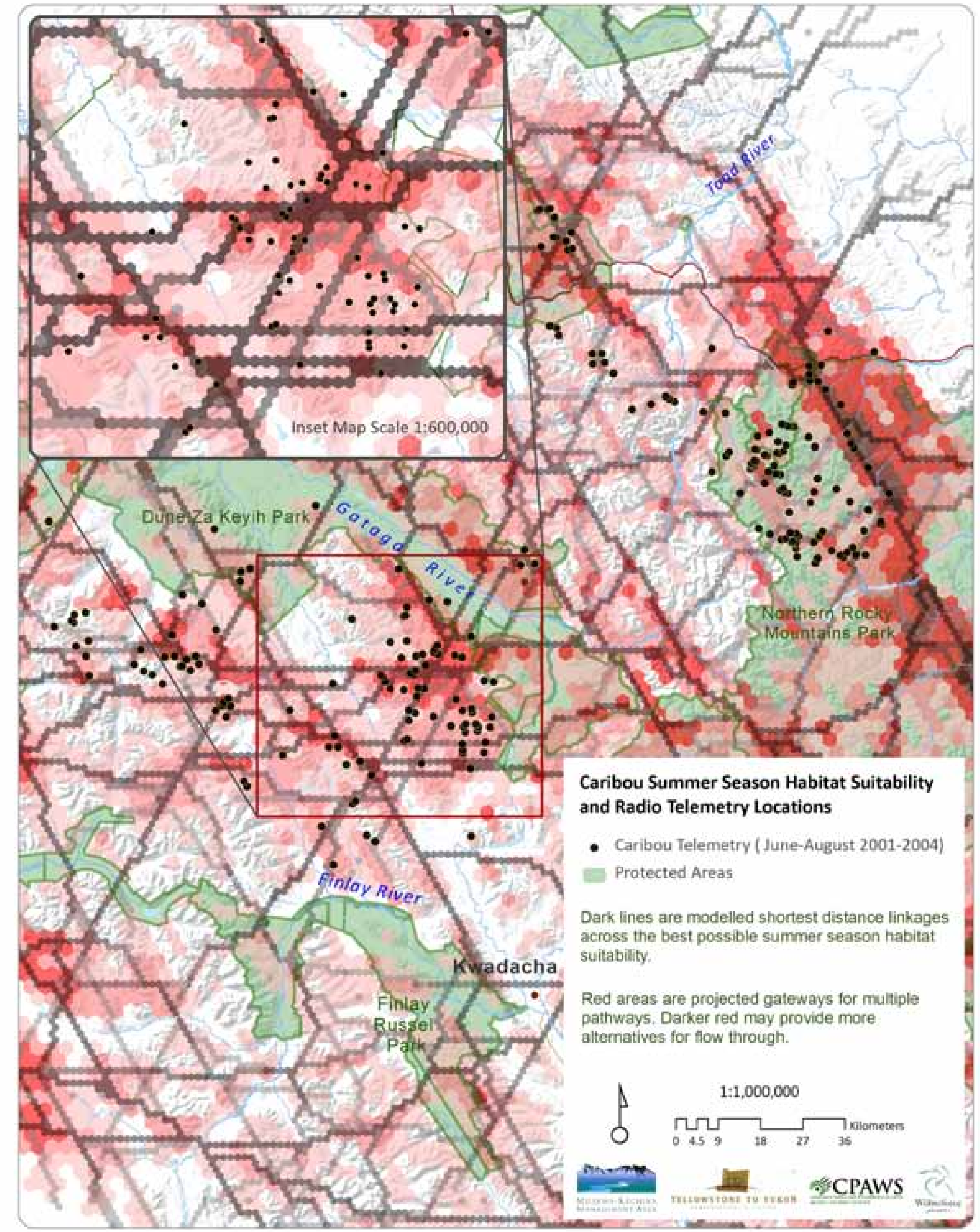
Johnny Mikes

MAP 29
Caribou Habitat Suitability Overlaid with Radio Telemetry Locations



Map 29 of the area north of Kwadacha and the Finlay River, shows radio telemetry evidence from GPS collars (purple dots) of caribou using areas with high to moderate summer habitat suitability (shown in green shades) during June-August, 2001-2004. Some of these point locations may be in upper valleys where there are patches of higher quality habitat, for example the data points in Northern Rocky Mountains Park . The lower red inset box is shown at a larger scale in the top map inset. These telemetry data were collected by the Province of BC and reflect non-sensitive location data. The habitat suitability model is from the 2004 MK CAD analysis; note the correlation between telemetry data points and habitat quality as mapped for the CAD.

MAP 30
Caribou Summer Habitat Connectivity Model Overlaid With Radio Telemetry Locations



Map 30, a complex map of the area north of Kwadacha and the Finlay River, shows radio telemetry evidence (black dots) of caribou using predicted wildlife pathways during June-August, 2001-2004. The lower red inset box is shown at a larger scale in the top map inset. Note that this map shows an apparent strong visual correlation between actual caribou use and the pathways predicted in the caribou linkage model in Map 18. Further assessment of this comparison between telemetry data and the connectivity map may help to validate the wildlife connectivity model for caribou and possibly for other species where telemetry data are available.

V. Climate Change Adaptation Assessment

The current climate in the M-KMA, characterized by an average annual temperature, is -1 degree Celsius with mean summer temperatures of about 10° C and mean winter temperatures of about -16° C. Mean annual precipitation ranges from 350 to 1,000 mm (or 15 to 40 in). The rugged, high mountains of the Muskwa Ranges trap moisture coming from the Pacific and produce a “rain shadow” effect with notably drier climates along the east-front ranges. Summertime surface heating leads to convective showers which, together with winter frontal systems, result in precipitation amounts that are evenly distributed throughout the year. Outbreaks of Arctic air are frequent during the winter and spring (from 2004 CAD).

The climate in the M-KMA region in 2050 is projected to be warmer and wetter, with the Mean Annual Temperature (MAT) increasing 3° C. These changes will have widespread but variable ecological effects. For example, in an alpine or boreal area where MAT increases but remains below 0° C, ecological change will not be as significant as it would if the MAT increases to exceed 0° C. In places where the MAT increases to above 0° C, soils will start to warm up, permafrost (if present) will slowly melt, nutrient cycling and decomposition will speed up, biological productivity will increase, the vegetation will respond accordingly and ecological change will be significant.

The future climate in the M-KMA region is projected to be warmer and wetter. This is the Moose Lake - Toad River area.

Theresa Gulliver

The change in precipitation will not be uniform over the study area. Winters will be wetter, with more rain than snow. Today the boreal forest within the M-KMA study area receives about 450mm of annual precipitation, with a range of between 350-600mm. When precipitation exceeds 650 mm and MAT exceeds 2 or 3 degrees C, the boreal ecosystem will cross a major threshold, with growing conditions transforming to those of a humid temperate forest, perhaps like contemporary interior “wet-belt” forests southeast of Prince George. (Historic analytical data for the study area was provided by the Pacific Climate Impacts Consortium, University of Victoria, 2009, based on data from available recording stations accumulated between 1961 and 1990, with projections to 2050 based on a model developed by the Canadian Centre for Climate Modelling and Analysis.)

1. Projected Ecological Upheaval from Climate Change

As climate changes in northern BC, Mean Annual Temperature, Mean Annual Precipitation and Growing Degree Days are all increasing; this will lead to changes in land cover and vegetation type. For example, some alpine ecosystems will be taken over by subalpine scrub and forest. There will be less change where the increased warmth (especially) and moisture are still insufficient to transform the land cover to a dramatically different condition, for example from grassland to forest. In general, forests will persist over much of the area but they will be different kinds of forest. Most alpine areas will shrink; grasslands could be threatened by a takeover by woody plants; large lakes and streams should persist, small shallow ones could dry up or fill in; riparian zones should persist; and wetlands will change, perhaps becoming less acid and more productive.

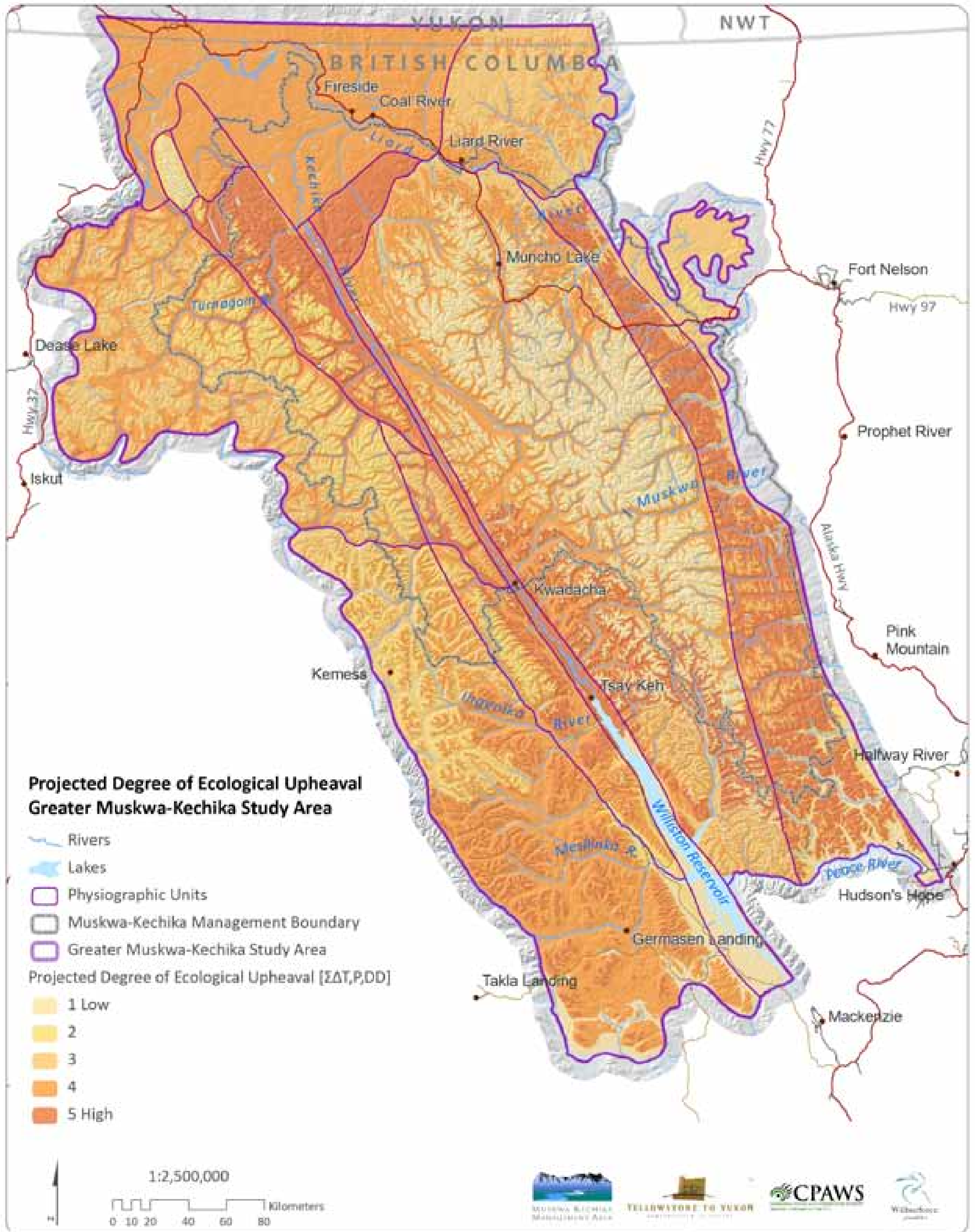
Pelly Lake.

Johnny Mikes

Ecosystems will undergo upheaval everywhere, but some will change more than others. A changing climate accompanied by a dramatically altered distribution and mix of plants means that sensitive species with specific biophysical habitat needs may be put significantly at risk. We need to answer questions such as: “Given changes in forest cover, snow density, lichen availability and the increase in biting insects, how much useable habitat will be available for caribou and where will it be located relative to where it is now?”; and, “How can we maintain and ensure the ability of animals to move in response to shifting environmental conditions?” (See Appendix 2 for a more detailed discussion of the projected impacts of climate change on wildlife species).

Map 31 depicts the relative degree or intensity of ecological upheaval projected over the study area to 2050, with the darker reddish areas projected to change the most, and the lighter coloured areas the least. Areas with a projected high degree of upheaval call for management strategies that maintain wildlife connectivity between areas of suitable habitat, to allow for species to move or adapt to the new conditions. Areas with low projected upheaval can be viewed as potential climate change refugia for species that use this habitat today.

MAP 31
Projected Ecological Upheaval from Climate Change



Box 7: How the ecological upheaval map was produced

The study team reviewed existing eco-classification reports pertaining to the study area to estimating the degree of ecological upheaval due to projected climate change.[15] The environmental characteristics of the biogeoclimatic (BEC) units that occur in the study area were reviewed in terms of elevation, physiography, climate, landforms/soils, and vegetation. The means and ranges of climate normals (typically 30-year normals for 1961 to 1990) were extracted for recording stations in the region's BEC units. A matrix of historic (1961 to 1990) and projected (to 2050s, as per CGCM3:A3 model and scenario - Third Generation Coupled Global Climate Model developed by the Canadian Centre for Climate Modelling and Analysis) climate normals was created for mean annual temperature (MAT), mean annual precipitation (MAP), and mean accumulated growing degree days (DD). We used analytical data for the region from the Pacific Climate Impacts Consortium, University of Victoria, 2009, which was based on data from available recording stations accumulated between 1961 and 1990. The difference (ΔT, ΔP, ΔDD) was calculated between historic and projected values for each combination of physiographic subprovince and biogeoclimatic (BEC) unit.

We ranked the differences in terms of classes of intervals of change. Intervals were determined by mean values and ranges that characterise contemporary BEC units and differentiate, for example, boreal/subarctic, subalpine, alpine and temperate environments, or subhumid, humid and very humid climates.

MAT=Mean Annual Temperature, MAP=Mean Annual Precipitation, DD=Growing Degree Days

MAT (oC)	MAP (mm)	DD (∑ >5 oC)
(-4)-(-3)	400-450	300-400
(-3)-(-2)	451-500	401-500
(-2)-(-1)	501-550	501-600
(-1)-(0)	551-600	601-700
0-0.5	601-650	701-800
0.5-1	651-700	801-900
1-1.5	701-800	901-1000
1.5-2.5	801-900	1001-1200
2.5-4	901-1000	1201-1400
4-6.0	1001-1100	1401-1600

Class intervals crossed in moving from historic to projected conditions were tallied. For example, the shift from historic Mean Annual Precipitation (MAP) of 474 mm to projected 610 mm crosses 3 MAP intervals. The sum of the crossed intervals was calculated for all three columns, for each physiographic/BEC combination. The relative degree of ecological upheaval was then assigned according to the scheme below.

T=Temperature, P=Precipitation, DD=Degree Days, as per explanation above

∑ΔT, P, DD	Degree of Upheaval (1 – relatively low to 5 – relatively high)
8--9	1
10-	2
11-	3
12-	4
13-14	5

15 For example, these included: MacKinnon, A., C. DeLong and D. Meidinger. (1990) *A field guide for identification and interpretation of the northwest portion of the Prince George Forest Region*. Land Management Handbook 21, BC Ministry of Forests, Victoria, B.C.; DeLong, C., D. Tanner and M. Jull. (1994) *A field guide for site identification and interpretation for the Northern Rockies portion of the Prince George Forest Region*. Land Management Handbook 29. BC Ministry of Forests, Victoria, B.C.

2. Projected Persistent Habitat Elements – Alpine

As the climate warms, trees begin to move up in elevation to colonize the shrub ("buckbrush") belt and shrubs move up to colonize the alpine tundra. The start of this rise in tree-line and loss of alpine can be noticed already in some places. Where the mountains are sufficiently high that the climate will still be intolerable for trees and erect shrubs, alpine tundra ecosystems will persist, although they will be smaller in area. Given enough time and high enough terrain, alpine could expand upward, recouping some of the losses lower down. Where the high country is not high enough, over time the alpine will disappear.

Maps 32 to 35 and Tables 3 to 5 show the current and projected future location and extent of alpine vegetation in the M-KMA study area. Current alpine in the region, shown on Map 32, generally occurs above 1450-1550 m. This contrasts with a future scenario in 2050, when a projected increase in Mean Annual Temperature of 3° Celsius could lift the lowest elevation for alpine to 1600-1800 (-2000) m, as shown on Map 33. For example, existing alpine is at great risk in the Rocky Mountain Foothills, where leeward slopes already get a strong thermal uplift from westerly air masses as they pour over and descend the Rockies.

The red and dark brown colours on Map 34 show areas of alpine conditions today and projected to 2050—the red areas will likely disappear with climate change. In the red areas there will be less alpine habitat available for wildlife such as caribou.

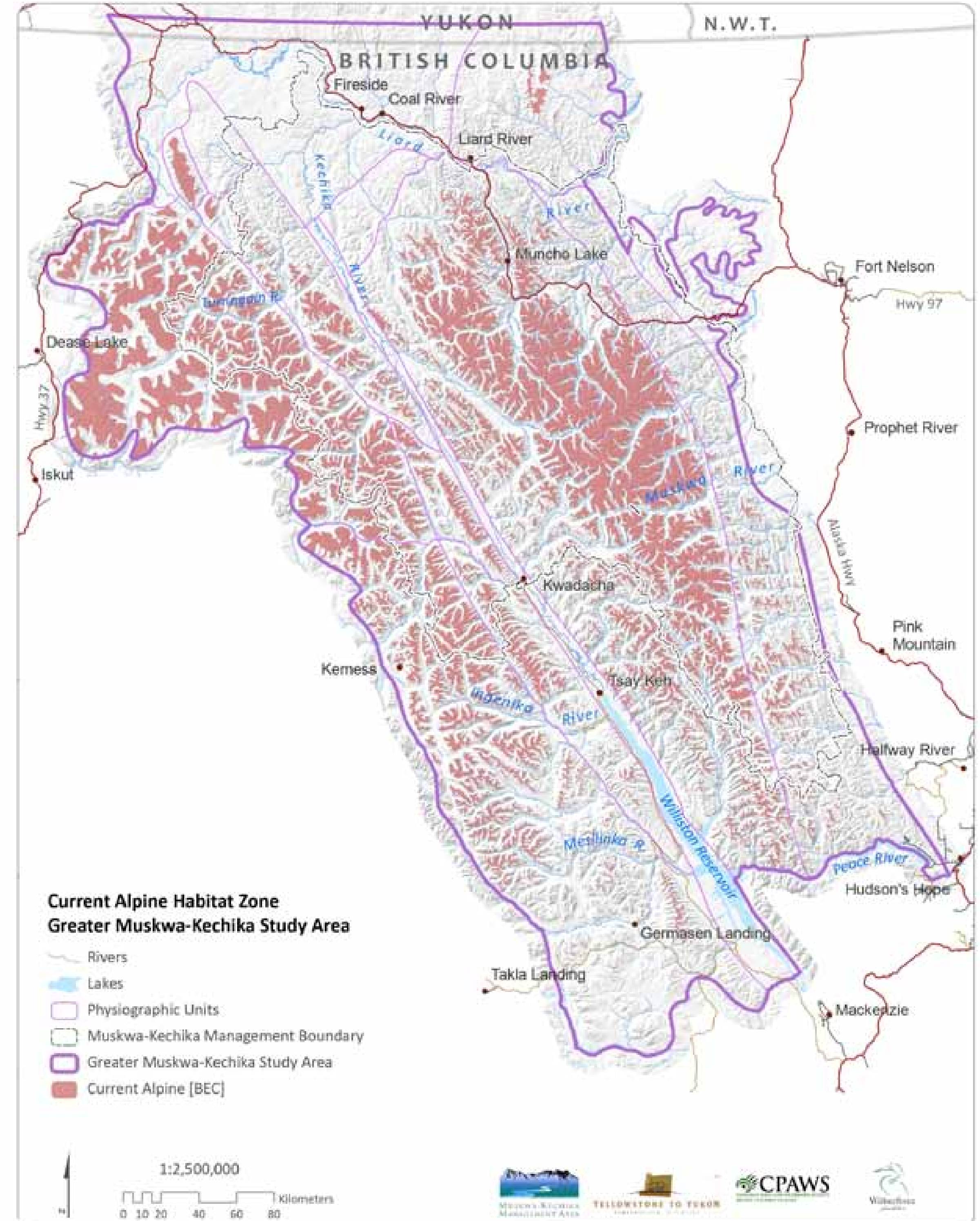
Table 2 shows the existing alpine zone as a percent of the M-KMA study area, with the current area taking in 18.1%, projected to decline to 10.3%, an overall loss of 43% of the alpine zone over the whole study area. Some physiographic provinces will lose more alpine area than others (Table 4). For example, the Liard Plateau is projected to lose 95% of its alpine, and the Rocky Mountain Foothills could lose 94%. Faring better with respect to loss of alpine, the Muskwa Ranges are still projected to lose close to 30% of the existing alpine habitat (see Table 5).

Compare the projected loss of alpine vegetation in the Rocky Mountain Foothills to the wildlife connectivity maps, especially for caribou. Map 42 (p. 93) shows the projected ecological upheaval from climate change relative to caribou connectivity in the M-KMA, and draws attention to future management challenges to maintain existing caribou herds.

Alpine habitat in the M-KMA is projected to decline by about 43% by 2050.

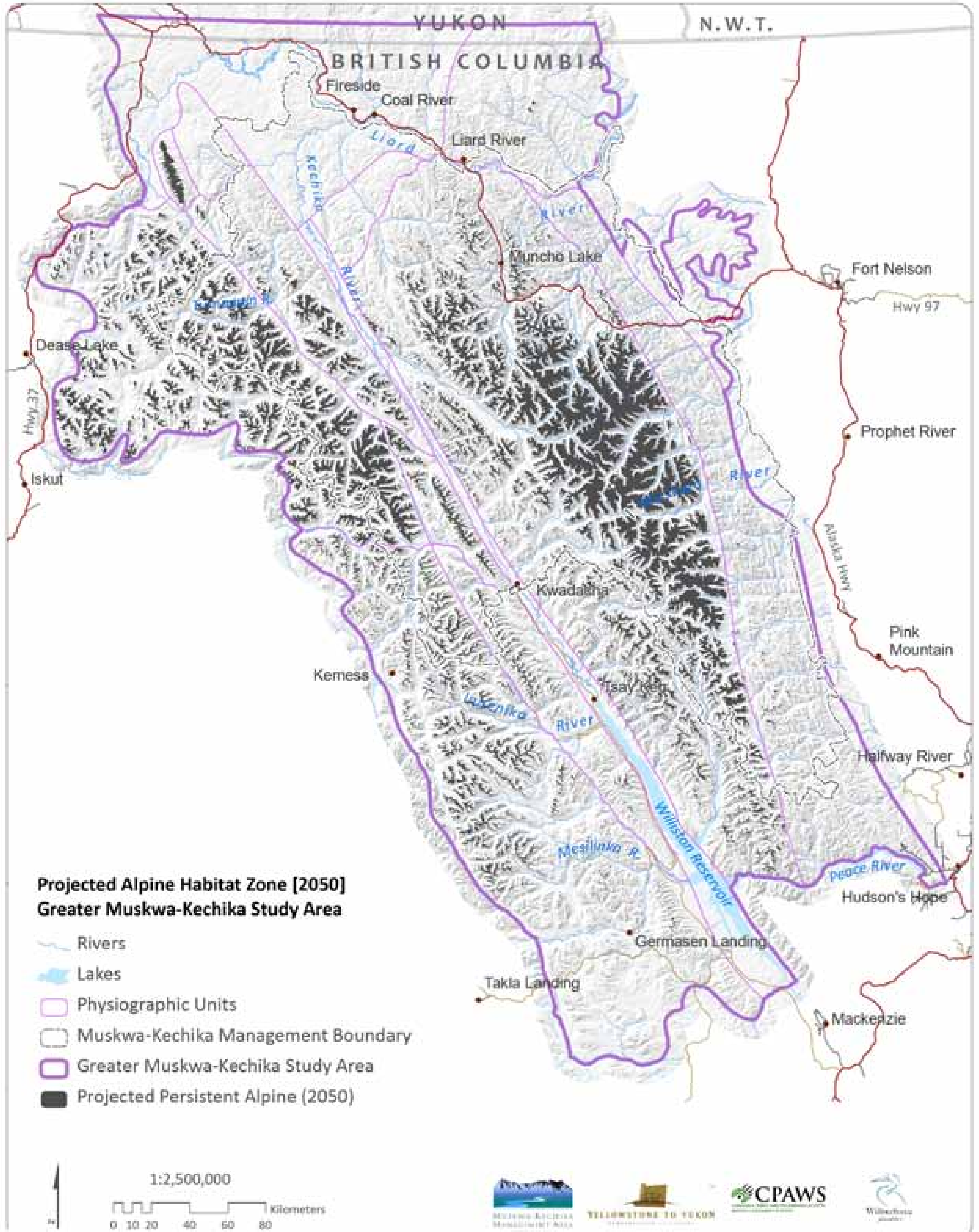
Wayne Sawchuk

MAP 32
Current Alpine Habitat Zone

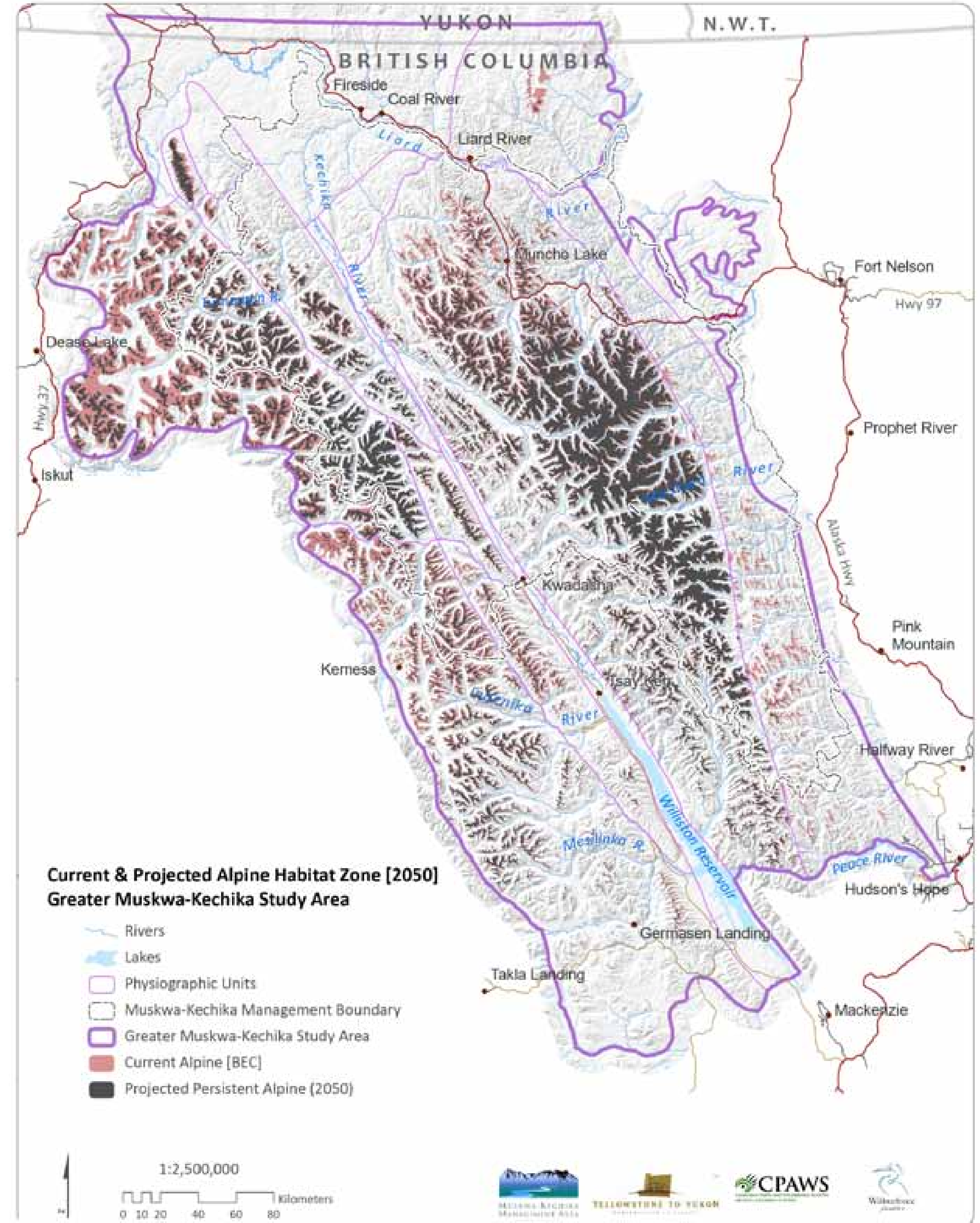


MK

MAP 33
Projected Alpine Habitat Zone – 2050



MAP 34
Current and Projected Alpine Zone



MAP 35
Current and Projected Alpine Zone – Stone Mountain Area

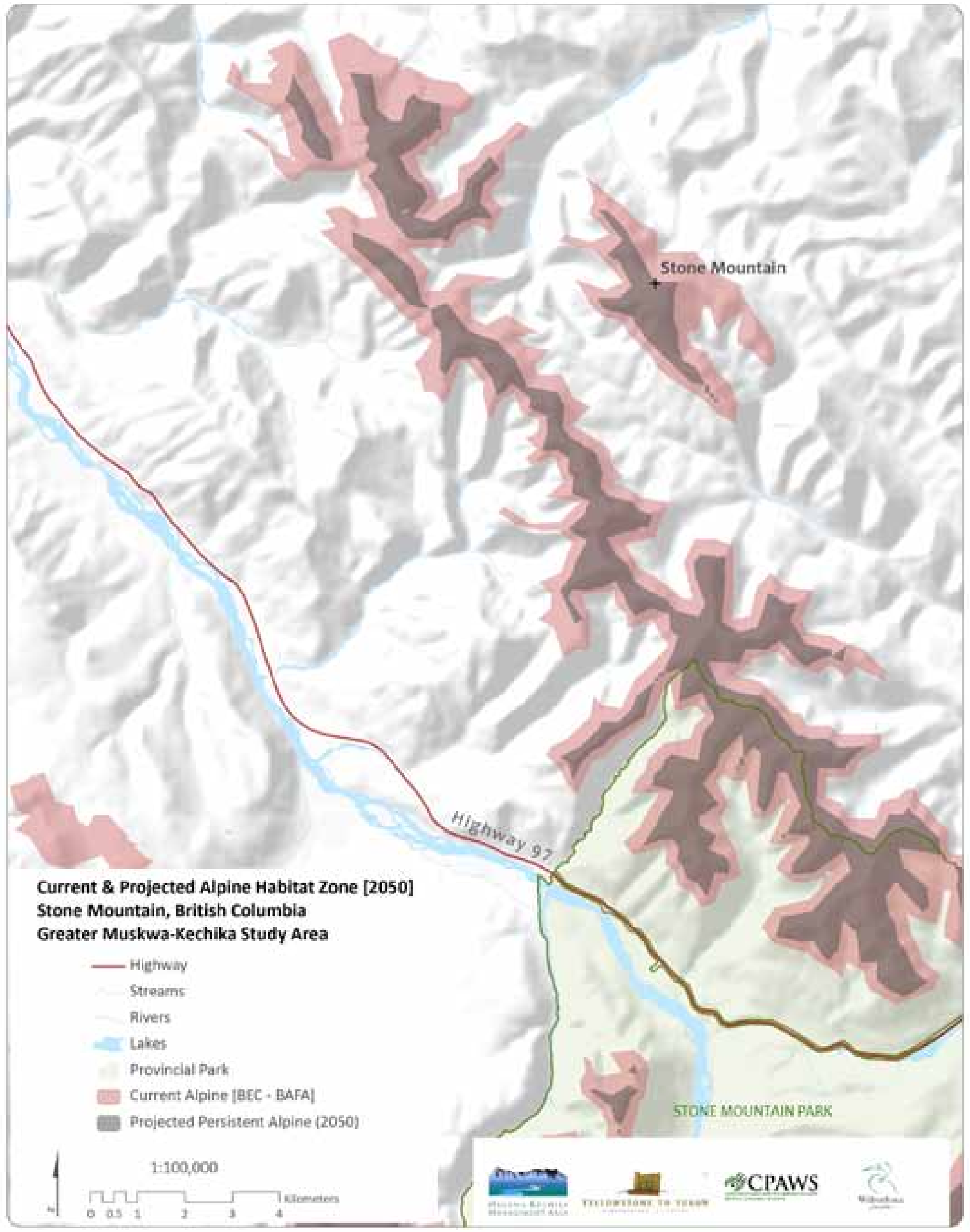


TABLE 2
Alpine Zone as a Percent of the MK Study Area to 2050

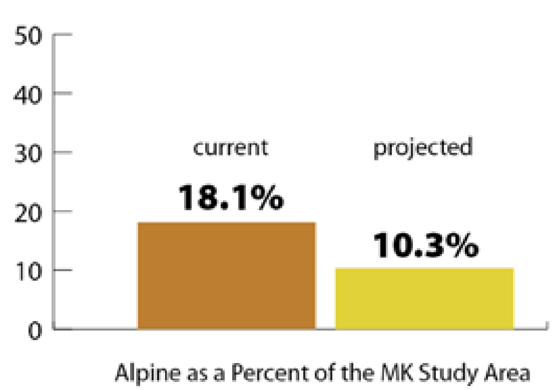
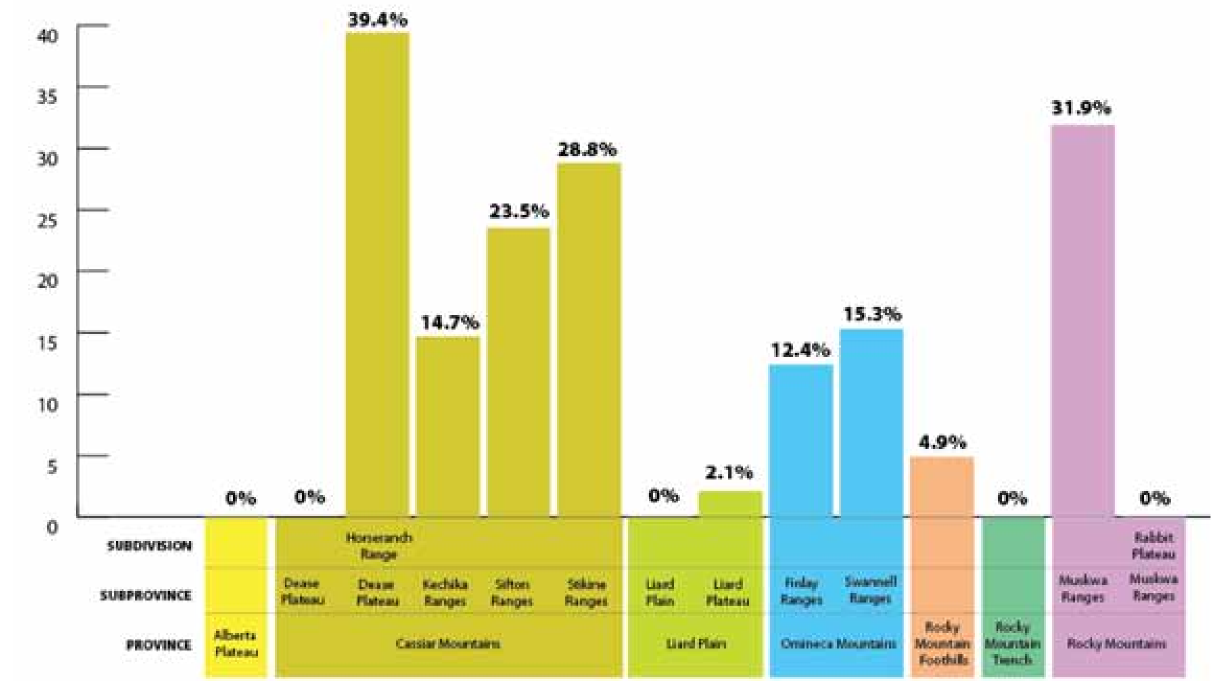


TABLE 3
Current Alpine as a Per Cent of Each Physiographic Unit



Note: The bar colours in Table 3 match the colour code of each physiographic unit shown in the inset map

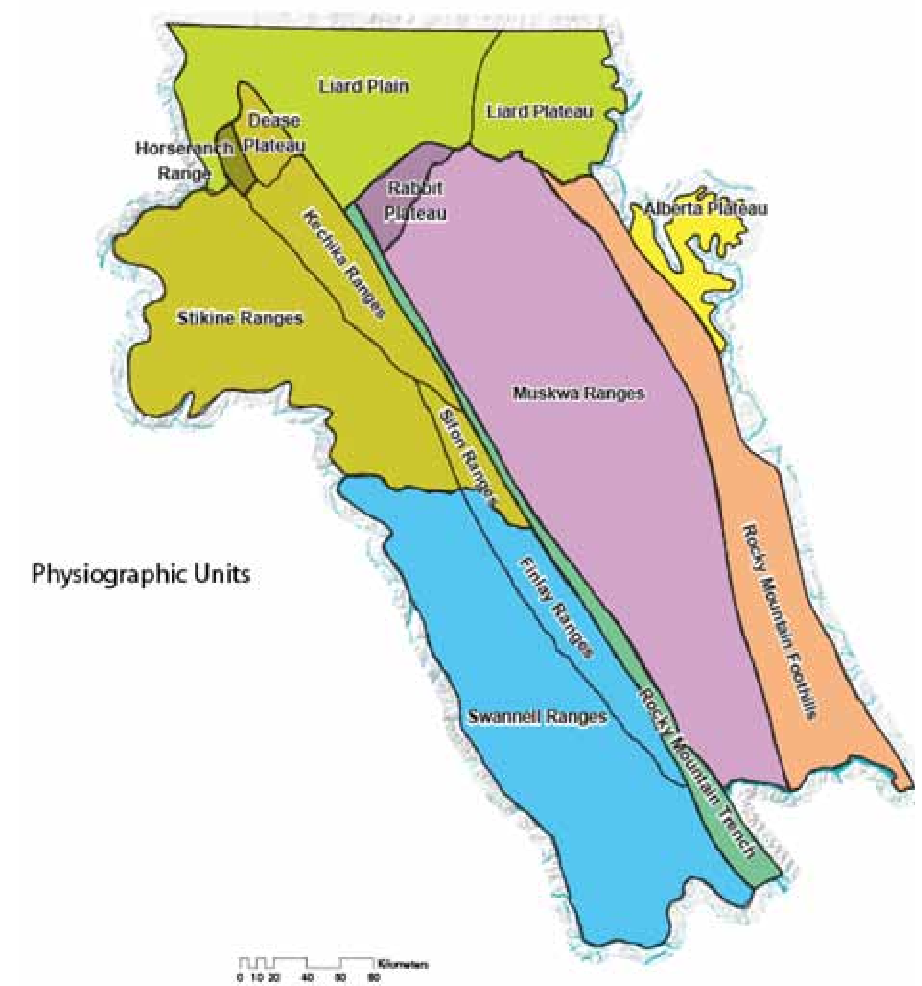
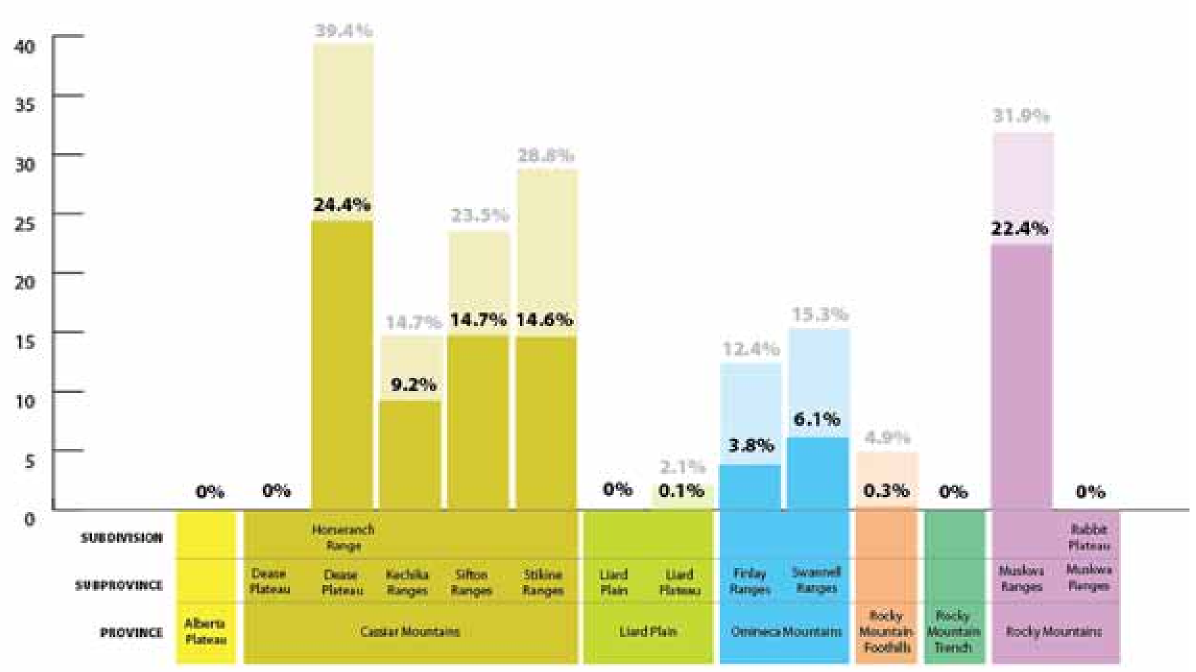
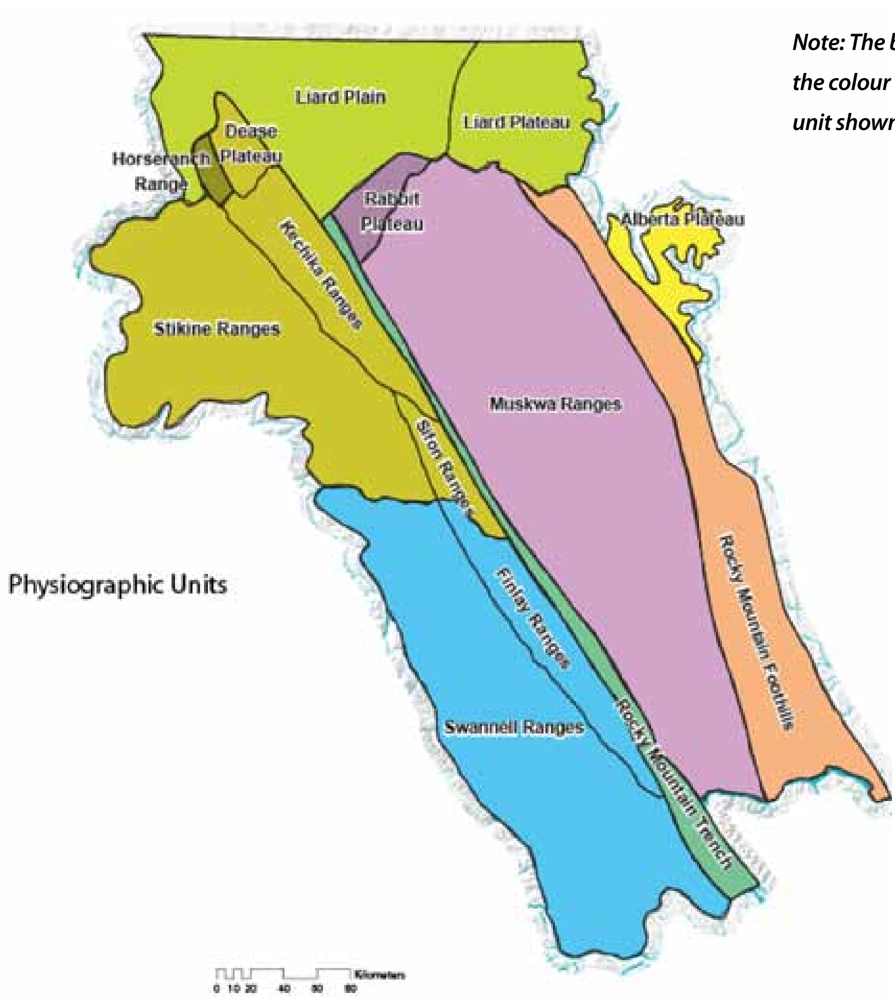


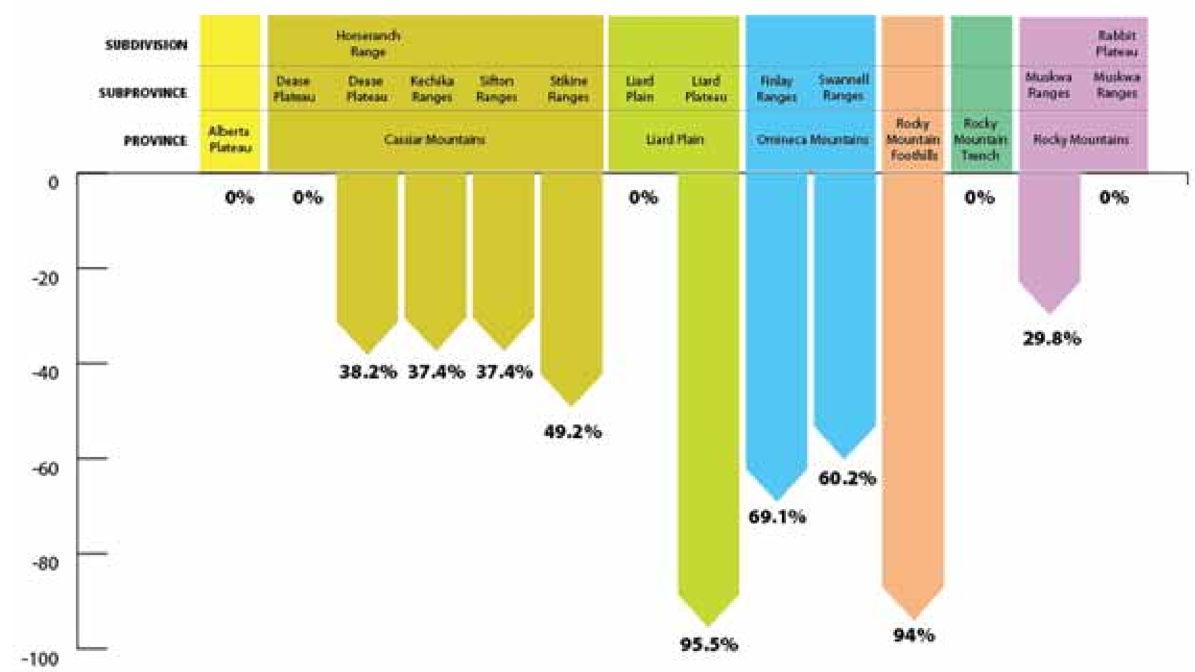
TABLE 4
Projected Loss of Alpine to 2050 by Physiographic Unit



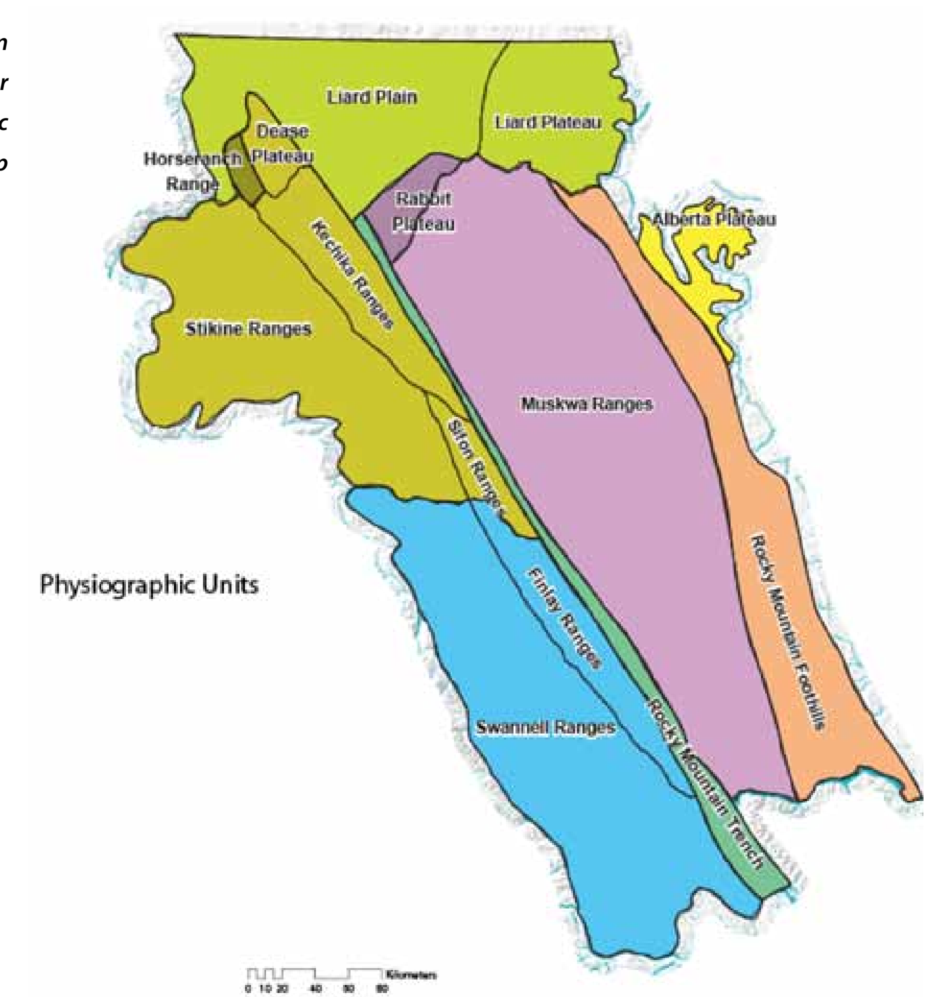


Note: The bar colours in Table 4 match the colour code of each physiographic unit shown in the inset map

TABLE 5
Total Reduction in Alpine Extent to 2050 as a Percent of Each Physiographic Province



Note: The bar colours in Table 5 match the colour code of each physiographic unit shown in the inset map



How will caribou be affected by a decline in alpine habitat?

Wayne Sawchuk

In the M-KMA alpine habitats are projected to decline, especially in the Rocky Mountain Foothills, which will affect caribou, sheep and goats. The Rocky Mountain Trench is also an area of projected high ecological upheaval, so it will be important to maintain the north-south connectivity and avoid development that could adversely affect wildlife movements along this productive valley corridor.

Box 8: How the projected loss of alpine areas map was produced

The matrix of historic (1961-1990) and 2050 climate data was reviewed. Most mean annual temperatures (MATs) of alpine zone are currently -2 or -3° C. If the climate warms 3° C, so that the MAT is around 0 (+/-1), it will enter the range of present-day MATs of subalpine (ESSF, SWB) zones. Today's tree line is around 1450-1550 m, while subalpine falls mostly between 900/1000 and 1400-1600 m. Therefore, 3 degrees of warming translates to a 400-500 m shift upward in climate envelopes, a shift to which, if it happens too quickly, trees in today's subalpine zone will be unable to adapt.

VI. Protected Areas in the Greater M-K Ecosystem

One of the objectives of the current assessment is:

> *To identify how well the existing protected areas and special management zones achieve broad conservation goals and, if necessary, recommend improvements in land use plans to increase the likelihood of meeting those goals;*

To fulfill this objective, the project team set out to measure the degree to which the current configuration of protected areas in the greater M-K ecosystem adequately represents the unique ecosystems within the study area boundaries.

1. What is representation and what is the goal for representation in protected areas?

Four goals are central to most regional biodiversity conservation strategies used by government agencies and conservation organizations (from 2004 CAD):

1. Represent, in a system of protected areas, all native ecosystem types and seral stages across their natural range of variation.
2. Maintain viable populations of all native species in natural patterns of abundance and distribution.
3. Maintain ecological and evolutionary processes, such as disturbance regimes, hydrological processes, nutrient cycles, and biotic interactions.
4. Design and manage the system to be resilient to short-term and long-term environmental change and to maintain the evolutionary potential of lineages.

The goal of a network of protected areas to represent the diversity of ecosystems has been a central tenet of BC's conservation planning for some time. Representation on the broadest provincial scale helps ensure that the protected areas system captures elements of all parts of the BC landscape. A representation approach in the various regions of the province helps ensure that all the protection is not concentrated in one landscape or ecosystem (e.g., high in the mountains) but includes other elements as well (e.g., river valleys and large lakes).

The representation goal is accomplished by using a "coarse filter" to select different types of landscapes for protection, and applying a "fine filter" to ensure that important special ecological elements that might slip through a coarse filter are included.[16] If enough of a region is protected in a thoughtful, broad-based

16 See also the more detailed discussion of coarse and fine filters in Appendix 1 of this report.

manner to capture the enduring diversity of that region (high and low elevations, wet and dry areas, rugged and gentle slopes, etc.), by default, the myriad small (sometime unique) ecosystems, habitats, and special wildlife features (e.g., mineral licks), should be captured too. A special features analysis (e.g., scenic waterfalls, cave systems, important wetlands, etc.) can be used to confirm that the broad representation approach includes all the elements needed to complete the network of protected areas.

2. Two Approaches to Assessing Representation: Ecosections and Physiographic Sub-provinces

Ecosections classify the regions of BC according to their vegetation, wildlife potential, climate, physiography, and hydrology—in other words their biotic (living) and abiotic (not living) factors. Protecting a portion of each ecosection, and the diversity of biogeoclimatic zones (BEC) within them, have been long considered an important step along the path to ensuring that a protected areas system for BC captures the province's rich variety of physical and ecological attributes. Ecosection representation was the basic building block of the provincial protected areas strategy[17] in the early 1990s.

BC is also divided into 20 physiographic provinces, 7 of which overlap the greater M-KMA study area (Holland, 1964, see Map 2). These are further divided into physiographic sub-provinces (PGSPs), which are mapped at a better scale for assessing the study area (see Map 3). PGSPs are based purely on non-living/abiotic factors such as geology and landforms, not on vegetation or forest types. PGSPs in BC do not have identical boundaries to ecosections but the two types of units are related and their names are often close enough to be confusing (e.g., there is an Eastern Muskwa Ranges Ecosection and a Muskwa Ranges PGSP).

As we noted above, the living layers of the greater M-KMA will undergo climate-driven change. However, the physical landscape, or enduring features as described in this study, is the template on which

The Muskwa-Kechika Management Area has 50 unroaded watersheds, with 27% of the land protected overall.

Wayne Sawchuk

17 Province of British Columbia (1993) *A Protected Areas Strategy for British Columbia*, Queen's Printer, Victoria, B.C.

new living ecosystems shaped by a changing climate will form. Thus, physiographic sub-provinces, based on the non-living and immoveable structure of the landscape, are important building blocks for ensuring that future biodiversity is represented in the protected areas network.

The physiographic unit is of primary importance in biodiversity conservation planning. Ideally each of the 14 or more units would be substantially represented in a regional system of protected areas and conservation lands. How they are represented is where the enduring features map comes in. In principle, a protected areas network should include, for each physiographic sub-province, all combinations of bedrock/landform/topography, as well as the most important and typical hydrologic systems. A practical approach would probably have to focus on the areas of greatest "enduring variety", and unify or knit things together by considering connectivity and hydrologic systems.

PGSP representation can also be thought of as "enduring features" representation. Planning for both adequate ecosection representation and physiographic sub-province representation optimizes the chances of maintaining species into the future. Using both approaches is a prudent current and future approach to allow for adaptation by species, ecosystems—and indeed local communities dependent on them—as the climate shifts.

The 2004 CAD identified approximately 75% of the study area as important either to meet ecosection representation goals or to maintain connectivity. The CAD identified 2.7 M ha of Primary Core Area within its M-K study area, which represents 42% meriting full protection. (Primary Core Areas were defined in the CAD as areas necessary to represent a minimum of 30% of key conservation targets, including focal species habitat values, terrestrial and aquatic ecosystem diversity and selected fine-filters). The CAD called for an additional 2.1 M ha (33% of the study area) of Connectivity or Secondary Core Area. These were defined in the CAD as areas necessary to provide linkages between Primary Core Areas or increase overall representation of conservation targets. Finally, the CAD recommended 30 Supplementary Sites covering 16,751 ha in the CAD study area.

While the CAD analysis identified substantial ecological values within the M-KMA itself, it also found substantial conservation or ecological values in the areas surrounding the M-KMA (e.g., 56% of the recommended Primary Core Area falls outside the M-KMA). From a regional perspective, the large amount of Primary Core Area found outside of the M-KMA boundary indicates the importance of these surrounding landscapes to the maintenance of robust natural systems within the Management Area (from 2004 CAD).

The conservation biology literature cites a range of protection targets to help ensure adequate protected area representation and connectivity. Meta-analyses of land use planning for conservation have found that the proportion of a region's land base that must be managed primarily to meet conservation objectives lies between 25 and 75%. The median protected area recommendation lies above 50%.[18]

18 For example, the B.C. Coast Information Team in the EBM Handbook recommend various percentages of protection depending on scale. At the landscape level as a percentage of natural forests, it is recommended that a minimum of 50 % is protected. p. 64 of http://ilmbwww.gov.bc.ca/citbc/c-ebm-scibas-fin-04May04.pdf. Overall, the Great Bear Rainforest Agreement protected 51% of the forested land base from intensive logging.

Therefore, in order to ensure that the network of protected areas within the greater M-K ecosystem contains sufficient land to ensure the future conservation of biodiversity, especially in the face of an uncertain climate future, it must adequately represent each of the ecosystem's physiographic sub-provinces and special elements, and should contain approximately 50% of the land base within its boundaries.

Horseranch Range looking East to the M-KMA.

Johnny Mikes

3. Protection Status in the M-KMA

About 27% of the M-KMA is fully protected today, while further protected lands are located outside the M-KMA, within the greater study area. From the perspective of ensuring that the protected areas network adequately represents the physical variety inherent in the region, it is also important to consider the lands protected according to each physiographic unit. As illustrated on the next page (Table 6), some units are well represented, while others such as plateaus and plains have significant representation gaps. Thus these productive but somewhat more homogeneous ecosystems lack protection or specific management strategies for biodiversity conservation.

Table 6 shows the percent of protected lands in each physiographic sub-province in the greater M-KMA study area, from highs of 25-27% in the Kechika Ranges, Rocky Mountain Foothills and Muskwa Ranges to lows of either none or less than 1% in the Alberta Plateau, Dease Plateau, Liard Plain and Rabbit Plateau. Within the context of a broad goal to protect the full range of variety, rarity and all types of physical landscapes within the greater M-KMA study area, there is a significant conservation shortfall in the plateaux and plains physiographic units.

For example, the Liard Plain is the sixth largest physiographic unit in the study area, and has significant gaps in protected representative physical features: only 4% of the area is protected and few of the most characteristic features are protected. The areas with concentrations of the highest physical variety and rarity are not protected. In contrast, the Rocky Mountain Trench has 7% in protected areas within the study area, capturing 43% of the highest physical variety but none of the areas of highest rarity.

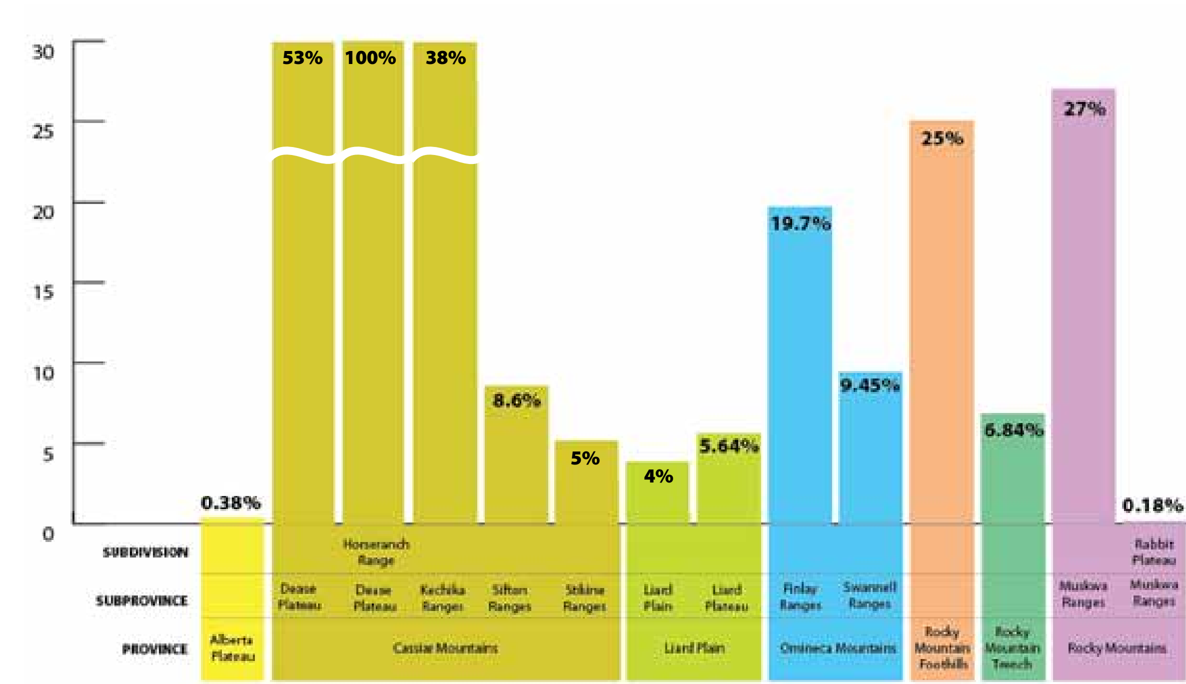
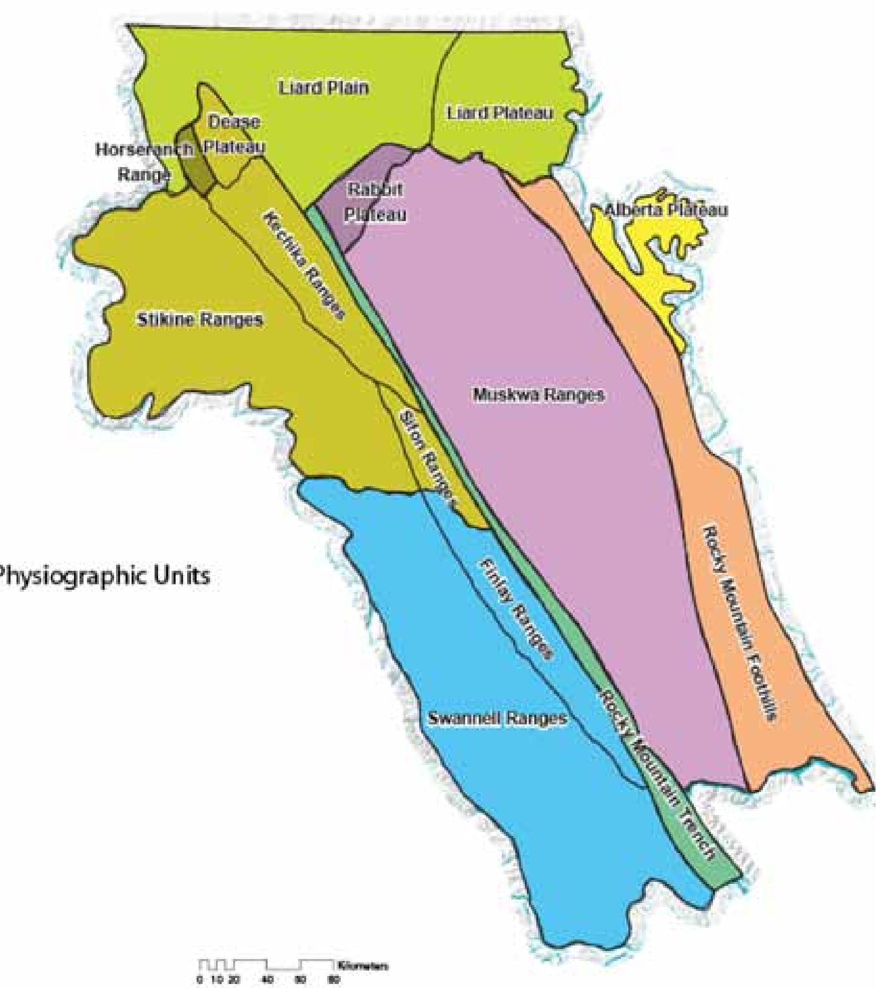


TABLE 6 Percentage of Each Physiographic Province Protected

Note: The bar colours in Table 6 match the physiographic unit colours in the inset map



Physiographic Units

4. Example Conservation Gap Analysis by Physiographic Province

Our assessment of existing conservation status for the study area as a whole provides a picture of where the most significant conservation gaps are located. The assessment points to focussing special land use management on areas with concentrations of high enduring feature variety or rarity, and in areas with little or no representation of typical enduring features.

The study team also completed a more detailed conservation gap analysis of each physiographic province in the study area. This assessment allows land managers to review conservation status and needs at a more manageable scale, and to set conservation priorities on lands outside existing protected areas.

An example physiographic province report is provided here; the full set of 14 assessments is in Appendix 3.

Physiographic Province Report

Physiographic Province: Rocky Mountain Foothills

Summary:

The Rocky Mountain Foothills are a narrow, upland area flanking the eastern side of the Rocky Mountains, extending 380 km south from the Liard River to the Peace River (and continuing into Alberta). Immediately south of the Toad River the Foothills are 16 km wide and are 65 km wide at the Peace River. Bordering the Interior Plains system to the east, they are part of the Eastern System of the Western Cordillera of North America. The Foothills are largely underlain by sedimentary rocks and summit elevations range up to 2,100 meters.

- Province area: 1,363,659 hectares
- 7 protected areas totalling 341,390 hectares (25% of the physiographic province)
- the 47 most frequent enduring features cover about 50% of the unit
- all 47 of these features are captured within the 7 protected areas.

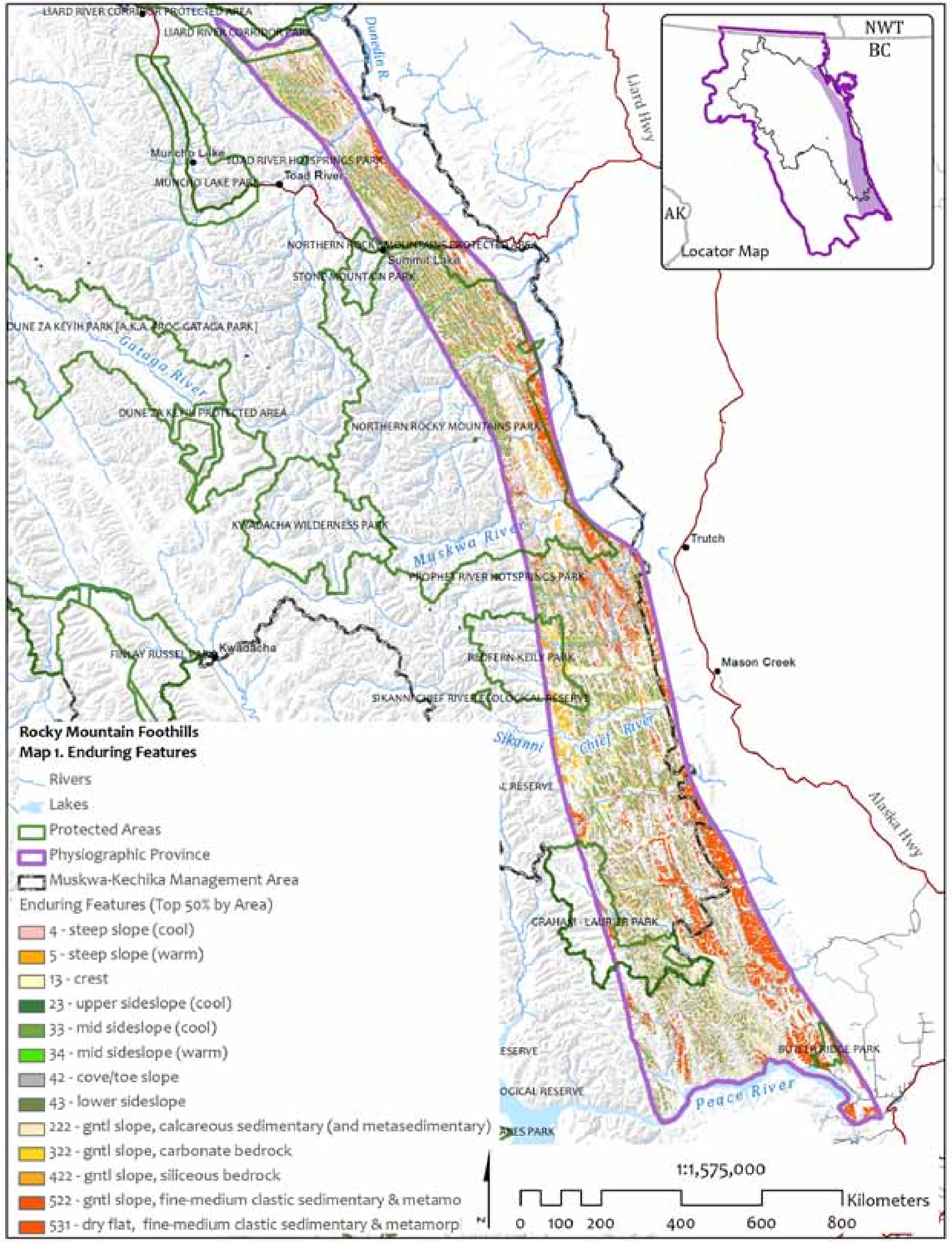
While 100% of the variety of these features is represented, only 25% of their areal extent within the province occurs in protected areas. Said differently, the high variety is captured within small representative patches.

Detail:

These are the parks and protected areas and their size within the Rocky Mountains Foothills physiographic province:

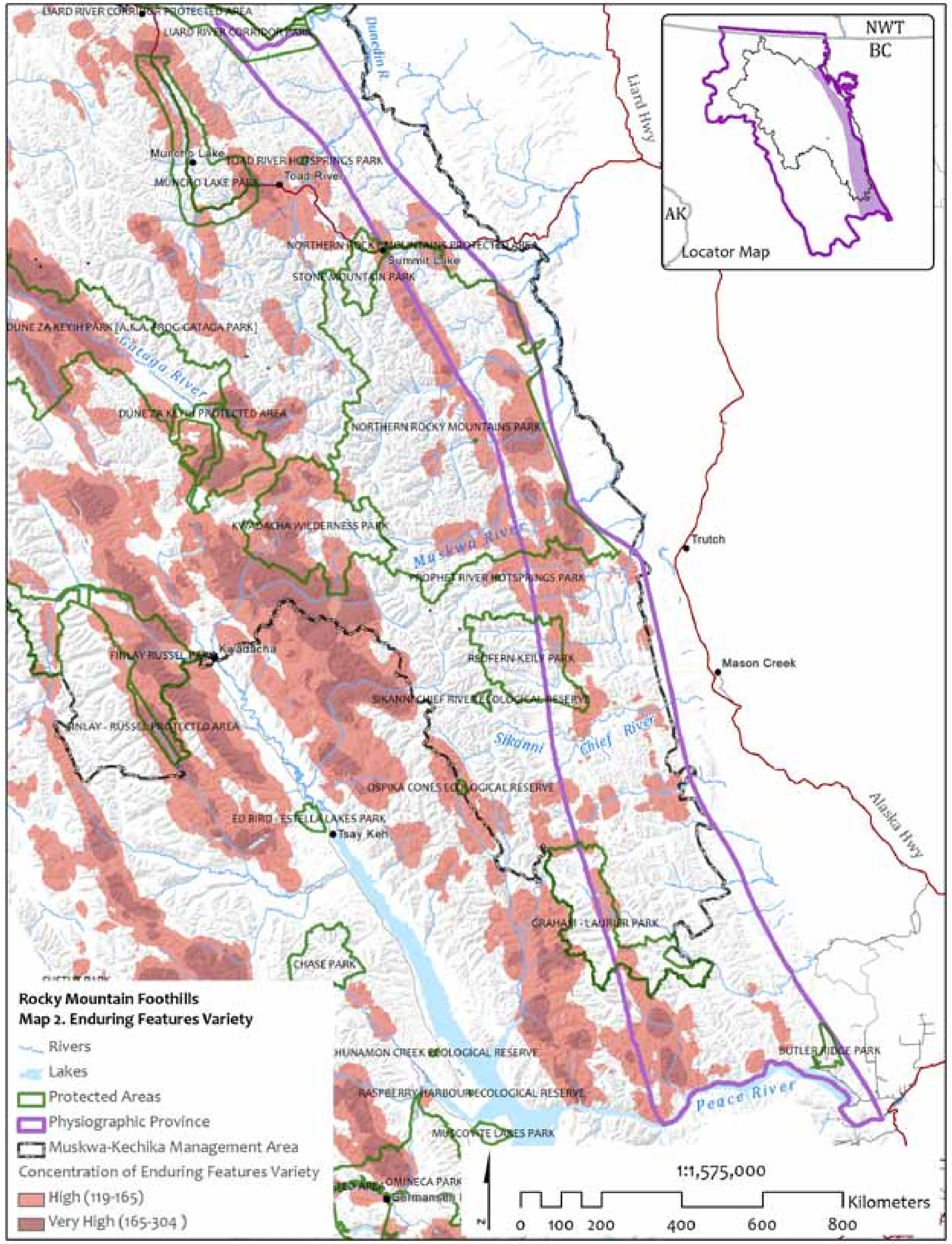
NORTHERN ROCKY MOUNTAINS PARK	(13,117,140 ha)
GRAHAM-LAURIER PARK	(2,201,013 ha)
REDFERN-KEILY PARK	(952,074 ha)
LIARD RIVER CORRIDOR PARK	(471,987 ha)
STONE MOUNTAIN PARK	(26,163 ha)
NORTHERN ROCKY MOUNTAINS PROTECTED AREA	(26,000 ha)
BUTLER RIDGE PARK	(2,198 ha)

MAP 36
Most Frequent Enduring Features Comprising 50% of Area of Rocky Mountain Foothills



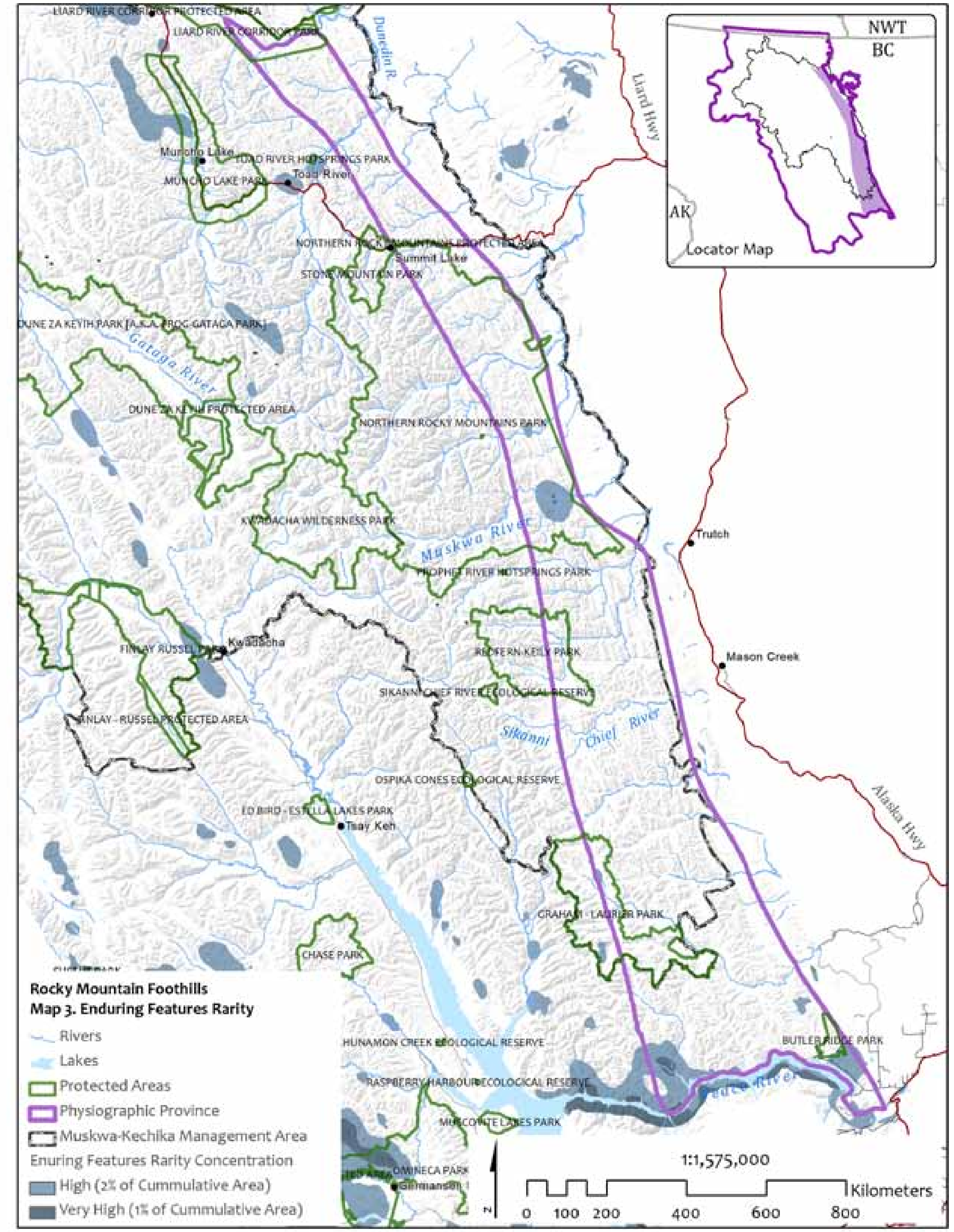
These 47 enduring features describe the common physical characteristics of the Foothills. All of these features are represented in existing protected areas, although in only 25% of their areal extent. (Note that not all 47 enduring features are displayed as elevation is excluded from the legend).

MAP 37 Enduring Features: Concentrations of High Physical Variety in the Rocky Mountain Foothills



Forty percent of the areas in the Rocky Mountain Foothills having the highest physical variety are included in protected areas. Northern Rocky Mountains Park contain concentrations of high physical variety.

MAP 38 Enduring Features: Concentration of High Physical Rarity in the Rocky Mountain Foothills



Twenty-eight percent of the most rare features in the Rocky Mountain Foothills are within protected areas. Northern Rocky Mountains Park captures the bulk of high concentrations of physical rarity protected.

VII. Projected Ecological Upheaval Compared to High Variety & Rarity

This conservation assessment, based on enduring features in each physiographic province and sub-province, provides information on the distribution and physical attributes of physical variety or rarity in the landscape. Since enduring features will persist through periods of climate change, we have combined data on expected climate change with enduring features to project areas of high or low ecological upheaval. This information helps land managers to make land use decisions today in anticipation of the potential effects of climate change on wildlife and vegetation.

Two maps were constructed to answer the questions:

a) Where do the areas projected to have the lowest degree of ecological upheaval (i.e., the bottom two categories on Map 39) overlap with the areas having the highest concentrations of physical rarity (i.e., the top two categories on Map10) and/or variety (i.e., the top two categories on Map 8)?
b) Where do the areas projected to have the highest degree of ecological upheaval (i.e., the top two categories from Map 40) overlap with areas having the highest concentrations of physical rarity and/or variety?

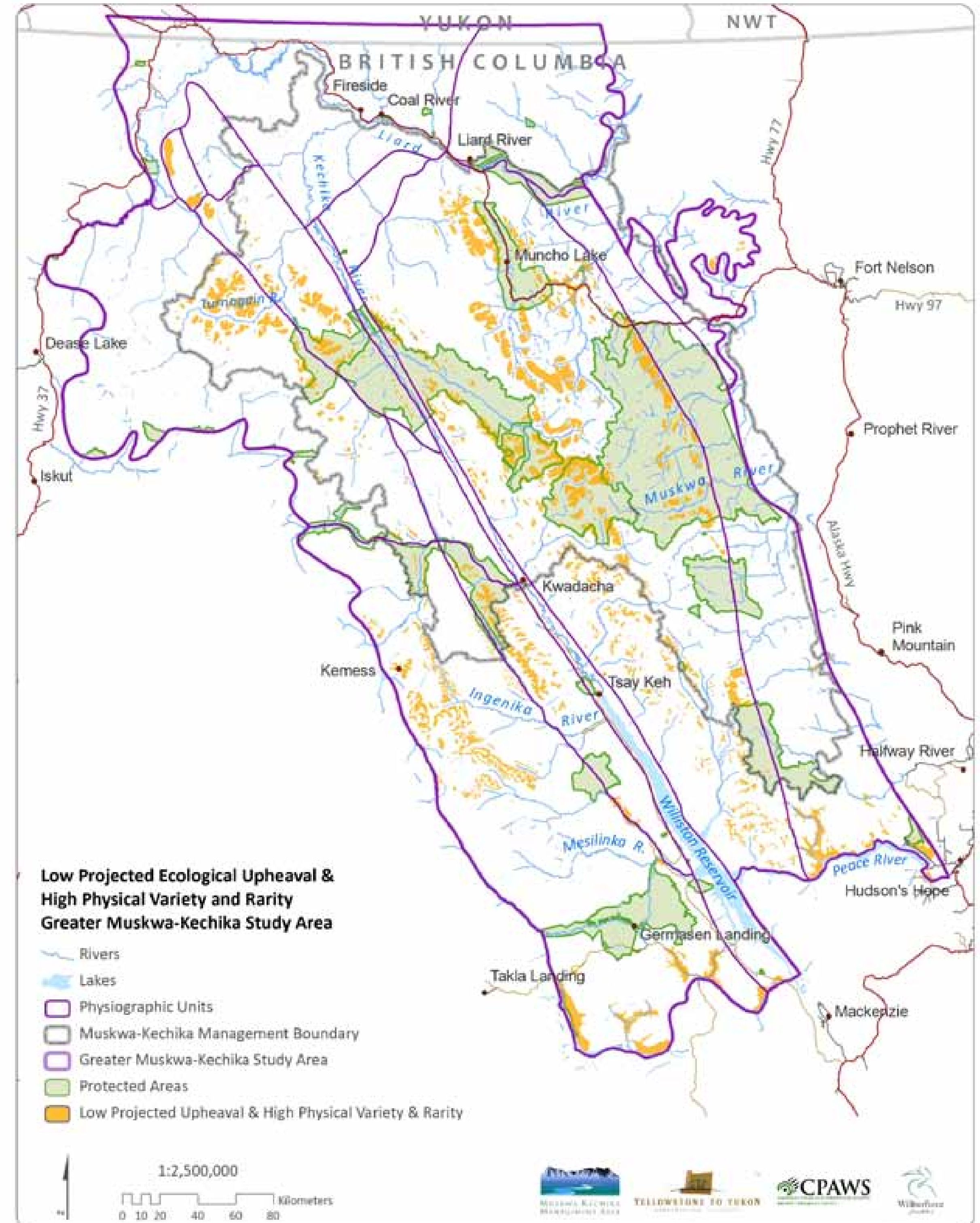
The analysis of these datasets highlights:

a) Areas that could contribute significantly to a climate conservation network (or climate change refugia), because they are projected to be relatively stable over time;
b) Areas of important physical features most at risk of ecological upheaval, consequently where protection of intactness and connectivity are most important to protect biodiversity and key ecological processes.

1. Areas of Low Projected Ecological Upheaval and High Physical Variety and Rarity

The areas highlighted in yellow on Map 39 show landscapes projected to have low ecological upheaval (two lowest categories) due to climate change, combined with high (two highest categories) physical variety and rarity scores. Headwaters south of Muncho Lake, the Turnagain watershed, the Fox and Ingenika headwaters, and along the southwest boundary of the study area are projected to be relatively stable and thus deserving of special management. These diverse places could provide important relatively secure habitat for species during climate change. Maintenance of habitat integrity and wildlife connectivity are key management strategies in these areas.

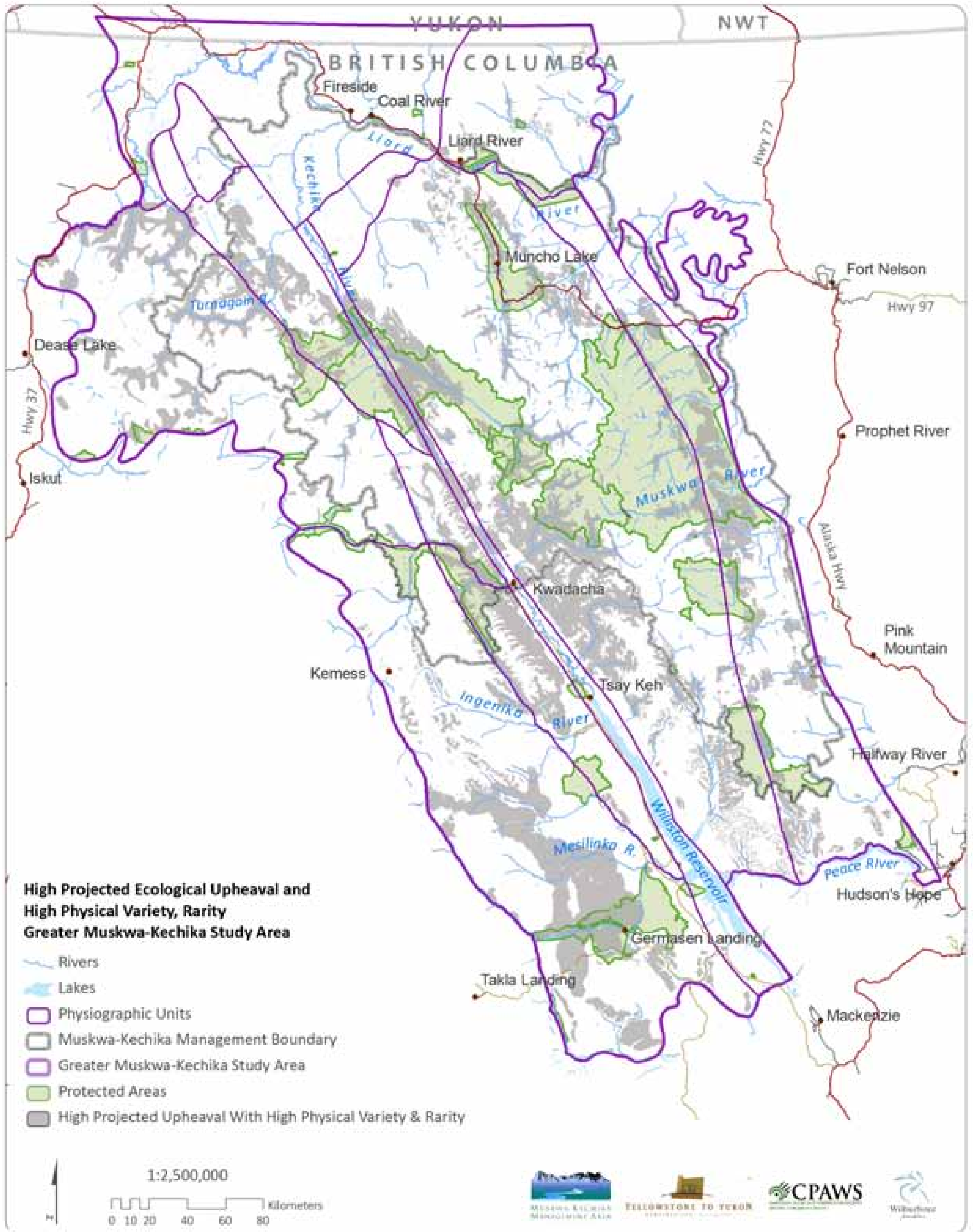
The areas highlighted in grey on Map 40 show landscapes projected to have high ecological upheaval (two highest categories) due to climate change, combined with high physical variety and rarity scores (two highest categories). Many such areas are outside existing protected areas, e.g., the southwest



MAP 39
Areas with Low Projected Ecological Upheaval and High Physical Variety and Rarity

corner of the study area, east of Kwadacha and northeast of Tsay Keh. While species composition and distribution will change over time, these areas should remain important for wildlife movement between areas of future suitable habitat. Maintenance of wildlife connectivity is a key management response in these areas.

MAP 40
Areas with High Projected Ecological Upheaval and High Physical Variety and Rarity



2. Projected Ecological Upheaval and Caribou Habitat

In this analysis we asked the question: where are the connectivity links and flows for caribou most impacted by projected ecological upheaval? Map 41 shows the current distribution of caribou herds in the M-KMA region, as reported in the 2004 CAD. We overlaid the caribou linkage and current flow models (Map 18) with the degree of projected ecological upheaval (Map 31) and colour coded the results. Map 42 displays the top caribou linkage and gateway areas using the colour code for five degrees of ecological upheaval. The map shows the areas where climate change is most likely to affect existing caribou connectivity—along the length of the Rocky Mountain Foothills, and areas in the Rocky Mountain Trench, especially towards the northern end of the study area.

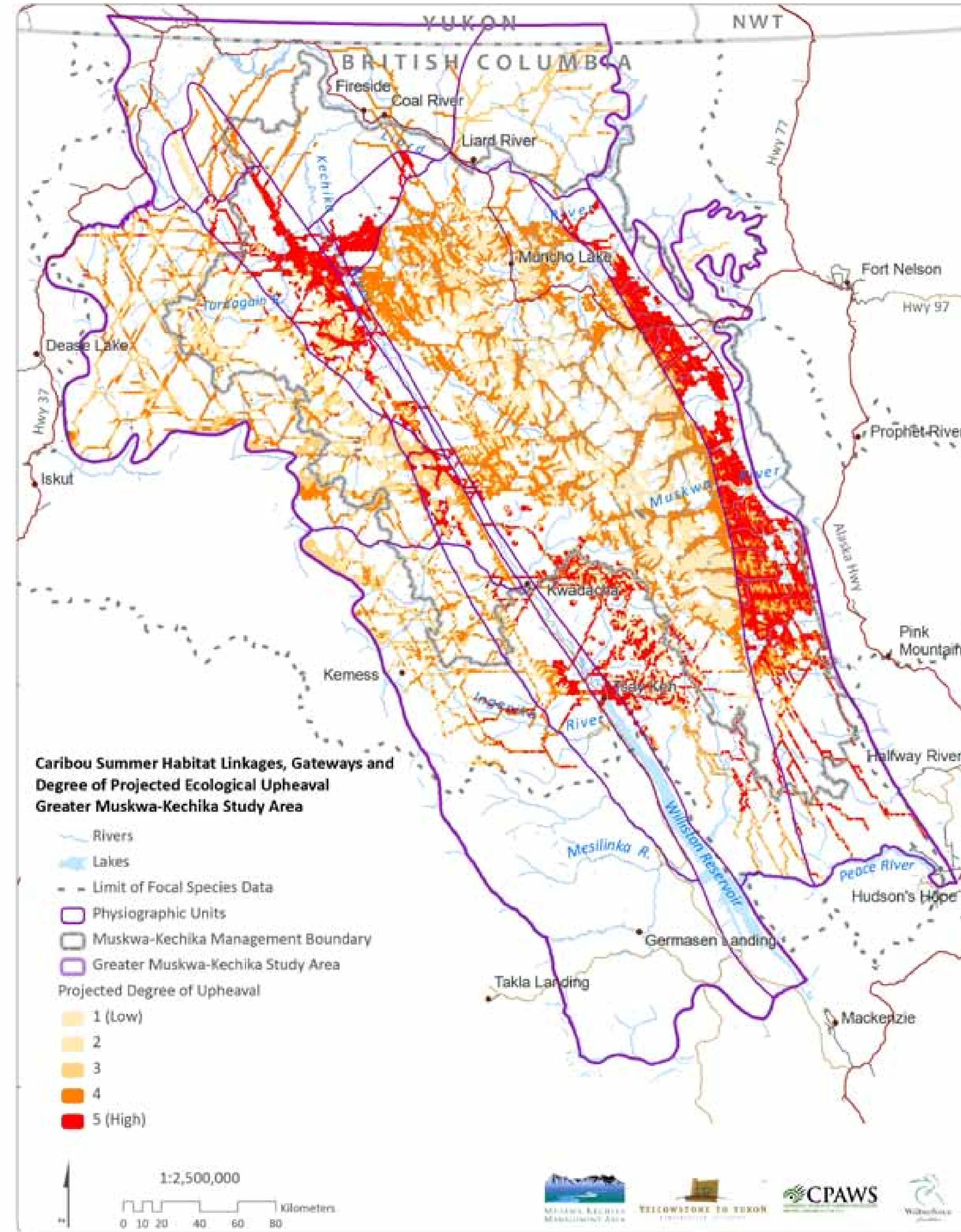
Note that data are not available for the south western part of the study area. The white areas of map do not indicate that there are no caribou; rather these areas had no compatible data and therefore were not assessed. Also important is the edge effect of available data—closer to the edge of the study area the data may be less complete. For example, at the far southern end of the Rocky Mountain Foothills, the map suggests truncated, less important or less numerous caribou connectivity links. However, this is likely the result of less data being available at the extreme edges of the study area, rather than an indication of diminished importance for caribou.

Caribou are vulnerable to climate change and the projected ecological upheaval in the greater M-K ecosystem.

Wayne Sawchuk

MAP 41
Current Distribution of Caribou Herds in the M-KMA Region (from 2004 CAD)

MAP 42
Caribou Summer Linkages/ Gateways and Degree of Projected Ecological Upheaval



VIII. Recommendations

1. Management Context

Planning for long term biodiversity conservation and climate change adaptation calls for a holistic approach to land management. The scope of these recommendations encompasses the entire Muskwa-Kechika Management Area, plus adjacent lands within the greater M-KMA ecosystem. The recommendations, primarily based on scientific analysis of enduring features and climate change data, are provided as advice to the M-KMA Advisory Board, which in turn may make recommendations to the BC government on implementing the proposed actions.

However, these recommendations are also pertinent to other land managers and levels of government, such as First Nations and communities, who may be developing or implementing land, watershed or resource use plans in the M-KMA region. Resource and tourism businesses also have a role to play in considering and supporting these recommendations, as do non-government organizations and the general public. Ensuring the ecological integrity of the M-KMA now and through projected long term climate-induced changes is the responsibility of all of these entities.

In fact, over time, decisions on road or resource development proposals at a watershed scale will play a significant role in achieving conservation goals, such as conserving the variety of wildlife and maintaining ecosystem integrity. However, the tools for evaluating cumulative effects of development at a watershed or larger scale are limited, as pointed out in a 2011 Special Report of the BC Forest Practices Board:

> *There is no requirement to assess the cumulative effects of the myriad of minor activities that are continually authorized on the land. The result is that cumulative effects of the natural resource development remain largely unknown and unmanaged. A commonly proposed solution to this problem is to conduct broad scale assessments (e.g., regional strategic environmental assessments). These solutions meet with limited success because there are no institutional mechanisms to use the results of the assessments—that is, there is no one to tell.* [19]

The environmental impacts of proposed developments in the greater ecosystem of the MKMA should be assessed at a site, watershed, and landscape scale.

19 *Cumulative Effects: From Assessment Towards Management*. (2010) Forest Practices Board Special Report. FPB/SR/39.

The M-KMA Act and Management Plan set the context for the recommendations in this report. Our recommendations are consistent with the Act and the intent of the Management Plan, and are also in line with the spirit of the strategic plans completed or being developed for:

- Wildlife (M-KMA Wildlife Management Plan)
- Oil and Gas (Pre-tenure Plans)
- Recreation (Recreation Management Plan)
- Forestry
- Provincial Parks (Park Management Plans)

The scientific findings, maps and recommendations presented in this report also link to existing management concepts used in the M-KMA Management Plan, such as:

Wilderness
- maintain wilderness characteristics and quality as outlined in the M-KMA operational definition of "wilderness," and incorporating the concept of "limits of acceptable change",

Ecosystem-Based Management
- actively manage human activities in a holistic manner that maintains ecological integrity,

Integrated Resource Management
- manage and coordinate a mosaic of land uses in a single area, with dual goals of optimising sustainability and reducing user conflicts,

Cumulative Effects Assessment and Management
- measure and limit the collective impacts to an ecosystem from the full range of activities in that ecosystem,

Adaptive Management
- monitor the results of management approaches and learn from the results to improve management techniques over time.

2. Importance of the Precautionary Principle

The Preamble to the international Convention on Biological Diversity defines the "biodiversity precautionary principle" as:

> *"…where there is a threat of significant reduction or loss of biological diversity, lack of full scientific certainty should not be used as a reason for postponing measures to avoid or minimize such a threat."*

Given the finality of extinction, biodiversity conservation planning should incorporate wide margins of safety against the potential loss of organisms, populations or ecological processes. In particular, biodiversity conservation plans must carefully consider the consequences of further human impact and loss of natural habitat, even when no obvious role or effect on the ecosystem has been empirically described. In other words, the absence of ecological data does not equate with the absence of ecological importance (from the 2004 CAD).

3. General Recommendations

This report's recommendations are organized into four broad categories based on these principles:

- Maintain the ecological integrity of high conservation value lands that are not represented in protected areas;
- Conserve existing wilderness;
- Implement an M-KMA climate change adaptation strategy to meet long term conservation goals;
- Enhance communications and public awareness about the M-KMA and the report recommendations.

a. Maintain the Ecological Integrity of High Conservation Value Lands

What are the recommended priorities for long term conservation in the M-KMA?

- As a management priority, maintain the ecological integrity of high conservation value lands identified in this assessment. These areas are mapped as having concentrations of high enduring variety, rarity, productivity or wildlife connectivity values. Focus special attention on high conservation value lands that are not represented in existing protected areas.

- Enhance the configuration of existing protected areas and special management zones within the M-KMA to meet current and future conservation goals, including maintenance of wildlife connectivity, given the projected ecological upheaval from climate change.

- Complete the network of representative protected areas to include the full spectrum of enduring features (physical environments) in the greater M-KMA region. Focus first on those physiographic regions that have no representation or less than 1% represented in protected areas, such as the Liard Plain, Rabbit Plateau or Dease Plateau.

- Seek ways to incorporate traditional and indigenous ecological knowledge (TIEK) to add to and validate the findings of this study. Support the use of TIEK in management and land use decisions to improve the information presented in this report by identifying unique, rare, or key habitats and features, as well as occurrences of species, biological hotspots and areas of key wildlife connectivity. For example, test the accuracy of wildlife connectivity maps by asking local people to compare the maps of focal species pathways with their knowledge of nearby watersheds.

- Provide the means for different resource sectors, such as mining, oil and gas, forestry and renewable energy, to compare updated resource value maps with the conservation maps in this report. Identify areas of high and low conflict between biodiversity conservation and resource development values. Work with industry to focus development in areas having lower conservation value. Provide GIS-based conservation data to industry to support this work.

b. Conserve Wilderness

How can wilderness contribute to long term ecosystem conservation goals?

- Maintain wilderness in the greater M-KMA ecosystem as part of a climate change adaptation strategy, and as a way to ensure the ecological integrity of areas with high physical variety, rare features, wildlife connectivity and high primary productivity.
- Implement the existing approved management recommendations to maintain wilderness in the M-KMA, as they also apply broadly to the maintenance and protection of areas of high physical variety, primary productivity, connectivity and value as part of a larger regional climate change sanctuary.

c. Implement a Climate Change Adaptation Strategy

What actions will help achieve effective conservation in the M-KMA in a time of rapid and uncertain climate change?

- Manage the M-KMA for its important role as part of a climate change adaptation strategy for the greater Yellowstone to Yukon region. Manage the intact landscapes and wildlife linkages in the M-KMA as a climate change sanctuary.[20]

An M-KMA climate change adaptation strategy will help to bring animals successfully through the projected ecological upheaval brought on by climate change. Within the context of the greater Yellowstone to Yukon region within which the M-KMA sits, the M-KMA offers an increasingly rare example of a very large, intact ecosystem with fully-functioning ecological processes and inherent resilience to climate disruption. The precautionary approach would be to manage the greater M-KMA region as a climate-change sanctuary, i.e., a theatre large enough for the ecological drama to unfold, where species can react and interact as best they can without excessive human-caused disturbances and habitat loss.

We recommend these general principles as a climate change adaptation framework for determining how to direct long term conservation efforts in the greater M-KMA ecosystem:

- Reduce adverse human impacts on species and ecosystems from sources other than climate change.
- Maintain and enhance connectivity in the M-KMA and greater ecosystem to enable wildlife and other organisms to adjust (as best they can) to changes in land use and climate.
- Focus management attention on areas with the best habitat suitability for species vulnerable to ecological upheaval.
- Consider the long term needs of focal wildlife species such as caribou, moose, grizzly bears, mountain goats and sheep.
- Increase the extent and effectiveness of conservation lands.
- Apply the best available science and support or create effective monitoring systems.
- Manage to maintain key ecosystem functions rather than status quo distributions of species and ecosystems.
- Engage communities to understand and discuss new challenges and create solutions.
- Collaborate at appropriate scales.

d. Enhance Communications and Public Awareness

How can we increase support for achieving long term conservation goals in the M-KMA region?

- Engage First Nations, industry associations, user groups, non-government organizations and other interested parties in a dialogue about the findings of this study and how they could apply to future biodiversity conservation challenges and opportunities in the greater M-KMA study area.

20 For more information on climate change in the Y2Y region see: Graumlich, L. and W.L. Francis, (2010) Moving Toward Climate Change Adaptation: The Promise of the Yellowstone to Yukon Conservation Initiative for Addressing the Region's Vulnerability to Climate Disruption. Yellowstone to Yukon Conservation Initiative, Canmore, AB

- Use the community outreach process on the findings of this study to help validate the maps on variety, rarity and wildlife connectivity. For example, test the accuracy of wildlife connectivity maps by asking local people to compare the maps of focal species pathways with their knowledge of nearby watersheds.

- Improve public and local community awareness of, and support for, achieving long term conservation goals in the M-KMA, particularly as they relate to climate change. Distribute and make this report and its maps available through multiple sources, including the M-KMA Board, government agencies, First Nations, public libraries, non-government organizations, industry, communities, and universities.

4. Specific Recommendations

The following recommendations describe more precise actions to achieve biodiversity conservation goals in specific areas of the MKMA, using existing management tools in combination with the maps and analysis in this assessment.

a. Maintain the Ecological Integrity of High Conservation Value Lands

1. Using existing management tools, integrate high conservation value lands identified in this study with the existing protected areas network in the greater M-KMA ecosystem.

For example, focus on conservation strategies for areas of high physical variety and rarity, primary productivity, or crucial wildlife connectivity corridors that are linked to or fall outside the existing protected areas. Ideally, this means capturing, for each physiographic sub-province, all combinations of bedrock/landform/topography (enduring features), as well as the most important and typical hydrologic systems. In practice, it means putting a priority on the areas of greatest "enduring physical variety" and knitting high conservation value lands together by considering wildlife connectivity and hydrologic systems. Also consider data collected by the Peace Regional Protected Areas Team for study areas and candidate protected areas, for example in the northwestern part of the M-KMA and extending outside the M-KMA boundaries.

2. As a management priority, maintain wildlife connectivity among existing protected areas in the M-KMA, and to protected areas adjacent to but outside the M-KMA. For example, maintain landscape-scale wildlife connectivity north across the Liard watershed and plain, west of the M-KMA to the Stikine country, and west of the Horseranch Range.

3. In Special Management or Integrated Resource Use Zones, assess the potential impacts of roads and development proposals through the lens of ecological effects on:

- wildlife connectivity corridors and gateways, (Maps 17-27: these are both wildlife pathways across the landscape and places where there is a high level or hub of wildlife use by different focal species);
- high concentrations of physical variety (Map 8: these are areas with concentrations of high biodiversity);
- high concentrations of physical rarity, (Map 10: these are areas with concentrations of rare enduring features, which often support rare biological elements or physical features: See Appendix 1);
- primary productivity (Map 12 : these are riparian areas, wetlands, and productive forests);
- projected ecological upheaval due to climate disruption (Map 31) and resulting impacts on the availability of key wildlife habitat for focal species (for example, with a projected loss of alpine habitats, how much habitat will be available for caribou in the future: Map 34).

b. Address the Specific Gaps in the Network of Representative Protected Areas

4. Address the conservation deficit as measured by those physiographic sub-provinces of the M-KMA study area that have limited or no representation within protected areas. (For more information, see the conservation gap analysis maps in Appendix 3). Also consider data collected by the Peace Regional Protected Areas Team for study areas and candidate protected areas, for example in the northwestern part of the MKMA and extending outside the MKMA boundaries).

Physiographic units with less than 5% protected include:

Rocky Mountains/Muskwa Ranges - Rabbit Plateau	(0%)
Alberta Plateau	(0.2%)
Liard Plain - Liard Plain	(4%)
Liard Plain - Liard Plateau	(2%)

Physiographic units with 5-10% protected include:

Cassiar Mountains - Stikine Ranges	(5%)
Cassiar Mountains - Sifton Ranges	(6%)

5. Maintain and protect high conservation value lands (high enduring feature variety or rarity, or wildlife connectivity values) that are outside the established protected areas network. Focus on high conservation value lands that are not represented in existing protected areas. (See Maps 8 and 10 illustrating the locations of concentrations of high physical variety and rarity. Map 11 shows the combined variety and rarity hotspots).

Physiographic units with no protection (0%) of the areas of high enduring feature variety include:

Rocky Mountains/Muskwa Ranges - Rabbit Plateau	(0%)

Physiographic units with protected areas capturing less than 5% of areas with high enduring feature variety include:

Liard Plain - Liard Plateau	(4%)
Cassiar Mountains - Stikine Ranges	(4%)

Physiographic units with protected areas capturing 5-15% of areas with high enduring feature variety include:

Omineca Mountains - Swannell Ranges	(10%)
Cassiar Mountains - Sifton Ranges	(11%)

Physiographic units capturing 1% or less of the areas with concentrations of high enduring feature rarity include:

Rocky Mountain Trench	(0%)
Alberta Plateau	(0%)
Rocky Mountains/Muskwa Ranges - Rabbit Plateau	(0%)
Liard Plain - Liard Plateau	(1%)
Liard Plain - Liard Plain	(1%)

Physiographic units capturing 1-15% of the areas with concentrations of high enduring feature rarity include:

Omineca Mountains - Swannell Ranges	(15%)
Omineca Mountains - Finlay Ranges	(4%)
Rocky Mountains - Muskwa Ranges	(6%)

Geographic areas with concentrations of combined high physical variety and rarity—these "hotspots" warrant further assessment to validate their potential for biodiversity conservation management or protection:

1. Stikine Ranges, East and Northeast of Dease Lake
There are two main areas of special interest, one east of Dease Lake, and the other northeast of Dease Lake and north of the Turnagain River. Both are outside or partially outside the MKMA boundary.

2. Finlay Ranges and Sifton Ranges, West of Kwadacha
Several nodes of combined high variety and rare features occur north of the Ingenika River, and immediately west of the Rocky Mountain Trench.

3. Swannell Ranges in Omineca Park Vicinity
A large concentration of high variety and rarity occurs to the northwest of Omineca Park in the Mesilinka and nearby watersheds.

4. Rocky Mountain Foothills and Muskwa Ranges
Two large concentrations of high variety and rarity occur at the southwest end of the study area, east of Williston Reservoir and north of the Peace River. Other smaller concentrations occur in the northern part of these ranges, for example just outside of Muncho Lake Provincial Park.

c. Implement A Greater M-KMA Region Climate Change Adaptation Strategy

6. As a long term strategic goal, conserve and represent the full spectrum of physical environments in the greater M-KMA region as one of the best ways to maintain biodiversity during climate change. Conserve and protect intact large watersheds, because these watersheds are functional ecosystems with the greatest likelihood of resilience to climate change and maintaining ecological integrity over the long term. As part of this strategy, use the enduring features assessment in this report to identify and conserve areas with high concentrations of physical rarity and variety.

7. Maintain habitat connectivity in the landscape for terrestrial and aquatic species to allow animals and other organisms to adapt to changes in land use and climate:

- apply the precautionary principle to maintain intact landscapes and watersheds in the M-KMA, with as few roads as possible,
- manage land uses to minimize habitat fragmentation,
- focus management attention on areas with the best habitat suitability for species vulnerable to ecological upheaval,
- manage land uses to conserve areas with high concentrations of wildlife linkages or wildlife movement hubs (e.g., Maps 18-27),
- avoid roads and other disturbance in areas with concentrations of enduring features variety or rarity; odds are these areas are biological hotspots and/or support rare or uncommon species (e.g., Maps 8-11),
- avoid roads and other development in areas identified as having a high value for wildlife connectivity, such as seasonal migration routes or corridors between key habitat areas (e.g., Map 23),
- undertake research to set appropriate thresholds of linear disturbance in the M-KMA landscape for focal wildlife species. In areas of integrated resource use, avoid developing a road density that exceeds these thresholds (Note: Determining linear disturbance thresholds was beyond the scope of this assessment. Research in boreal forest landscapes in Alberta suggests a maximum road density of 0.6 km of road per square kilometre of area, but these studies were not necessarily completed in mountainous terrain. The Alberta Grizzly Bear Recovery Plan 2008-2013 also recommends a threshold of 0.6 km/km^2),
- where roads are permitted, allow for temporary use with road closure and rehabilitation to follow once the need for the road has ended.

8. As a high priority to manage for climate change adaptation at a landscape scale, protect or carefully manage areas of high climatic and topographic variety, (e.g., Map 37).

9. Protect or carefully manage areas of high physical diversity and high rarity combined with high projected ecological upheaval, (e.g., Map 40).

10. Based on the mapping results in this assessment, protect or carefully manage priority areas for enhancing resilience to climate change, for example where current habitat for a focal species is connected to or near projected future habitat, (e.g., Maps 37 & 38).

11. In areas with concentrations of wildlife linkages that also are projected to have high ecological upheaval from climate change, place a priority on protecting or carefully managing areas with the best habitat suitability for focal species, (e.g., Map 42).

12. To conserve focal species, identify priority conservation areas from the projected overlap of species habitat over time, by locating optimal "climate corridors" that allow dispersal to new habitat as climate shifts. (For example, identify which ungulate populations are going to be most affected by ecological upheaval and manage land uses to conserve habitat connectivity for these herds. For instance, sheep are more likely to disperse whereas goats have higher fidelity to specific sites. Nonetheless, in areas of high ecological upheaval, sheep habitat will be more vulnerable to change. Strategic prescribed burning could help maintain key sheep habitats.)

13. Undertake research and mapping to project how focal species habitat will shift in response to climate change. Such an assessment will be useful in projecting changes to wildlife connectivity patterns.

14. Regard the M-KMA as a laboratory for climate change adaptation; apply the principles of adaptive management and develop a climate change monitoring program.

15. Evaluate the need for proposed industrial road corridors that bisect existing protected areas or that could reduce wildlife connectivity during projected ecological upheaval; assess these corridors for their potential conservation value, and manage these areas to maintain ecological integrity and wildlife connectivity.

d. Communications and Public Awareness

16. To improve public and local community awareness of, and support for, achieving long term conservation goals in the M-KMA,

- announce completion of and release this M-KMA conservation assessment to the public, focussing on how the report provides guidance for climate change adaptation in the future,
- post the conservation assessment in PDF format on the M-KMA website,
- distribute and make the report and maps available through multiple sources, including the M-KMA Board, government agencies, First Nations, public libraries, non-government organizations, industry, communities, and universities,
- provide a briefing on the report findings and recommendations to provincial, First Nation, regional and municipal governments.

17. To enable the use of this report's maps and data, and to facilitate implementation of these recommendations,

- house the assessment data and GIS maps in accessible public websites, such as the M-KMA, BC government agencies, and Y2Y, to allow for on-going use by land managers, First Nations, communities, scientists and other researchers, and non-government organizations,
- support a strategy to present the study findings in M-KMA region communities,
- provide conservation data to resource industries for their planning work, or conduct follow-up in-house work to update maps of renewable and non-renewable resource values in the greater M-KMA, to identify areas of overlap between high conservation value lands and other economic resources.

IX. Conclusion

This conservation assessment and outreach project aims to help solve challenges in the future management of the greater Muskwa-Kechika Management Area (M-KMA) ecosystem. We provide a variety of tools to assess the existing network of conservation lands, strengthen conservation measures in light of climate change, plan and evaluate land and resource use proposals within this shifting environment, and gain further public and community understanding of and appreciation for the biodiversity values of the M-KMA.

The Yellowstone to Yukon Conservation Initiative (Y2Y) supports this work because of the important role that the M-KMA plays within the Yellowstone to Yukon region. The northern reaches of the Yellowstone to Yukon region, including the greater M-KMA ecosystem, contain some of the best remaining natural habitats on the continent. The management model for the M-KMA is a globally-leading example of large landscape conservation, in which core protected areas are embedded in a landscape available for limited and sustainable commercial and industrial uses. The future management of this ecosystem will determine the success or failure of the Y2Y vision for biodiversity conservation, including conserving the wide ranging focal species that are emblematic of the M-KMA.

The northern Rocky Mountains are a benchmark for biodiversity and focal species conservation in the Y2Y region.
Wayne Sawchuk

Conclusion

In this report we:

1. Provide strategies to help ensure that the wilderness and wildlife goals of the Muskwa-Kechika Management Area are met;
2. Identify how well the existing protected areas and special management zones achieve broad conservation goals based on a scientific analysis of enduring features and, recommend strategies to increase the likelihood of meeting those goals;
3. Provide map-based tools to enable land managers within the greater M-KMA ecosystem to employ precautionary strategies to maintain wildlife and ecosystems in the face of climate change;
4. Provide conservation planners and managers with additional map-based information against which to assess the potential impacts of developments proposed within the greater M-KMA ecosystem;
5. Identify key wildlife habitat linkages within and outside the M-KMA;
6. Contribute information that will support First Nations' land use planning efforts in northern B.C. on lands in and adjacent to the M-KMA;
7. Inform any future review of land use plans in the greater MKMA ecosystem.

As suggested in our recommendations, planning for long term biodiversity conservation and climate change adaptation calls for a holistic approach to land management. Our recommendations provide advice to the M-KMA Advisory Board, but are also pertinent to other land managers and levels of government, such as First Nations and communities. Industry and local businesses also have a role to play in acting on these recommendations, as do non-government organizations and the general public.

This report and its scientific findings are potentially useful to a wide range of organizations and people who work to conserve the remarkable biodiversity and wilderness of the greater M-KMA ecosystem. It is also designed to help inform the assessment of proposed resource developments. To that end, Y2Y welcomes the opportunity to further explain the report findings to key audiences, and to assist in implementing its recommendations.

Bibliography

Anderson, M.G. and Ferree CE. (2010) *Conserving the Stage: Climate Change and the Geophysical Underpinnings of Species Diversity*. PLoS ONE 5(7): e11554. doi:10.1371/journal.pone.0011554

Beier, P. and B. Brost. (2010) *Use of land facets to plan for climate change: conserving the arenas, not the actors.* Conservation Biology 24: 701-710.

Bostock, H.S. (1948) *Physiography of the Canadian cordillera, with special reference to the area north of the fifty-fifth parallel*. Geological Survey Memoir 247. Canada Department of Mines and Resources, Ottawa, ON. 106 p.

Carroll, C., B. McRae, and A. Brookes. (2011) *Linkage mapping and centrality analysis across habitat gradients to conserve gray wolf population connectivity in western North America*. Conservation Biology, Conservation Biology 26:78-87.

Cumulative Effects: From Assessment Towards Management.(2011) BC Forest Practices Board Special Report, FPB/SR/39.

DeLong, C., D. Tanner and M. Jull. (1994) *A field guide for site identification and interpretation for the Northern Rockies portion of the Prince George Forest Region*. Land Management Handbook 29. BC Ministry of Forests, Victoria, B.C.

Graumlich, L. and W.L. Francis. (2010) *Moving Toward Climate Change Adaptation: The Promise of the Yellowstone to Yukon Conservation Initiative for Addressing the Region's Vulnerability to Climate Disruption*. Yellowstone to Yukon Conservation Initiative, Canmore, AB.

Groves, C., L. Valutis, D. Vosick, B. Neely, K. Wheaton, J. Touval and B. Runnels. (2000) *Designing a Geography of Hope: A Practitioner's Handbook for Ecoregional Conservation Planning, Volume II*. The Nature Conservancy, pp. A6-1 to A6-4.

Heinemeyer, K., et al. (2004) *Conservation Area Design for the Muskwa-Kechika Management Area (MKMA).*

Holland, S.S. (1964) *Landforms of British Columbia: A physiographic outline*. Bulletin No. 48, British Columbia Department of Mines and Petroleum Resources, Victoria, B.C. 138p.

MacKinnon, A., C. DeLong and D. Meidinger. (1990) *A field guide for identification and interpretation of the northwest portion of the Prince George Forest Region*. Land Management Handbook 21, BC Ministry of Forests, Victoria, B.C.

Muskwa-Kechika Advisory Board, *An Operational Wilderness Definition for the M-KMA*, February 29, 2004.

Muskwa-Kechika Management Area Act, Statutes of British Columbia, 1998, Chapter 38.

Pojar, J. (2010) *A new climate for conservation: Nature, carbon and climate change in British Columbia*. Report prepared for the Working Group on Biodiversity, Forests and Climate, an alliance of environmental non-governmental organisations. Vancouver, B.C. 99 p.

Province of British Columbia. (1993) *A Protected Areas Strategy for British Columbia*, Queen's Printer, Victoria, B.C.

Appendices

Appendix 1

A Scientific Framework for Using the Enduring Features Approach to Support the Conservation Assessment – Dr. Jim Pojar, 2011

Climate Change

There is no serious doubt that human-caused increases in atmospheric greenhouse gas concentrations are causing and increasingly will cause unpredictable changes to Earth's climate. Climate change will result in biome shifts; species losses, gains and reassembly in communities; changes to snowpack and to stream temperatures, flows and fish habitat; melting of permafrost; increased frequency of extreme events in general, with increased damage from storms, floods, and erosion including mass soil movements, droughts and wildfires; and more frequent and extensive outbreaks of pests, like bark beetles and needle/leaf diseases.[21] Under a changing climate, northern B.C. can expect major transformations in biodiversity on land, in water, and across all levels (genes, species, ecosystems, and the interactions among them). In these circumstances, the management priority for the M-KMA must be maintaining as much as possible of the its life support systems, and the resilience and adaptive capacity of species and ecosystems.

Climate Change and Biodiversity Conservation Planning

Most land use and conservation planning in British Columbia to date has not incorporated potential large-scale environmental change. To even hope to achieve its goals for biodiversity conservation, any such planning must address climate change and its implications. Planning should consider not only the current environment and contemporary plant and animal communities, but also and more fundamentally, future environmental scenarios underpinned by the physical components of regional landscapes and waterscapes—the different types of bedrock geology, physiography, landforms, lakes and streams. That is to say, planning should be focussed in large part on physical enduring features that are projected to not change much as climate changes, as species sort themselves out and as biological communities reassemble. The mountains, rivers and big lakes will remain, the plateaus will persist, morainal blankets and outwash terraces will stay as they are,[22] even as the life they support changes.

Biodiversity Conservation in a Dynamic Climate

Most current approaches for addressing climate change in conservation planning focus on 1) projections of future suitable habitat for individual species based on climate envelope models, 2) securing areas projected to be future refuges for species, and 3) maintaining or strengthening habitat connectivity in general, so that species can move around as their ranges shift. These are all worthy conservation efforts, but they are challenged by large uncertainties and dicey assumptions about climate models, greenhouse gas emission scenarios, species behaviour and dispersal, future habitat conditions, and the sheer unpredictability of biological response to rapidly changing climate. An alternative or complementary approach is to base conservation planning on physical features, i.e., on habitat elements that will persist unaltered as climate changes. The assumption in this approach is that habitat heterogeneity drives species richness, that biodiversity is largely a consequence of geophysical diversity, that conserving physical diversity should conserve biological diversity under present and future climates. There is evidence that regional geophysical factors (i.e., the underlying tapestry of rocks and soils, slope, aspect and humidity) shape patterns of species diversity and distribution through their influence on the chemical and physical properties of water and soil, thereby creating a variety of microclimates and habitats.

Coarse Filter/Fine Filter

Conservation biologists propose that by protecting a representative array of ecosystems, the majority of species (most of which we know little or nothing about) and their genetic diversity will be protected as well. This is termed "coarse-filter" conservation. However, some species and ecosystems will fall through the pores of the coarse filter, because of specialized requirements, or because they are rare, at risk, harvested for food, over-exploited, or otherwise of particular interest to managers. These species and ecosystems will require individual attention and management—the "fine-filter". Effective biodiversity conservation planning requires the application of both filters.

Conservation biologists traditionally have planned for three types of conservation targets: 1) abiotic or physical environment units, 2) biological communities and ecosystems, and 3) species. One can apply the coarse-filter/fine-filter screens to each of the three types of targets. To date most biodiversity conservation efforts have been directed at the second and third targets, i.e., the living elements of diversity. The premise of this study is that more attention should be paid to the first target, to physical features or non-living components of ecosystems, especially now in light of climate change. Initially this shift in emphasis is most usefully applied to the coarse filter.

Coarse filter

The rationales for using a coarse filter approach to select biodiversity conservation targets include a) our incomplete knowledge of the myriad species that live in an area, and thus the need for surrogates of biodiversity, and b) the impermanence of the living component of ecosystems—especially in times of rapid environmental change. The incompleteness of biological knowledge and the reality of climate change argue for placing more emphasis in conservation planning on the better known (or more readily accessible), less changeable components of ecosystems: physical landscape, geology, landforms, and watersheds.

Abiotic/Non-living elements: enduring features

Planning for biodiversity conservation based on representative enduring features is one coarse filter approach. Representation of a region's physical enduring features in a biodiversity conservation network is especially important in the context of climate change. If today we protect 50,000 ha of boreal forest, in 20 or 50 years it will not have the same mix of plant and animal species nor will it support the same

21 Pojar, J. (2010) *A new climate for conservation: Nature, carbon and climate change in British Columbia*. Report prepared for the Working Group on Biodiversity, Forests and Climate, an alliance of environmental non-governmental organisations. Vancouver, B.C. 99 p. http://www.forestethics.ca/new-climate-for-conservation-report

22 Over centuries, not through geological time (millions of years).

ecosystems as it does now; indeed it may no longer be forested. But the physical landscape will persist. Topography, bedrock geology, landforms and drainage systems will not change (barring landslides), and soils will change relatively slowly. The physical landscape is the template for ecosystems; it is the stage upon which the drama of climate change is playing out.

The physical landscape can most usefully be characterised in terms of physiographic units (big chunks of the regional landscape, like Muskwa Ranges and Rocky Mountain Trench), topography, bedrock geology, landforms, and hydrologic systems or "ecological drainage units". Digital information on physical variables such as elevation, topography, terrain, and substrate exists for the entire region. These data can be overlain and combined into digital terrain models and interpretive maps, with derived combinations of enduring features as proxies for ecosystems and ecological processes and as biodiversity conservation targets.

Fine filter

The enduring features approach can also enhance the fine filter screen for biodiversity conservation targets. Special physical elements/enduring features in northern B.C. include:

- bedrock features – regionally unusual or rare bedrock, karst systems, canyons and cliffs (physiographic edges), big waterfalls, ultrabasic (serpentine) rock,
- glacial history features – eskers, kames, pitted outwash, crevasse fillings, kettle lake complexes and other glaciofluvial (originating in rivers that drained glaciers) and glaciolacustrine (originating in lakes formed by glaciers) landforms,
- process features – landslide complexes, slumps in permafrost landscapes, rock glaciers, hoodoos.

Small-scale ecosystem elements also having a major enduring features component that should be considered in biodiversity conservation plans include:

- mineral springs and hot springs,
- essential or key wildlife habitats, traditionally used and limited in availability – maternity areas, winter ranges, mineral licks,
- lakes with open water all winter or early in spring,
- concentrated spawning areas in streams,
- short streams that connect lakes (important corridors),
- stream segments with groundwater discharge of quantity and quality to support aquatic species throughout the winter (persistent winter-open water in streams),
- unusual or special wetlands/wetland types (e.g., rich fens, migratory stopovers),
- boreal grasslands.

Species of unusual specialised habitats (e.g., archaebacteria and molluscs in thermal springs, rare ferns on ultrabasic bedrock) are more likely to persist as long as their special habitats continue to exist. In any case, their special enduring features (thermal springs, serpentine cliffs and talus) will probably continue to support regionally rare or unusual species and ecosystems indefinitely. Karst terrain will continue to support some sort of regionally unusual biota regardless of how much climate changes. In our present circumstances, it makes conservation sense to focus on the special enduring features as much as on their unusual contemporary species.

More generally, the biodiversity hotspots of today will probably continue to be hotspots in future climates, but with a different assemblage of species. To the extent that biodiversity hotspots are a function of physiography, topography, geology, sharp climatic gradients and complex local climates, as well as of moisture, nutrients and primary productivity, they will persist—unless climate changes so much that such physical variation and gradients are overwhelmed.

This report's authors propose that an enduring features approach, that is, basing biodiversity conservation plans on the physical environment rather than on projected distributions of individual species and their habitat, is likely to be more effective in conserving biodiversity over the coming centuries. Over the coming decades, merely conserving the stage ("geophysical settings"[23]) or arena ("land facets"[24]) will not necessarily sustain the actors, and will neither prevent local extinctions of individual species nor guarantee survival of focal species like caribou or Stone's sheep. We also need to continue with focal species management, protecting critical habitat for threatened species, hotspot analysis, connectivity conservation, and landscape design based on contemporary land cover and patterns of productivity. Conservation is a complicated endeavour; we need a variety of approaches and tactics, especially to get as much biodiversity as possible through the "big squeeze" to the end of this century.

This goal can best be accomplished through management that minimizes habitat fragmentation, secures core sanctuaries with buffers, and around the conservation lands and waters provides a supportive, Nature-friendly matrix with functional migration corridors and connectivity on land and in the water. The precautionary approach would be to establish big climate-change sanctuaries, i.e., theatres large enough for the ecological drama to unfold, where species have the best opportunity to react and interact as best they can without additional human-caused disturbances and industrial insults. The M-KMA ecosystem provides one such theatre in which management priorities and stakeholder values already favour large scale and long term management for biodiversity conservation.

23 Anderson, M.G. and C.E. Ferree. (2010) *Conserving the stage: climate change and the geophysical underpinnings of species diversity*. PLoS ONE 5(7): e11554: 1-10.
24 Beier, P. and B. Brost. (2010) *Use of land facets to plan for climate change: conserving the arenas, not the actors*. Conservation Biology 24: xx-yy.

Appendix 2

Wildlife and Climate Change: Selected Projections and Speculations About Large Mammals in Northern BC [25]

One of the projected consequences of warmer winters with more precipitation falling as rain than snow is a shrinkage of snowpack. A changing snowpack will have multiple effects. With more frequent thaw-freeze and rain-on-snow events, crusts and ice layers in the snowpack will reduce the availability of ground lichens and reduce the amount and quality of low-elevation caribou winter range. Caribou will shift to tree lichens (especially the long hair-like species) if they can't dig for ground lichens. This means that they will shift to mature, productive spruce-fir forests that have good lichen loads on the trees. Conflict with timber harvesting will probably ensue. Ultimately woodland caribou could be forced to behave more like the threatened mountain caribou of southeastern BC, as their valley bottom winter range degrades and they spend more time at higher elevations, searching for forests loaded with arboreal lichens, and alpine plateaus and ridges sufficiently windblown that they can get at ground lichens.

All things considered, things don't look good for the long-term survival of large herds of woodland caribou. It looks like they will be dealt a bad hand, which includes:

- a changing snowpack and less availability of ground lichens,
- increased harassment at lower elevations by biting insects,
- possibly less availability/suitability of frozen lakes as winter escape terrain, if the lakes increasingly experience delayed freeze-up,
- increased predation, especially by wolves and perhaps cougars, as an indirect consequence of increasing populations of moose, elk, and deer.

If the season during which insects are active increases in length, large mammals, particularly caribou, will suffer. This could lead to reduced vigour prior to the fall rut and consequently produce fewer and less vigorous calves in the spring. If conditions are intolerable, caribou will change their habits, and could spend less time in the forest and more time at higher elevations.

Another important ungulate, moose, should persist, at least for the next several decades. They are a generalist species and should be able to find plenty to eat and enough suitable habitat, as long as the landscape continues to be predominantly forested with a mix of successional stages (young, middle-aged, and old), as well as abundant wetlands, productive riparian zones, and shrublands. However, there are at least two big "ifs." If climate changes to such a degree that today's boreal forest becomes more like drier warmer Douglas-fir—ponderosa pine forests or wetter warmer hemlock—cedar forests, then conditions will be less favourable for moose. Deer and elk and perhaps bison would be favoured more by drier warmer conditions; most ungulates don't thrive in really wet (snowy) interior wetbelt environments.

Ticks could become a big problem for moose. Tick numbers could increase with earlier spring thaws and green-up because, after dropping off the host animals, more ticks would land on the ground or duff instead of on the snow, and tick survival would increase. If the tick population booms and if the moose population is concentrated at higher densities on tighter winter ranges, then more moose would get infected. If the moose are also otherwise stressed, their population could decline significantly. If numbers of elk increase—as is quite possible—the problem could be compounded on shared range because moose and elk are pestered by the same tick species.

Elk and bison will continue to increase if the warming climate is accompanied by an increase in open, especially grassy habitats. If, however, the climate also continues to get wetter, heavy forest cover persists, and winter snowpacks deepen, then elk and bison numbers would be kept down. The nature of the plant cover will depend to a great extent on disturbance, especially fire and insect epidemics; and on the type, extent, frequency and severity of such disturbances. Prescribed burning could continue to play a major role in maintaining or increasing open habitats at the expense of forests, but should be evaluated in the larger context of climate change and the undesirable effects of greater numbers of elk and bison on species like caribou and moose.

Similar comments apply to deer (mostly mule deer but perhaps also whitetails), which are already increasing in the north and will probably continue to do so. With deer come cougar, and probable increased predation on secondary prey like caribou and moose.

In the long run, thinhorn sheep will probably decline while mountain goats should hold their own and could increase and thrive—assuming in both cases that hunting pressure doesn't become excessive and that there aren't unusual outbreaks of parasites or diseases. The reasoning is that sheep are specialized grazers. They depend especially on localised winter ranges with high-quality grassy vegetation and low snowpacks and suitable escape terrain. In contrast, goats are more generalist feeders, can tolerate deeper snowpacks, and are probably limited more by the availability of steep rugged escape terrain. Grassy sheep ranges will decline as woody vegetation encroaches in a warmer moister climate, whereas escape terrain will persist regardless.

In the short run, both species could increase because cool, overcast, wetter summers result in the production of more, higher quality forage, and thus the animals enter the rut in better shape. This could result in more lambs and kids, and better survival of these offspring. There is some evidence that sheep populations have increased in the past following cool wet summers that periodically have occurred in response to north Pacific decadal oscillations. However, sheep fortunes are helped if their winter forage is well-cured in the fall (which depends on fine weather, clear and warm during the day and cold at night), and hurt by thaw-freeze events and snow crusting and icing during the winter.

Black bears will most likely fare well, so long as the landscape continues to be largely forested. Grizzly bears also could thrive, although they would be favoured more by wetter warmer than by drier warmer conditions, largely because of more and better food supplies.

25 Adapted from an unpublished report prepared for the Kaska Nation: Pojar, J., R. Peart, S. Patton, and E. Riccius. (2008) *Climate Change, Biodiversity and the Benefit of Healthy Ecosystems.*

Appendix 3

Appendix 3, which is a detailed conservation gap analysis for each of the sixteen physiographic subprovinces within the greater M-K study area, is available as a separate PDF document.

Greater Muskwa-Kechika Study Area Enduring Features Representation GAPs

	Cassiar Mountains Dease Plateau	Cassiar Mountains Dease Plateau Horseranch Range	Cassiar Mountains Stikine Ranges	Cassiar Mountains Kechika Ranges	Cassiar Mountains Sifton Ranges	Omineca Mountains Swannell Ranges	Omineca Mountains Finlay Ranges	Liard Plain Liard Plateau	Liard Plain Liard Plain	Rocky Mountain Trench	Rocky Mountains Muskwa Ranges Rabbit Plateau	Rocky Mountains Muskwa Ranges	Rocky Mountain Foothills	Alberta Plateau
A. How Well are the Subprovinces Protected?														
Subprovince Area (ha)	129,873	55,383	2,842,623	518,384	167,471	2,229,934	443,977	649,877	1,329,205	640,761	154,821	3,743,782	1,363,659	257,790
Subprovince Protected (%)*	53	100	5	38	9	9	20	6	4	7	0.2	27	25	0
B. How Much Physical Variety and Rarity is Not Captured in Protected Areas? The larger the percent the more features we have missed. (Capturing 50% is a minimum target)														
1. Most Frequent Enduring Features**														
GAP in Areal Extent of Features Protected (%)	100	100	96	79	94	92	85	98	99	94	100	71	75	100
2. High Variety, or "Hot Spots" of Features (top two classes)***														
GAP in High Variety Protection (%)	46	0	5	94	89	90	74	96	46	57	100	74	60	87
3. High Rarity of Features (top two classes)****														
GAP in High Rarity Protection (%)	NA	0	100	100	68	85	96	100	100	100	0	94	72	100

Notes:

* Two subprovinces extend beyond the Greater Muskwa-Kechika study area and may contain additional protected areas. (Rocky Mountain Trench, Alberta Plateau)

** These are the common physical features in a subprovince, representing about half of the subprovince area.

*** These categories result from an analysis across the Greater Muskwa-Kechika Study Area and place the subprovince within this context. For example, 74% of the highest variety of enduring features are not captured by existing protected areas.

The top two variety categories are defined by the following number of unique features: Category 1 (165 -304); Category 2 (119 - 165)

**** These categories result from an analysis across the Greater Muskwa-Kechika Study Area and place the subprovince within this context. The larger the percentage number, the more we have missed rare features in the network of protected areas.

The top two rarity categories include the following values: Category 1 (1% of area); Category 2 (2% cumulative area). In total, these two categories represent the smallest features by areal extent up to 3% of the cumulative study area.

Note that this table reflects the new protected area in the Horseranch Range, which was negotiated in January 2012 by the Kaska Nation and the BC Government.

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For the full report, go to www.y2y.net.

Yellowstone to Yukon Conservation Initiative

Muskwa-Kechika Management Area

CPAWS Canadian Parks and Wilderness Society British Columbia Chapter

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