Conservation Blueprint of Northern Alberta

Prioritizing areas for protected areas planning

CPAWS

CANADIAN PARKS AND WILDERNESS SOCIETY
NORTHERN ALBERTA

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Alison Ronson
Danielle Pendlebury

Columbian ground squirrel- Danielle Pendlebury

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The maps in this report are for illustrative purposes only. Do not rely on these maps for a precise indication of routes, locations of features, or as a guide to navigation.

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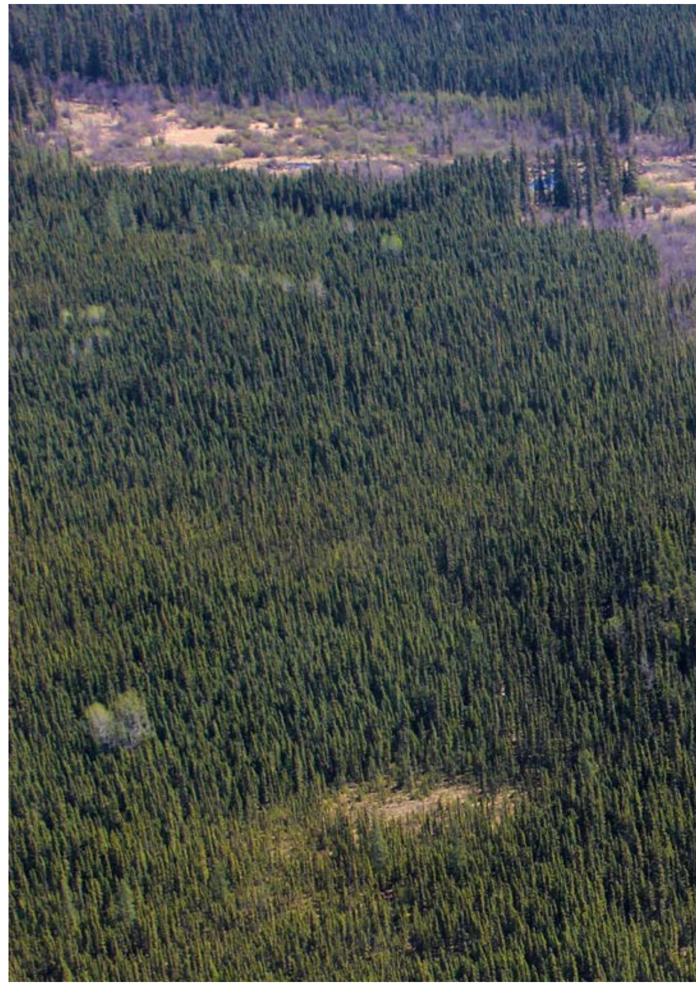

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Boreal wetlands - Danielle Pendlebury

Foreword

When I was a boy growing up in Alberta in the 1960s, most of the province north of the Edmonton region was a vast wilderness. We were taught in school about the huge Swan Hills grizzly bear. We knew that Wood Buffalo National Park's wild interior was home to the last whooping cranes in the world. It was largely a blank space on a map, home to traditional First Nations practises and an enticing dream for those who were drawn to wilderness travel.

Then, three big things happened to the wilderness of Northern Alberta.

A large forest products industry was created out of the blue by the Government of Alberta in the late 1980s. Vast swaths of wild boreal forest were allocated to industry with no thought given to conservation. Simultaneously, the conventional oil and gas industry became increasingly active across the north, cutting hundreds of thousands of kilometers of seismic lines for exploration and building tens of thousands of well sites and access roads. The synergistic effect of forestry and oil and gas was not managed with a view to preventing cumulative impacts and no large areas were set aside to secure the wild things or the traditional lifestyles of the people who live there. The negative consequences for boreal and foothills forests and the species that live in them were huge. Calls for conservation efforts fell on deaf ears. Caribou started their rapid decline. But the transformation of the landscape did not stop there.

The huge impacts of conventional oil and gas and forestry were compounded by commercialisation of the tar sands (as they were then universally called) or oil sands in the 1990s. The oil sands were known to be an enormous unlocked but perhaps unlockable reserve of oil. We grew up on the dream that Alberta would be a very wealthy place if we could figure out a way to produce that bitumen commercially. A billion dollars of public investment led by the federal and Alberta governments was successful in discovering the secret to detaching the oil from the sand it is stuck to.

It was a great day for Alberta's and Canada's economy. Another huge development boom immediately followed, this time concentrated in the oil sands region of northeastern Alberta. By 2010 the oil sands were the largest industrial project on Earth. Most of the world's major private oil companies and state oil companies are invested there. The oil sands generate enormous wealth but they also have an enormous impact on boreal forests, fish and wildlife, water quality and the emissions from their production affect the regional atmosphere and the global climate.

> "We Albertans love Nature and it is time we showed it too"

In the rush to industrialization we have pushed Nature too hard and too fast in Northern Alberta. Now that low oil and gas prices have slowed the hectic pace of activity it is a good time to start focusing on sharing the land with other species and to consider the people downstream. Northern Alberta is the headwaters of the Mackenzie River Basin, which is one of the world's largest watersheds. It is unacceptable to lose wilderness and wildlife from this vast area in just a generation. We know better and we should act better.

Boreal Forest - Danielle Pendlebury

It is time for us to set conservation goals that are as ambitious as our industrial goals for Northern Alberta in the entire Mackenzie River Basin. Just as we insist on economic viability for resource extraction so we should insist on the viability of conservation strategies. They must be effective to protect Nature through time.

Conservation studies by scientists around the world have demonstrated that, if we want to maintain all species in natural patterns of abundance and distribution, maintain their ecosystems and the benefits of freshwater and carbon fixing that Nature provides free of charge, and to allow for resilience to climate change and other stressors, we need to protect in an interconnected way at least half of any given natural system. We should very much want to do that because functioning natural systems that regulate the climate and provide freshwater and pollination are essential to humanity continuing to flourish on earth.

This report explains why Northern Alberta is no different than the rest of the world. It is time to bring some balance back to this landscape and to protect in an interconnected way at least half of Northern Alberta and the Mackenzie Basin.

Both Ontario through its *Far North Act* and Quebec through its *Plan Nord* have made commitments to protect half of their respective northern areas. We Albertans love Nature and it is time we showed it too. Our province needs to step up to the bar of environmental performance when it comes to Nature conservation.

We owe it to ourselves to raise our sights and to practise conservation with the same zeal that we showed when we created a large forest products industry and world class oil, gas and oil sands industries in Northern Alberta. These pages demonstrate that it is entirely feasible to do so. We should all take this *Conservation Blueprint* to heart and get to work on making it a reality.

Harvey Locke
Banff, Alberta
September, 2015

Introduction

The Canadian Parks and Wilderness Society ("**CPAWS**") is a nation-wide, charitable non-profit organization dedicated to the protection of public lands and waters across Canada.[1] Established in 1963, CPAWS has been influential over the last 50 years in advancing protection of more than half a million square kilometres of land in Canada. CPAWS' vision is that Canada will protect *at least half* of its public lands and waters for all time.

CPAWS Northern Alberta's mission is to advance the protection of wilderness and biodiversity[2] in northern Alberta, focusing roughly on the northern two-thirds of the province from the City of Red Deer, in central Alberta, north to the border with the Northwest Territories. To achieve this mission, CPAWS Northern Alberta, located in Edmonton, advocates for the creation of parks and protected areas managed with nature as the number one priority, and collaborates with government, industry representatives, and Aboriginal communities across the province to manage the impact of industrial activity on public lands. In Alberta, 60% of the land base is publicly owned at this time. However, only 12.4% is protected – the majority by the federally-owned national parks system, and the majority of that being in the Rocky Mountains. Alberta's provincially owned parks and protected areas represent only 4% of the province and are often less than $10km^2$ in area. Because of this they suffer from a lack of connectivity and do not adequately represent the natural landscapes and biodiversity of the province. In order to meet scientific and internationally accepted principles of protected areas planning, Alberta needs to commit to protecting at *least* 50% of its land base forever – and at least 20% by the year 2020.

> "In order to meet scientific and internationally accepted principles of protected areas planning, Alberta needs to commit to protecting *at least* 50% of its land base forever - and at least 20% by the year 2020"

1 Public lands and waters refer to those lands and waters owned by either the federal government of Canada or by provincial governments across Canada.

2 The International Union for Conservation of Nature (IUCN) defines biodiversity as "the variability among living organisms from all sources including terrestrial, marine and other aquatic ecosystems, and the ecological complexes of which they are part; this includes diversity within species, between species, and of ecosystems." See IUCN, *About Biodiversity* (July, 2010), at http://iucn.org/iyb/about/

The government of Alberta's Land Use Framework ("**LUF**"),[3] introduced in 2008, provides a significant opportunity for environmental non-governmental organizations ("**ENGOs**"), such as CPAWS Northern Alberta, to recommend and provide guidance on conservation and protected areas planning in the province. The LUF requires the government to draft regional plans for seven regions across the province, each region delineated according to watershed boundaries. Three of the LUF regions, the Upper Athabasca, Upper Peace, and Lower Peace regions, are slated to begin being planned in 2016. In order to provide a scientifically-sound basis for conservation and protected areas planning in these three regions, a system for identifying geographic areas with high conservation value is needed.

Bear cub - Ryan Peruniak

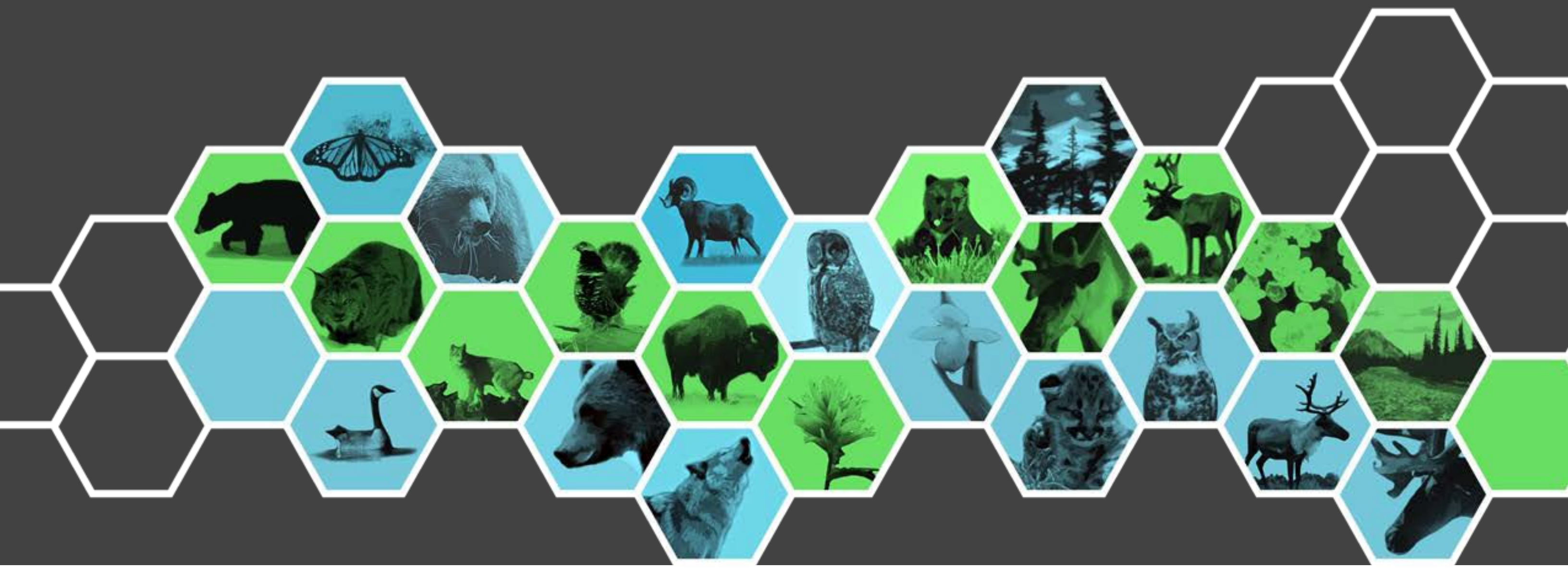
This report, *Conservation Blueprint of Northern Alberta: Prioritizing areas for protected areas planning* (the "**Conservation Blueprint**"), details CPAWS Northern Alberta's work using current science and geographic information systems to develop a series of maps designed to be used in conservation and protected areas planning in northern Alberta. The Conservation Blueprint is designed to be a flexible tool for use in ongoing discussions with government and other partners, and aims to achieve representation of species occurrences, ecological systems, and landscape-level physical features while considering the socio-economic cost of protected areas on the busy Alberta landscape. This report outlines the first stage of CPAWS Northern Alberta's Conservation Blueprint project; the Conservation Blueprint will be continuously updated as CPAWS Northern Alberta works with other organizations, communities, and government partners, or focuses on different impacts to the land.

This report details the methodology behind the Conservation Blueprint and presents some of the resulting scenarios for conservation planning in northern Alberta. Chapter One discusses the history and science behind protected areas planning both in Alberta and globally, and sets the stage for the Conservation Blueprint's results. Chapter Two outlines the study area of the Conservation Blueprint, the datasets and modelling inputs used in the mapping analysis, and the methods for determining conservation values. Chapter Three provides the results of the scientific analysis, including the habitat models for Alberta's at-risk species as well as the many protected areas scenarios presented by the mapping, along with a discussion of each protection scenario. Chapter Four provides suggestions for future conservation priorities for northern Alberta and the future of the Conservation Blueprint.

> "The Conservation Blueprint is designed to be a flexible tool for use in ongoing discussions with government and other partners"

3 Government of Alberta, *Land-Use Framework* (2008), at https://landuse.alberta.ca/LandUse%20Documents/Land-use%20Framework%20-%202008-12.pdf

Chapter One



Protected Areas and Northern Alberta

Northern Alberta: A Diverse Landscape

Northern Alberta's landscape is diverse. To the unknowing eye, the northern half of the province may appear to be an unending tract of forest that peters out into the urban footprint of the City of Edmonton. However, in that same apparently unending tract, a discerning visitor will find numerous varieties of deciduous and coniferous trees, extensive and varied wetlands, shrubland and parkland, headwaters, foothills, and mountains. This varied landscape provides a multitude of habitats for plant and animal species, many of whom are endangered or at-risk in the province. If the visitor is lucky, he or she may stumble across a caribou roaming through muskeg, hear a song from one of the millions of migratory songbirds trying to find their mate, or stumble across a rare orchid peering out of the ground.

The boreal forest extends through much of northern Alberta, providing landscapes that are rich in both biodiversity and natural resources. This vast swath of forest is globally significant for being one of the last remaining northern ecosystems that supports healthy populations of wildlife such as large mammals and fur-

"The boreal forest extends through much of northern Alberta, providing landscapes that are rich in both biodiversity and natural resources"

Elk Island National Park - Alison Ronson

bearing animals, songbirds, waterfowl, and fish.[4] The boreal forest is not only a haven for wildlife, it is one of the largest sources of freshwater on the planet, with the Canadian boreal containing approximately 25% of the world's wetlands, and the boreal in northern Alberta containing the headwaters of the Mackenzie River Basin, the largest watershed in the world.[5] This flow of freshwater is so large that it helps to drive global oceanic currents.[6] Locked in the boreal is also one of the world's largest reservoirs of carbon, vast oil and gas resources, and abundant minerals.

The human quest to unlock the resources of the boreal forest has resulted in a tattered and fragmented landscape. However, many species of wildlife require large areas of intact habitat in order to thrive and maintain healthy populations and to sustain the impacts of climate change.[7] Given the pace of industrial development in Alberta, it is therefore important that areas of high conservation value are identified and established as protected areas and managed with ecological integrity as the number one priority. These protected areas should be representative of the diversity of northern Alberta's landscape, and allow for connectivity of ecosystems across the province.

> "The human quest to unlock the resources of the boreal forest has resulted in a tattered and fragmented landscape"

4 Badiou *et al.*, "Conserving the World's Last Great Forest is Possible: Here's how," *International Boreal Conservation Science Panel* (July 2013), accessed Sept 2015, http://borealscience.org/wp-content/uploads/2013/07/conserving-last-great-forests1.pdf, [Hereinafter, Badiou *et al.*]

5 Boreal Songbird Initiative, *Conservation Values of the Boreal Forest: Water*, accessed Sept 2015, http://www.borealbirds.org/conservation-values-boreal-forest

6 Dai, A., and K.E. Trenberth, "Estimates of freshwater discharge from continents: Latitudinal and seasonal variations," *Journal of Hydrometeorology* 3 (2002): 660-683

7 Badiou *et al., supra*

> "In addition to protecting biodiversity, protected areas ensure that communities have clean water to drink, help to moderate the climate by storing carbon, and offer an opportunity for people to connect with nature"

Protected Areas and Land Use Planning in Alberta

Protected Areas: The solution for the future

When most people think of parks and protected areas, they conjure an image of their favourite outdoor space in which to enjoy a picnic, take a hike, go camping, or paddle a canoe. In addition to being beautiful places to explore, Alberta's parks and protected areas are also the key tool to helping the world slow a global extinction. Scientific consensus is firm – there is now "universal recognition that protected areas are essential not only to preserving nature, but to slowing the pace of extinction."[8]

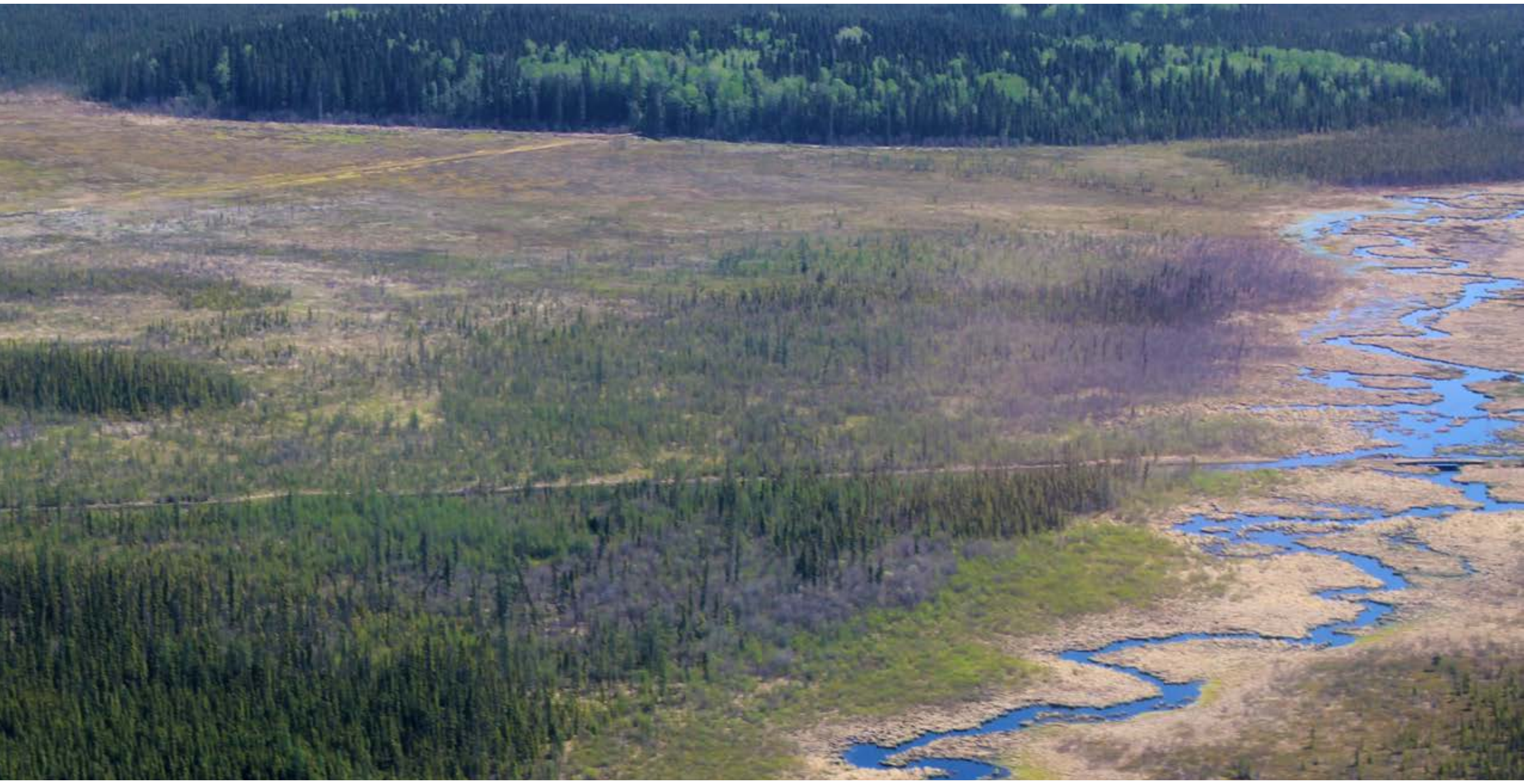
Even northern Alberta is faced with the possibility of extinctions. This is an era of increasing land use and human development that has resulted in species going extinct at a rate 100 to 1000 times faster than before humans inhabited this earth.[9] The overarching causes of this extinction include habitat loss, habitat fragmentation, overexploitation, and negative impacts from invasive species.[10] Alberta is a province dependant on resource extraction for the majority of its revenues. New roads, seismic lines, pipelines, well pads, mines, and forestry harvest blocks are cut into northern Alberta's boreal forest at a massive annual scale, while little forest reclamation or restoration occurs. It is estimated that, from 2001 to 2013, over 3,135,647 hectares of tree cover was lost in Alberta, while only 651,141 hectares was replaced.[11] This level of forest and habitat fragmentation in Alberta has led to declines in the health and well-being of the province's wildlife; all of Alberta's woodland caribou herds are classified as "Threatened" under both the

8 John Terborgh. "Foreword." In *Protecting the Wild: Parks and Wilderness, the Foundation for Conservation*, edited by George Wuerthner *et al.*, xi-xvii. San Francisco: The Foundation for Deep Ecology in partnership with Island Press, 2015 [hereinafter, Terborgh]

9 Stuart L Pimm et al., "The Future of Biodiversity," *Science* 269, no. 5222 (1995): 347–50

10 Terborgh, *supra*

11 Global Forest Watch, *Canada: Alberta* (August 2015) at http://www.globalforestwatch.org/country/CAN/1



Linear features in the boreal, like these, are one of the reasons for the decline of caribou - Danielle Pendlebury

federal *Species at Risk Act*[12] and Alberta's *Wildlife Act*,[13] with one herd already extirpated from the province within the last decade. Many of Alberta's boreal song and game birds are at risk due to loss of habitat and breeding grounds,[14] and the most recent estimates put Alberta's threatened grizzly bear population at only 691 individuals.[15]

Protected areas are the foundation of regional conservation strategies, representing the biodiversity of each region and separating it from threats and pressures that compromise its health.[16] Setting aside parks and protected areas that preclude human development therefore provides the space and habitat protection needed for a diversity of species to survive. In addition to protecting biodiversity, protected areas ensure that communities have clean water to drink, help to moderate the climate by storing carbon, and offer an opportunity for people to connect with nature.

In 1987, The United Nations released *Our Common Future*, commonly known as The Bruntland Report. In that document, the United Nation's World Commission on Environment and Development stated, "[t]he challenge facing nations today is no longer deciding whether conservation is a good idea, but rather how it can be implemented…"[17] The Bruntland Report also recommended that the world's percentage of

12 SC 2002, c 29

13 RSA 2000, c W-10

14 See the Boreal Songbird Initiative at http://www.borealbirds.org/

15 Government of Alberta, Fish and Wildlife Division, "Status of the Grizzly Bear (Ursos arctos) in Alberta: Update 2010," *Alberta Wildlife Status Report No. 37* (2010), at http://aep.alberta.ca/fish-wildlife/species-at-risk/species-at-risk-publications-web-resources/mammals/documents/SAR-StatusGrizzlyBearAlbertaUpdate2010-Feb2010.pdf

16 C R Margules and R L Pressey, "Systematic Conservation Planning.," Nature 405 (2000): 243–53 [Hereinafter, Margules and Pressey]

17 United Nations World Commission on Environment and Development. *Our Common Future.* Oxford: Oxford University Press, 1987 [hereinafter, Bruntland Report]

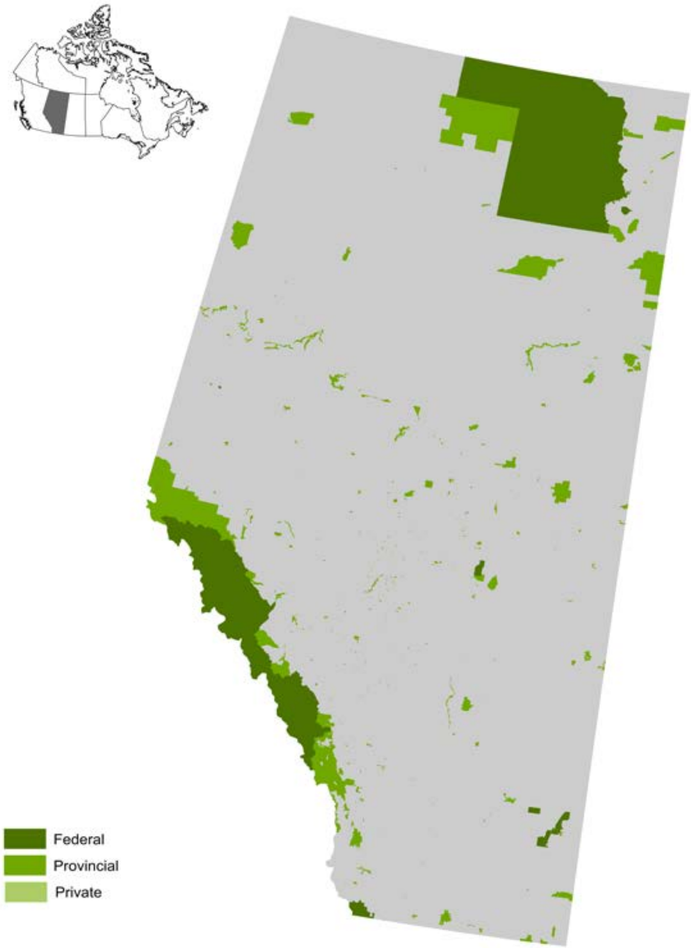


Figure 1| Protected areas in Alberta

“The current scientific consensus is that, to maintain biological diversity, allow movement of large mammals and predators across landscapes, ensure important biological and ecological processes, and to protect representative wilderness for the continued enjoyment of future generations, *at least* 50% of landscapes and representative ecosystems need to be protected”

protected area be increased to 12% of the globe “if it is to constitute a representative sample of Earth’s ecosystems.”[18] This 12% target was set with the belief that sustainable development could ensure that, on the remaining 88% of the planet, ecosystems were managed properly. However, when world leaders met again in 2010 to create the United Nations *Convention on Biological Diversity* (the “**CBD**”), it was clear that the idea that sustainable development could protect Earth’s environment had been proven wrong.[19] The CBD now aimed to “improve the status of biodiversity by safeguarding ecosystems, species and genetic diversity.” This was supported by the CBD’s Aichi Target 11, which set the goal of achieving 17% protection of terrestrial and inland water, and 10% of coastal and marine areas globally by the year 2020.[20]

Unfortunately, even the Aichi Target 11 of 17% protection for terrestrial areas and inland waters cannot come close to ensuring the existence of wilderness and biodiversity for future generations. The current scientific consensus is that, to maintain biological diversity, allow movement of large mammals and predators across landscapes, ensure important biological and ecological processes, and to protect representative wilderness for the continued enjoyment of future generations, *at least* 50% of landscapes and representative

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18 Bruntland Report, *supra*

19 United Nations, *Convention on Biological Diversity* (1992), accessed Sept 2015 at https://www.cbd.int/convention/text/

20 Aichi Target 11 states, “By 2020, at least 17 per cent of terrestrial and inland water areas and 10 per cent of coastal and marine areas, especially areas of particular importance for biodiversity and ecosystem services, are conserved through effectively and equitably managed, ecologically representative and well-connected systems of protected areas and other effective area-based conservation measures, and integrated into the wider landscape and seascape.” United Nations Convention on Biological Diversity, *Strategic Plan for Biodiversity, 2011-2020, Target 11* (2015), accessed Sept 2015 at https://www.cbd.int/sp/targets/rationale/target-11/ [Hereinafter, CBD Aichi Target 11]

ecosystems need to be protected.[21] A protected area, defined by the International Union for Conservation of Nature ("**IUCN**"), is "a clearly defined geographical space, recognised, dedicated and managed, through legal or other effective means, to achieve the long term conservation of nature with associated ecosystem services and cultural values."[22] The IUCN's categories of protection include nature reserves or wilderness areas, national parks and monuments, species management areas, protected landscapes or seascapes, and protected areas with sustainable use of natural resources. None of these categories include urban or industrial development.[23]

In Alberta, provincially protected areas often cover areas of less than 10km^2, and are frequently small islands of protection in the midst of a fragmented landscape. Currently, only 12.4% of the province of Alberta is protected, the majority of which is protected via several large, federally-owned and managed national parks, such as Wood Buffalo, Banff, Jasper, and Waterton Lakes National Parks. Provincially, Alberta has protected only 4.2% of its territory (Figure 1).

Alberta's provincial *Plan for Parks*[24] guides protected areas planning in the province until 2019, but does not commit the province to meeting scientifically sound or even internationally accepted policy targets. Instead, Alberta's *Plan for Parks* only sets a target of 5% protection for each of the natural landscape types within the 21 natural sub-regions across the province.[25] This is simply not good enough. If Alberta is truly committed to the goal of preserving its natural heritage, maintaining current levels of biodiversity, being a leader in environmental issues, and reducing its impact on climate change, it needs to think big – big, connected, protected areas.

CONIFEROUS FOREST - ALISON RONSON

21 Locke, Harvey. "Nature Needs (at least) Half: A Necessary New Agenda for Protected Areas," in *Protecting the Wild: Parks and Wilderness, the Foundation for Conservation*, edited by George Wuerthner *et al.*, 3-15. San Francisco: The Foundation for Deep Ecology in partnership with Island Press, 2015 [hereinafter, Locke]

22 International Union for Conservation of Nature, *What is a Protected Area?* (Nov 4, 2013), accessed Sept 2015 at https://www.iucn.org/about/work/programmes/gpap_home/pas_gpap/

23 Locke, *supra*

24 Government of Alberta, *Alberta's Plan for Parks* (2009), accessed Sept 2015 at http://www.albertaparks.ca/media/123436/p4p.pdf

25 Canadian Parks and Wilderness Society, *Protecting Canada: Is it in our nature? How Canada can achieve its international commitment to protect our land and freshwater* (2015), accessed Sept 2015 at http://cpaws.org/uploads/CPAWS_Parks_Report_2015-Single_Page.pdf [Hereinafter, CPAWS]

Little Smoky river - Alison Ronson

Alberta's Land Use Framework

Alberta is a province rich in natural resources. Because of this, it is facing increasing pressures and multiple competing land uses. Recognizing a need for more sustainable land use, in 2008 the government of Alberta established the LUF to integrate provincial policies at the regional scale, with the aim of ensuring the responsible management of provincial land. The province's land base was divided into seven regions based on provincial watershed boundaries: the South Saskatchewan Region, Red Deer Region, North Saskatchewan Region, Upper Peace Region, Lower Peace Region, Upper Athabasca Region, and Lower Athabasca Region. Each region was to be separately planned in accordance with the unique pressures facing it, with areas designated for industrial activity, commercial activity, residential and urban development, and importantly, conservation (Figure 2).[26]

The LUF represented a significant opportunity for the province to create new, representative, connective, provincially protected areas in the province, and to fill substantial gaps in the provincial protected areas system. In 2016, it is anticipated that the Government of Alberta will begin planning for potential conservation areas in three of the LUF regions: the Upper Peace, Lower Peace, and Upper Athabasca regions in northwestern Alberta. The Conservation Blueprint is CPAWS Northern Alberta's tool for participation in the LUF, but may be used in any protected areas or land use planning process entered into by the province now or in the future, as a tool for the identification of priority areas of conservation using a current, science-based assessment.

26 Government of Alberta, *Land Use Framework*, accessed July 2015 at https://landuse.alberta.ca/PlanforAlberta/Landuse-Framework/Pages/default.aspx

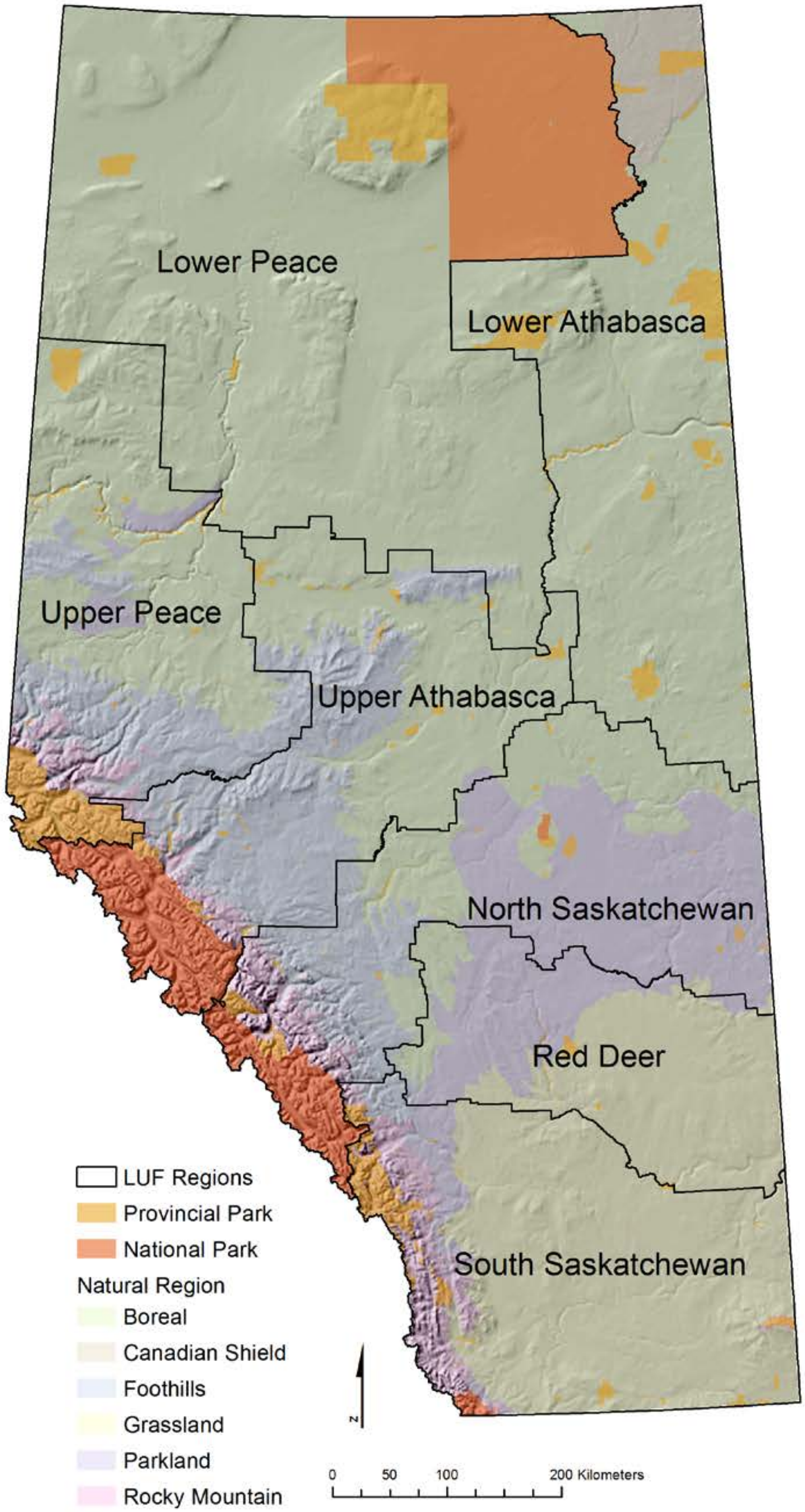


Figure 2| Land Use Framework Planning Regions in Alberta

> "If Alberta is truly committed to the goal of preserving its natural heritage, maintaining current levels of biodiversity, being a leader in environmental issues, and reducing its impact on climate change, it needs to think big - big, connected, protected areas"

Chapter Two

Methods

CPAWS Northern Alberta’s Conservation Blueprint

The Conservation Blueprint was developed using current, science-based geographic information systems (“**GIS**”) and mapping methodology and identifies high-value areas for conservation in northern Alberta. It is meant to be used by government, ENGOs, industry, and community partners in regional land use planning in northern Alberta, and in planning for northern Alberta’s protected areas. The Conservation Blueprint is a comprehensive tool, taking into account coarse, landscape-level features that may drive conservation, as well as the finer-scale habitat preferences of rare or at-risk plant, animal, and insect species in the province of Alberta. The Conservation Blueprint also provides the ability for its users to consider both the economic value of Alberta’s natural resources and the impact of linear disturbance on the landscape when planning for protected areas.

Conservation decisions are often biased to reduce agricultural, forestry, and oil and gas conflicts, resulting in the protection of landscapes that are not necessarily threatened, do not have high biological diversity, or which have limited conservation value. This bias can be reduced by using a systematic conservation planning approach where trade-offs between conservation and economic objectives become part of the planning process to ensure high biological diversity while considering socio-economic cost.[27] Systematic conservation planning is a powerful tool that requires clear choices about the features to be used as surrogates for overall biodiversity and is based on explicit goals and targets. It has been implemented around the world in recent years due to its comprehensiveness, its efficiency in using limited resources to achieve conservation goals, its flexibility with competing land uses, and its accountability in allowing decisions to be critically reviewed.[28]

27 Richard R Schneider et al., “Achieving Conservation When Opportunity Costs Are High: Optimizing Reserve Design in Alberta’s Oil Sands Region.,” *PloS One* 6, no. 8 (2011) [Hereinafter, Schneider *et al.*]

28 Margules and Pressey, *supra*

Grizzly- Alana Elliott

Bighorn Wildland - Cassidy van Rensen

Goals and Objectives

The primary goal of CPAWS Northern Alberta's Conservation Blueprint is to inform protected areas planning in the province of Alberta so as to enable the province to become a leader in habitat protection. The Conservation Blueprint identifies gaps in the province's protected areas network in terms of landscape features and wildlife habitat, and illuminates the way forward for at least 50% protection of each Natural Subregion in northern Alberta. To achieve this goal, the Conservation Blueprint sets out to achieve the following two conservation objectives:

1) to create a protected areas design in northern Alberta that will preserve the range of landscapes and biodiversity found in the region; and

2) to create a protected areas design that achieves connectivity between protected areas, allowing for the migration of animals and the adaptation of both plants and animals to a changing climate.

CPAWS Northern Alberta acknowledges that incorporating social and economic factors during conservation planning ultimately influences the success of conservation efforts, in that less socially disruptive protected area networks are more likely to be implemented. Often, conservation planning software finds multiple areas on the land that can achieve its conservation objectives, but which may have differing social or economic costs. Areas that have high conservation value or are unique and thus irreplaceable will always be prioritized. Where trade-offs are possible, however, protected area designs that have a lower socio-economic cost may be considered.

> "The Conservation Blueprint will identifies gaps in the province's protected areas network in terms of landscape features and wildlife habitat, and illuminates the way forward for at least 50% protection of each Natural Subregion in northern Alberta"

Conservation Blueprint Template

Systematic conservation planning provides alternate conservation designs based on objectives, targets, costs, or conservation features. Therefore, a number of scenarios can be run, each providing a selection of protected area designs that can then be deliberated upon by stakeholders. Below are a series of steps followed by CPAWS Northern Alberta for each scenario to create a set of conservation designs for the Conservation Blueprint.

1. Identify conservation and socio-economic goals and objectives

Define clear conservation goals and objectives for the protection and restoration of biodiversity. In addition, recognize socio-economic goals that protect the social and economic interests of the province and its people.

2. Select the study area and divide it into planning units

Based on the goals and objectives identified and the data available, determine the study area and appropriate size and shape of planning units.

3. Compile data for conservation features

Compile data sets that serve as surrogates for biodiversity across the study area. These are termed conservation features and can include physical features of the land as well as ranges of rare or at-risk species.

4. Establish conservation targets and design principles

Conservation targets are used to determine how much of each of the conservation features will be protected within the conservation network. In addition, design principles can influence the configuration of the conservation design, such as protected area size, shape, number, and connectivity.

5. Review existing protected areas and identify gaps

Existing protected areas can contribute to the goals and targets of the protected area network. How they are included in the analysis can impact the efficiency of the conservation design.

6. Create a set of GIS-based reserve designs

A series of alternative designs are generated that lays out a range of options weighing the costs and benefits of each design. This provides a selection of conservation designs that can be used in discussion among stakeholders.

Forest - A Ronson

Early morning fog on Maligne Lake - Danielle Pendlebury

Study Area

The study area for the Conservation Blueprint covers approximately 560,000 km^2 and is based on the Natural Subregions of Alberta which intersect with three LUF regions (the Lower Peace, Upper Peace, and Upper Athabasca regions). This area focuses on the political regions in northern Alberta while also incorporating ecological processes, thus ensuring that analyses are run on a similar scale to which ecological processes operate.[29] The study is confined within the Alberta border to minimize bias from the availability and compatibility of datasets (Figure 3).

Planning units are the building blocks for protected areas planning, and can be any unit of land used to partition the study area. Smaller planning units produce more efficient conservation solutions (lower cost to achieve the same target), although increase the time needed to run the model. For the Conservation Blueprint, 500 hectare hexagonal planning units were selected, giving a total of 113,800 planning units over the study area. This size and shape were selected due to the low edge-to-area ratio and the efficient and smooth output when compared to square planning units, as well as the effective representation of both local and landscape-scale conservation features.[30]

29 The Canadian BEACONS Project, "The Canadian BEACONs Project", accessed Aug 12, 2015 at http://www.beaconsproject.ca/rpu

30 Bruno A. Nhancale and Robert J. Smith, "The Influence of Planning Unit Characteristics on the Efficiency and Spatial Pattern of Systematic Conservation Planning Assessments," *Biodiversity and Conservation* 20, no. 8 (2011): 1821–35

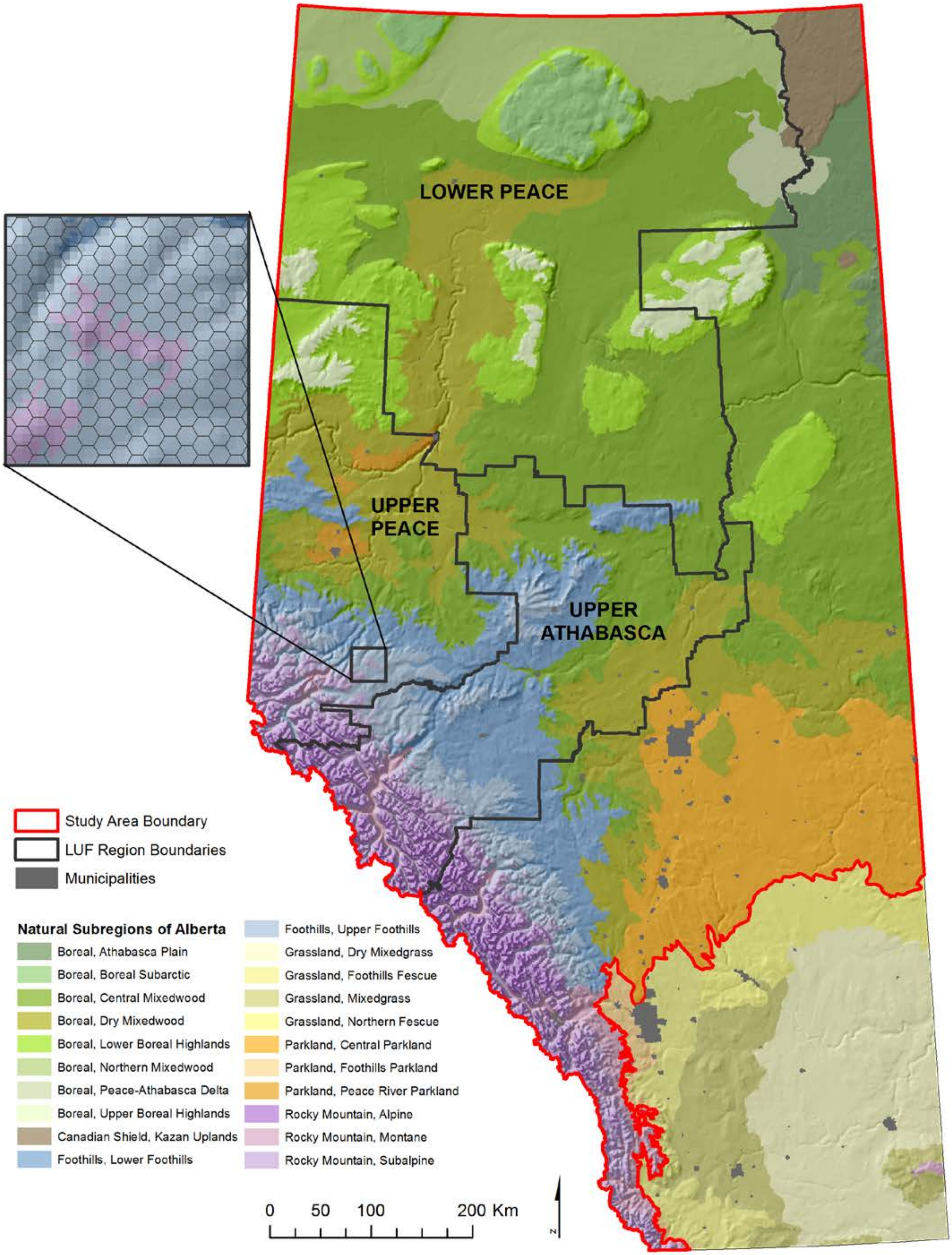


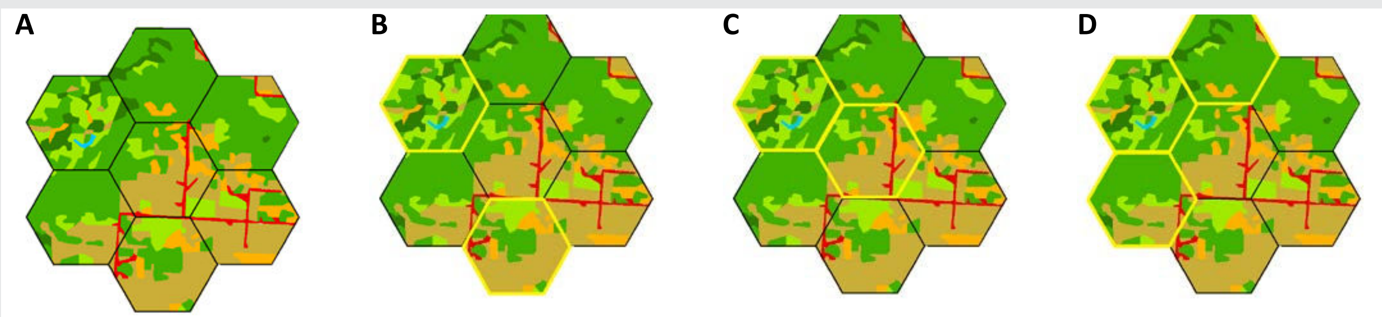
Figure 3| Study area for the Conservation Blueprint, selected using the Natural Subregions that intersect with the three northwest LUF regions within the province of Alberta.

Software

Marxan is publicly available software that serves as a decision-support tool for the creation of new protected areas.[31] It has been used by over 1,200 organizations and governments in more than 100 countries worldwide to assist in the prioritization of land for conservation.[32] It serves as decision support for the creation of new protected areas by providing a range of "good" decisions that meet both conservation and socio-economic objectives, thereby facilitating the exploration of trade-offs.[33] Using simulated annealing computer algorithms, Marxan selects planning units that will meet the user's objectives based on inputs of conservation features (landscape features, species ranges, etc.), targets (amount of each feature to be protected), and costs (including measures such as human disturbance or socio-economics in each planning unit). An example of how Marxan selects planning units is shown in Figure 4.

An important consideration when using Marxan is the quality of the datasets to be used. Often, geographical ranges or distributions of species are unavailable or are too coarse to be useful in protected areas planning. Point locations of where species have been found over the years are often more easily accessible, although using these point locations directly in Marxan is not recommended. Rather, models of the species distribution on the landscape should be used as an input. Maximum Entropy software ("**MaxEnt**") is one of the most popular tools used worldwide to model species distributions on the landscape.[34,35,36] It has

Figure 4| Example of the selection of planning units in Marxan.



(A) Each planning unit (hexagon) in Marxan has a certain number and amount of conservation features, represented by different colors. To protect 20% of each conservation feature, Marxan might select the hexagons outlined in yellow in (B). The user can choose to clump selected planning units together, as in (C), where 20% of each conservation feature is still protected but where the edge-to-surface area ratio is reduced in the protected area design. Marxan can also assess 'costs' on the landscape, such as the linear features in red. To reduce the linear features in the protected area design Marxan may choose the three planning units in (D) that still meet the 20% targets and are clumped to reduce the edge-to-surface area ratio, but have fewer linear features.

31 Marxan software can be downloaded at: http://www.uq.edu.au/marxan/index.html?page=77654&p=1.1.4.1 (as of Oct 1, 2015)

32 Ian R. Ball, Hugh P. Possingham, and M. Watts, "Marxan and Relatives: Software for Spatial Conservation Prioritisation," *Spatial Conservation Prioritisation: Quantitative Methods and Computational Tools*, 2009, 185–95.

33 Jeff A. Ardron, Hugh P. Possingham, and Carissa J. Klein, "Marxan Good Practices Handbook," (2008): 155.

34 MaxEnt software can be downloaded at: https://www.cs.princeton.edu/~schapire/maxent/ (as of Oct 1, 2015)

35 S.J. Phillips, R.P. Anderson, and R.E. Schapire, "Maximum entropy modelling of species geographic distributions." *Ecological Modelling,* 190 (2006): 231-259.

36 C. Merow, M.J. Smith, and J.A. Silander Jr, "A practical guide to MaxEnt for modeling species' distributions: what it does, and why inputs and settings matter." *Ecography*, 36 (2013): 1058-1069.

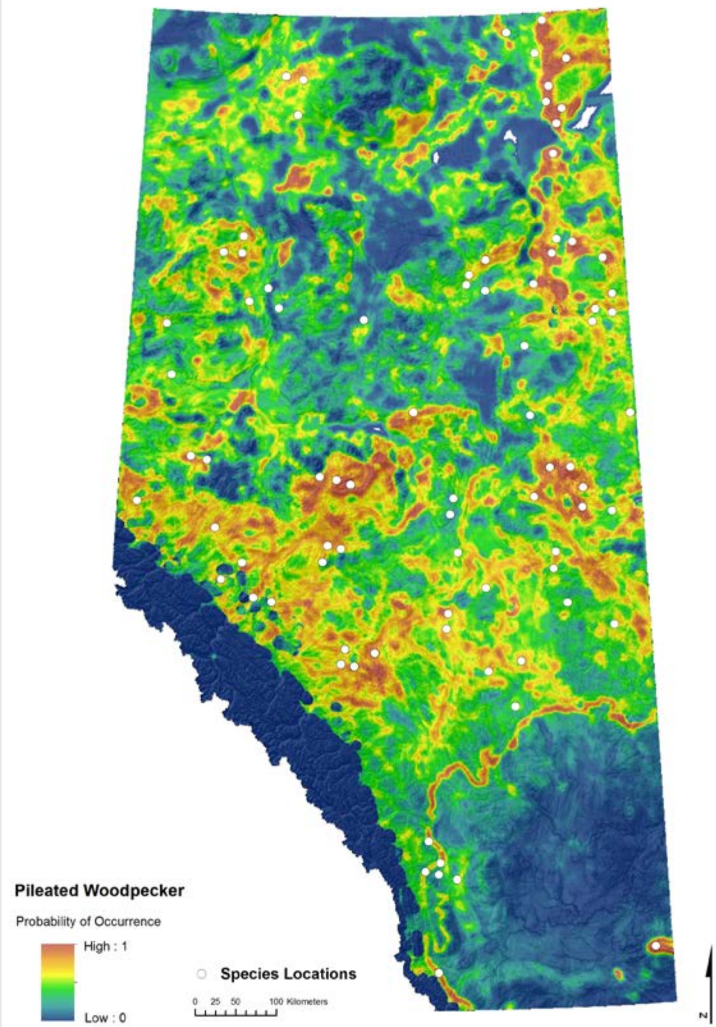


Figure 5| Example of a pileated woodpecker species distribution model from MaxEnt.

Known presence locations of the pileated woodpecker (white circles) were used by MaxEnt to model, or predict, prime pileated woodpecker habitat in Alberta based on 46 environmental predictor variables such as climate, elevation, land cover classes, and surficial geology. High probability of finding a pileated woodpecker is shown in red on the map. This information can then be used in Marxan to ensure species habitats are represented in a protected areas design. Image credit: pixabay.

been shown to outperform other methods in its predictive accuracy,[37] and is relatively straightforward to use. To model species distributions, MaxEnt takes a list of species locations on the landscape along with known environmental predictors such as climate, elevation, or land cover classes, and gives the probability of finding the species in a given area. An example of a species distribution model from MaxEnt is shown in Figure 5 for the pileated woodpecker.

ArcGIS is GIS software designed for working with maps and spatial data. CPAWS Northern Alberta used it to compile and pre-process all of the data prior to running models in Marxan and MaxEnt.

Marxan requires tab-delimited text files that, depending on the amount of data, can be millions of rows of data. Data management software that can handle that much data is required to compile the input files. CPAWS Northern Alberta used R,[38] which is free, open-source software for data manipulation, calculation, statistics, and graphics.

37 J. Elith et al., "Novel Methods Improve Prediction of Species' Distributions from Occurrence Data. M," *Ecography,* 29, (2006): 129–51.

38 R software can be downloaded at https://cran.r-project.org/mirrors.html (as of Oct 1, 2015)

“The goal in any protected areas network is to protect the range of biodiversity on the landscape”

Ecosystem representation (Conservation Features)

One of Marxan’s strengths is its ability to achieve representation of landscapes and biodiversity in its conservation design. The goal in any protected areas network is to protect the range of biodiversity on the landscape; however, not all of the species on this planet have been discovered, described, or have accurate geographical data gathered for them. Marxan therefore uses conservation features, which can be any measurable and spatially defined component, to act as surrogates for biodiversity. Typically, two types of features are used in conservation design: coarse filter features that represent habitats, landforms, or climatic regions; and fine filter features to ensure representation of rare or unique features such as species locations or habitat ranges.[39] By ensuring representation of all coarse filter features, most ecological processes and species will be protected.[40,41,42] However, some species and landforms, especially the rarest, will fall through this coarse filter “crack.” Therefore, fine filter features need to be applied to ensure that rare species are captured in the analysis.[43]

39 Reed F. Noss, “From Plant Communities to Landscapes in Conservation Inventories: A Look at the Nature Conservancy (USA),” *Biological Conservation* 41, no. 1 (1987): 11–37

40 Paul Beier and Brian Brost, “Use of Land Facets to Plan for Climate Change: Conserving the Arenas, Not the Actors,” *Conservation Biology* 24, no. 3 (2010): 701–10 [Hereinafter, Beier and Brost]

41 D. P. Faith and P. A. Walker, “Environmental Diversity: On the Best-Possible Use of Surrogate Data for Assessing the Relative Biodiversity of Sets of Areas,” *Biodiversity and Conservation* 5, no. 4 (1996): 399–415

42 Malcolm L. Hunter, George L. Jacobson, and Thompson Webb, “Paleoecology and the Coarse-Filter Approach to Maintaining Biological Diversity,” *Conservation Biology* 2, no. 4 (1988): 375–85

43 Beier and Brost, *supra*.

Boreal wetlands - Danielle Pendlebury

Coarse Filter Conservation Features

The Conservation Blueprint incorporated coarse-filter ecosystem variation using five datasets that represent variation in habitats, soils, and climate (Table 1).

Table 1| Datasets used for coarse filter conservation features

Conservation Feature	**Description**	**Source**
Natural Regions and Subregions	Defined on the basis of landscape patterns, vegetation, soils, physical features, climate, topology, and geology	Alberta Environment and Parks
Land Cover Classes	ABMI wall to wall land cover. Spatial distribution of land cover across the province of Alberta. Includes water, snow/ice, rock, shrubland, grassland, agriculture, coniferous forest, broadleaf forest, mixed forest, and urban or industrial developments	ABMI (v2010)
Alberta Merged Wetland Inventory	Depicts wetlands within five major classes (bog, fen, marsh, open water, and swamp) based on the Canadian Wetland Classification System (CWCS)	Alberta Environment and Parks
Surficial Geology	Interpretation of quaternary geology in regional scale	Alberta Geological Survey
Climate Moisture Index	Amount of moisture available for vegetation	Dr. Richard Schneider (U of A)

Biogeographic divisions such as ecozones or ecoregions are commonly used in conservation planning. The Natural Regions and Subregions of Alberta dataset is a provincial biogeographic classification developed by the Government of Alberta and used in resource management planning since the 1970s.[44] It is a hierarchical classification based on a comprehensive analysis of landscape patterns, vegetation, soils, physical features, climate, topology, and geology and divides the province up into six Natural Regions and 21 Natural Subregions. CPAWS Northern Alberta used the Natural Subregion level to incorporate ecosystem-level variation into the analysis, which resulted in 16 Subregion classes within the study area (Figure 6A).

Land cover can provide a meaningful representation of biodiversity by describing the vegetation that covers the land. The wall-to-wall land cover map from the Alberta Biodiversity Monitoring Institute ("**ABMI**") is a representation of 11 types of land cover in Alberta: water snow/ice, rock, shrubland, grassland, agriculture, coniferous forest, broadleaf forest, mixed forest, and urban or industrial developments. It is based on the digital classification of 30m Landsat satellite imagery by combining two raster datasets, the Canadian Forest Service ("**CFS**") Earth Observation for Sustainable Development ("**EOSD**") Landcover dataset and Agriculture and Agri-Food Canada ("**AAFC**") Landcover dataset, with major rivers, water bodies, roads, railways, power lines and pipelines burned in to the input rasters.[45]

Wetlands are essential habitat for many species of wildlife in Canada, with up to one third of species-at-risk relying on wetlands during some part of the life cycle.[46] The Canadian Wetland Classification System ("**CWCS**") has identified five types of wetlands: Bogs, Fens, Marshes, Swamps, and Open Water, each of which provide unique habitat to wildlife. The Alberta Merged Wetland Inventory is a dataset compiled by the government of Alberta which combines wetland data from multiple sources, including Ducks Unlimited Canada ("**DUC**"), industry, and municipalities.[47] It uses the CWCS classification of the five major wetland types.

Both wetland and land cover classes are similar in that they describe what is covering the land. CPAWS Northern Alberta combined the landcover and wetland classes to create unique landscape classes representing ecological variation on the landscape. These landscape classes reflect differences on the landscape that may equate to habitat differences for wildlife. For example, 'Fen and Coniferous Forest' would likely support a different set of species to the landscape classes 'Coniferous Forest (no wetland)' or 'Fen and Broadleaf Forest.' Because the goal is to identify areas that are representative of biodiversity and can act as suitable habitat for wildlife, landscape classes that contained agricultural, urban, or industrial development landcover were removed from the analysis. For the wetland classes that intersected with 'No Data,' 'Open Water,' or 'Snow/Ice' landcover classes, the classes were merged to form one landscape class for each wetland type. In total, 37 unique landscape classes were created for the study area (Figure 6B).

For finer-scale ecosystem representation CPAWS Northern Alberta used the Alberta Geological Survey's surficial geology data set. Surficial geology has been shown to determine where within a range a species is located, directly shaping finer-scale species diversity patterns.[48] In addition, surficial geology is the basis for

44 Natural Regions Committee (2006) Natural Regions and Subregions of Alberta: Alberta Environment, Edmonton, Alberta.

45 ABMI Wall-to-wall Land Cover Map Guide Version 2.1 (ABMIw2wLCV2010v1.0). Accessed on abmi.ca Sept 25, 2014

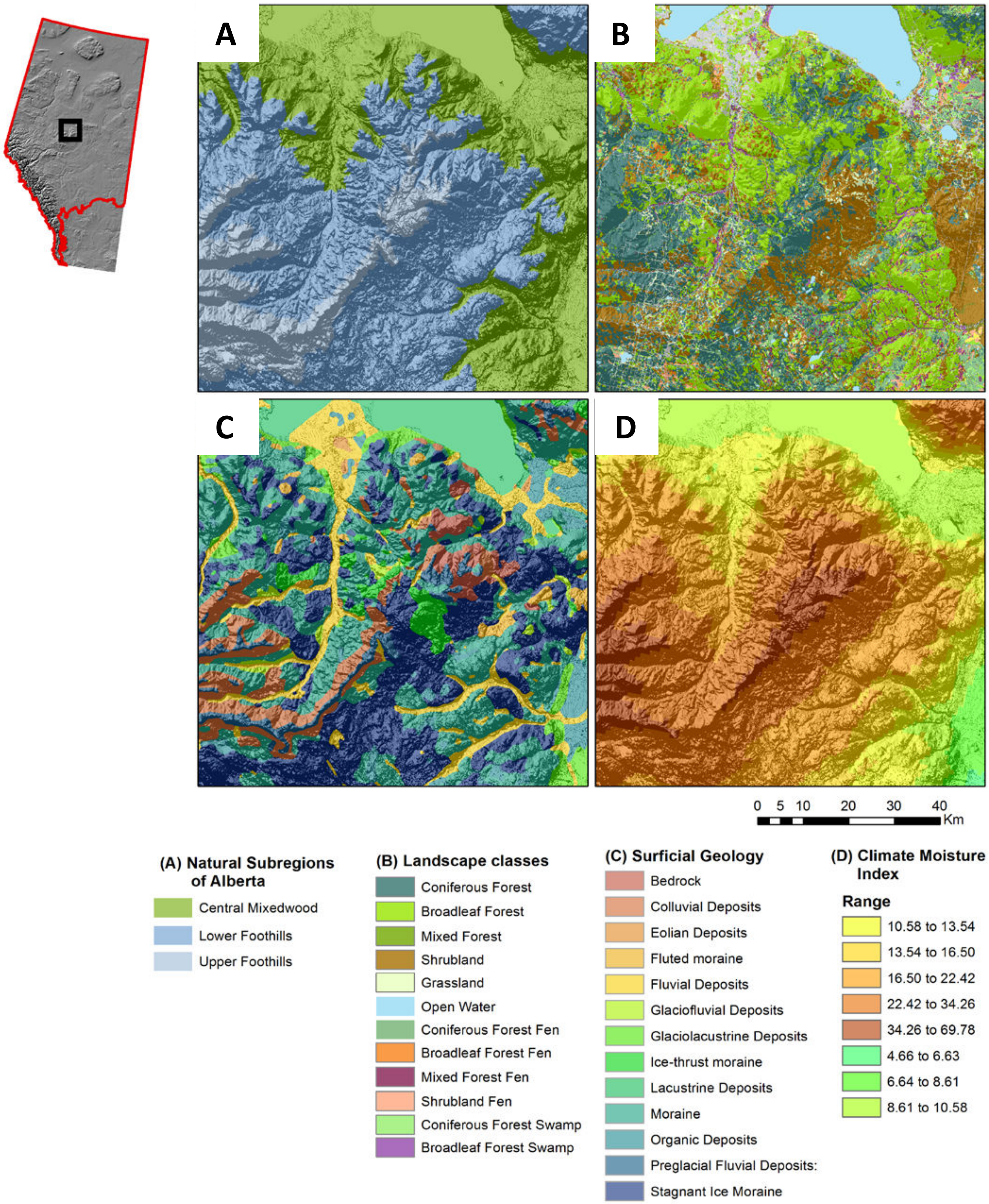
46 Ducks Unlimited Canada, *Learn About Wetlands*, accessed August 2015 at http://www.ducks.ca/learn-about-wetlands/

47 Alberta Merged Wetland Inventory downloaded January 28, 2015. Funding partners: Government of Alberta, Ducks Unlimited Canada, United States Forest Service (USFS), the PEW Charitable Trusts, United States Fish and Wildlife Service (North American Wetlands Conservation Act), Alberta Pacific Forest Industries Inc. (Al-Pac), Weyerhaeuser Company Ltd, Suncor Energy Foundation, Imperial Oil Resources, Lakeland Industry and Community Association (LICA), Shell Canada, EnCana Corporation, Canadian Boreal Initiative, Environment Canada (EC), Canadian Space Agency (CSA).

48 Mark G. Anderson and Charles E. Ferree, "Conserving the Stage: Climate Change and the Geophysical Underpinnings of Species Diversity," *PLoS ONE* 5, no. 7 (2010): e115544

Figure 6| Coarse filter conservation features used in the Marxan analysis

(A) Natural Subregions (B) landscape classes (C) surficial geology classes and (D) climate moisture index classes for an area south of Slave Lake, Alberta. Each color represents a different conservation feature used in Marxan. Only the main landscape classes are shown in the legend (too many classes to display).



Paintbrush - Alison Ronson

identifying natural landscape types within Natural Subregions in Alberta and is used by Alberta Environment and Parks ("**AEP**") in protected areas planning.[49] The surficial geology dataset by Alberta Geological Survey interprets quaternary geology at the regional scale. CPAWS Northern Alberta used the different surficial geology types to incorporate finer scale ecosystem classification in the analysis, which resulted in 14 classes within the study area (Figure 6C.

The Climate Moisture Index ("**CMI**"), or the amount of moisture available to vegetation on the landscape, determines the zonation of vegetation in Canada and defines the southern line of the boreal forest.[50] Several landscape characteristics including presence of conifers,[51] peatlands,[52] height of aspen,[53] and soil zonation[54] are sensitive to climatic moisture regimes, suggesting that CMI can be representative of ecosystem variation. The CMI dataset used in the Conservation Blueprint is calculated using mean annual precipitation ("**P**") minus mean annual potential evapotranspiration ("**PET**", P-PET) from interpolated 30 year climate normals. The dataset is in raster form with continuous values of CMI, and was re-classified into 20 classes within the province using quantiles, resulting in 18 classes within our study area for use in Marxan (Figure 6D).

Together, CPAWS Northern Alberta's unique landscape classes, Natural Subregion classes, surficial geology classes, and CMI classes provided a total of 85 coarse conservation features for use in Marxan (Appendix A1).

49 Alberta Parks. *Natural Regions and Subregions of Alberta, A Framework for Alberta's Parks*. Edmonton: Alberta Tourism, Parks and Recreation (2015), 72pp.

50 Edward H. Hogg, "Temporal Scaling of Moisture and the Forest-Grassland Boundary in Western Canada," *Agricultural and Forest Meteorology* 84, no. 1–2 (March 1997): 115–22

51 Stephen C. Zoltai, *Southern Limit of Coniferous Trees on the Canadian Prairies*, Northern Forest Research Centre, Canadian Forestry Service, Environment Canada, 1975. 24pp

52 Dale H. Vitt, Linda A. Halsey, and Stephen C. Zoltai, "The Bog Landforms of Continental Western Canada in Relation to Climate and Permafrost Patterns," *Arctic and Alpine Research* 26, no. 1 (1994): 1–13

53 E. H. Hogg and P. A. Hurdle, "The Aspen Parkland in Western Canada: A Dry-Climate Analogue for the Future Boreal Forest?," *Water, Air, and Soil Pollution* 82, no. 1–2 (1995): 391–400

54 W. K. Sly, "A Climatic Moisture Index for Land and Soil Classification in Canada," *Canadian Journal of Soil Science* 50, no. 3 (1970): 291–301

Fine Filter Conservation Features

To ensure that sensitive wildlife species are represented in the protected areas design, CPAWS Northern Alberta used eight datasets from AEP: caribou ranges, grizzly bear zones, sensitive raptor ranges (including bald eagle, ferruginous hawk, peregrine falcon, and prairie falcon), sensitive amphibian ranges, mountain goat and sheep ranges, colonial nesting birds (including great blue heron and American white pelican), trumpeter swan waterbodies, and piping plover waterbodies.[55] The caribou range dataset was separated into 14 classes representing individual caribou herds, since each herd corresponds to a unique breeding population.[56] In total, the sensitive wildlife datasets by AEP provided 25 fine conservation features for use in Marxan (Appendix 2).

There are over 1,100 sensitive or at-risk species in Alberta for which geographical range or distribution data is not publicly available.[57] CPAWS Northern Alberta accumulated presence locations for species listed federally as *Endangered*, *Threatened*, or *Special Concern* under the recommendation of the Committee on the Status of Endangered Wildlife in Canada ("**COSEWIC**"), or provincially as *At Risk*, *May Be at Risk*, or *Sensitive* under the recommendations of Alberta's Endangered Species Conservation Committee. In addition, culturally important species such as moose (*Alces alces*) and beaver (*Castor canadensis*) were added to the analysis to ensure representation in a protected areas network. Point locations were collected by accessing public data available through the ABMI, Alberta Conservation Information Management Systems ("**ACIMS**"), and the Fish and Wildlife Management Information Systems ("**FWMIS**").

GREAT BLUE HERON - RYAN PERUNIAK

"There are over 1,100 sensitive or at-risk species in Alberta"

55 Alberta Environment and Parks, *Wildlife Sensitivity Maps*, accessed October 2014 at http://esrd.alberta.ca/forms-maps-services/maps/wildlife-sensitivity-maps/default.aspx. Trumpeter Swan dataset updated on September 23, 2015.

56 Alberta Sustainable Resource Development and Alberta Conservation Association. "Status of the Woodland Caribou (*Rangifer tarandus caribou)* in Alberta: Update 2010." *Wildlife Status Report No. 30*. Edmonton (2010). 88pp.

57 1,119 species were recorded as having a status of 'At Risk', 'May be at Risk', or 'Sensitive' in the Alberta Wild Species General Status Listing, 2010: http://aep.alberta.ca/fish-wildlife/species-at-risk/wild-species-status-search.aspx accessed on February 3, 2015.

Species presence locations tend to be biased towards areas where humans are more likely to encounter a species, such as near cities or highways. In addition, species locations are based on historical or present day occupancy, yet areas that are unoccupied today may still be suitable habitat for a species in the future (Figure 7).

Species distributions were therefore modeled using MaxEnt (v 3.3.2) using 46 environmental predictor variables ranging from elevation, natural regions, landcover, wetlands, surficial geology, and climate (for the full list see Appendix 3). Only species that had more than 10 point locations were modeled,[58] resulting in a total of 186 culturally important and species at-risk species distribution models ("**SDMs**"). Environmental variables were compiled along a $1km^2$ grid and averaged to a 6km moving window to account for landscape scale variation and inaccuracies in species presence locations. Only linear and quadratic features were modeled to prevent over-fitting of small datasets.[59] Species with poor omissions rates or area under the curve ("**AUC**") scores of less than 0.7 were removed,[60] resulting in 177 SDMs that were used in the Marxan analyses (see Appendix 1d). Combined with the species range data from AEP this resulted in 202 fine filter conservation features.

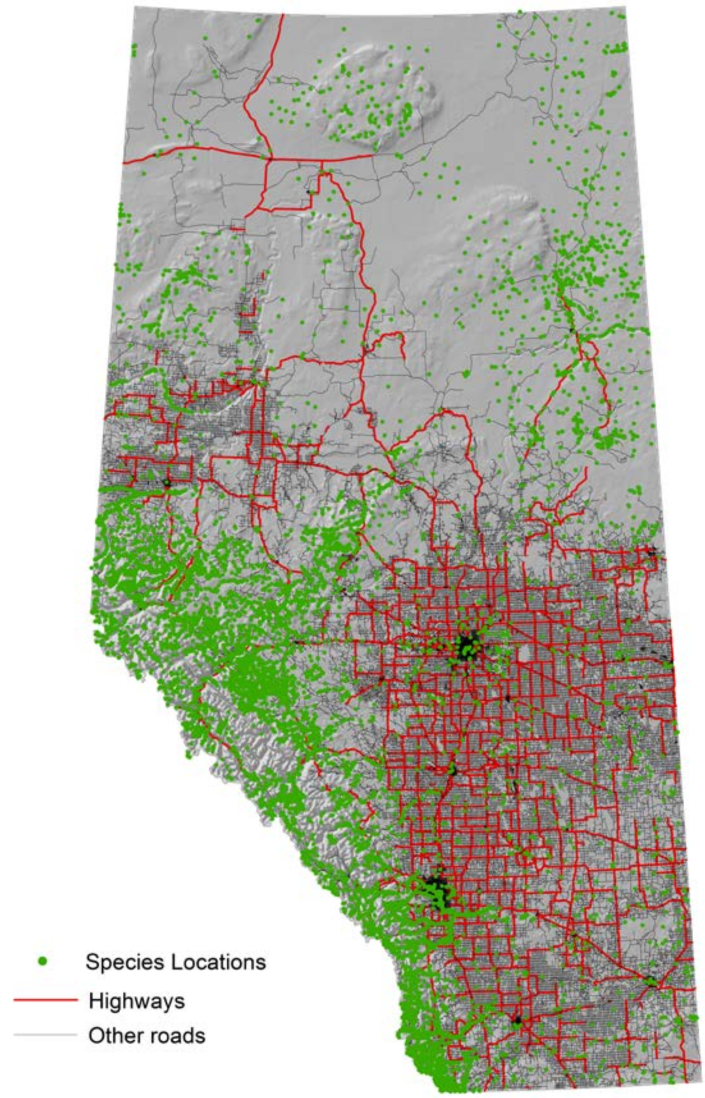


Figure 7| Sampling for species (green dots) tends to be biased towards cities and roads

Conservation features within planning units

For Marxan to achieve representation of all conservation features in a protected areas design, it must know how much of each feature is within each planning unit. To create the conservation feature versus planning unit file for Marxan, CPAWS Northern Alberta converted each conservation feature to 100m rasters and tabulated their area by planning unit in ArcGIS (v10.1). Each species distribution model output from MaxEnt contains values between 0 and 1 that predict the species probability of occurrence across the study area. Only values higher than the logistic threshold for equal training sensitivity and specificity were used as a measure of the accuracy of the SDMs to ensure that only potentially suitable habitat was predicted as occupied.[61,62]

58 Personal communication, Scott Nielsen (Dec 12, 2014)

59 Personal communication, Scott Nielsen (Dec 12, 2014)

60 Jennie Pearce and Simon Ferrier, "Evaluating the Predictive Performance of Habitat Models Developed Using Logistic Regression," *Ecological Modelling* 133, no. 3 (2000): 225–45

61 Ming-Gang Zhang et al., "Using Species Distribution Modeling to Improve Conservation and Land Use Planning of Yunnan, China," *Biological Conservation* 153 (2012): 257–64

62 Kerrie Wilson et al., "Sensitivity Of Conservation Planning To Different Approaches To Using Predicted Species Distribution Data," *Biological Conservation* 22, no. 1 (2006): 99–112. [Hereinafter, Wilson *et al*.]

Grizzly- Ryan Peruniak

In order to maintain the ranking of 'best' habitat in Marxan, the mean probability of occurrence for each planning unit was multiplied by the area of the planning unit.[63] For example, AEP's grizzly bear range data is divided into two habitat zones: core range and secondary range. CPAWS Northern Alberta prioritized the core range of grizzly bear habitat by giving a rank of 1 for core range and 0.5 for secondary range. This ranking was then multiplied by the area of grizzly bear habitat within each planning unit. All tabular outputs for each conservation feature were then merged by planning unit in R (v3.1.2) and normalized as a percentage of each conservation feature's total abundance in the study area. This normalization was used to ensure equal weighting of every conservation feature in Marxan regardless of differences in area or density.[64] The tabular matrix of planning units versus conservation features was then converted to a sparse (relational) format using Marxan.

63 Wilson *et al.*, *supra*

64 Jeff A Ardron, Hugh P Possingham, and Carissa J Klein, eds., *Marxan Good Practices Handbook*, Version 2 (Victoria, Canada: Pacific Marine Analysis and Research Association, 2010), pacmara.org.

Logs waiting to be transported to the mill - Danielle Pendlebury

Targets

The setting of biodiversity targets in conservation planning is a problem that conservationists, scientists, and policy-makers continuously struggle with. Although it is often agreed that the best biodiversity targets are those that are established from an evidence-based approach (for example, minimum dynamic protected area sizes or minimum viable populations), obtaining these targets are time consuming and data-heavy. Protected area targets set in policy, such as Aichi Target 11, are usually social decisions rather than ecological thresholds grounded in science, and are on average three times lower than evidence-based targets.[65] Currently, Canada has only protected 10% of its land base. At this level of protection, if larger, connected protected areas are not put in place, 50% of the country's species could be lost forever.[66] A recent review of evidence-based conservation targets in the literature found that those targets that addressed the concepts of representation, resiliency, and redundancy recommended at least 60% protection,[67] with one study estimating that 75% protection or more is needed.[68]

Marxan aims to identify a conservation or protected areas system that will meet user-defined biodiversity targets for each conservation feature. For example, a possible biodiversity target could be to ensure that at least 20% of the abundance of every wetland class in Alberta is represented in a protected areas network. Establishing evidence-based targets for all of the conservation features in this study is beyond the scope of this project. CPAWS Northern Alberta therefore chose a range of biodiversity targets (20%, 50%, and 80%) for each conservation feature that cover the range of evidence-based targets in the literature. Having multiple targets allows CPAWS Northern Alberta to prioritize which areas of the landscape have the highest value for conservation, illuminating the way towards achieving *at least* 50% protection.

"Currently, Canada has only protected 10% of its land base. At this level of protection, if larger, connected protected areas are not put in place, 50% of the country's species could be lost forever"

65 Leona K. Svancara et al., "Policy-Driven versus Evidence-Based Conservation: A Review of Political Targets and Biological Needs," *BioScience* 55, no. 11 (2005): 989, doi:10.1641/0006-3568(2005)055[0989:PVECAR]2.0.CO;2. [Hereinafter Svancara *et al.*]

66 Svancara *et al.*, *supra*

67 Svancara *et al.*, *supra*

68 R.F. Noss *et al.*, "Bolder thinking for conservation," *Conservation Biology* 26 (2012): 1-4 [Hereinafter, Noss *et al.*]

"conservation gains can still be achieved on the land in exchange for minimal economic losses"

Trade-offs in conservation planning

Systematic conservation planning often finds multiple protected area designs that will each achieve its conservation objectives, but which often have differing social or economic costs. Marxan is useful in assessing these trade-offs between socio-economic and conservation objectives by assigning a cost to each planning unit. Often there are competing demands for land, especially in a province such as Alberta where resource development is high. Many studies have shown that conservation gains can still be achieved on the land in exchange for minimal economic losses when spatial distributions of both biological benefits and economic costs are incorporated into conservation planning.[69,70,71,72] Areas that have high conservation value will always be prioritized, although in scenarios in which socio-economics are included, Marxan will identify areas that are less socially disruptive. Two methods for estimating socio-economic value were used in the Conservation Blueprint: linear feature density and net present value of resources on the land.

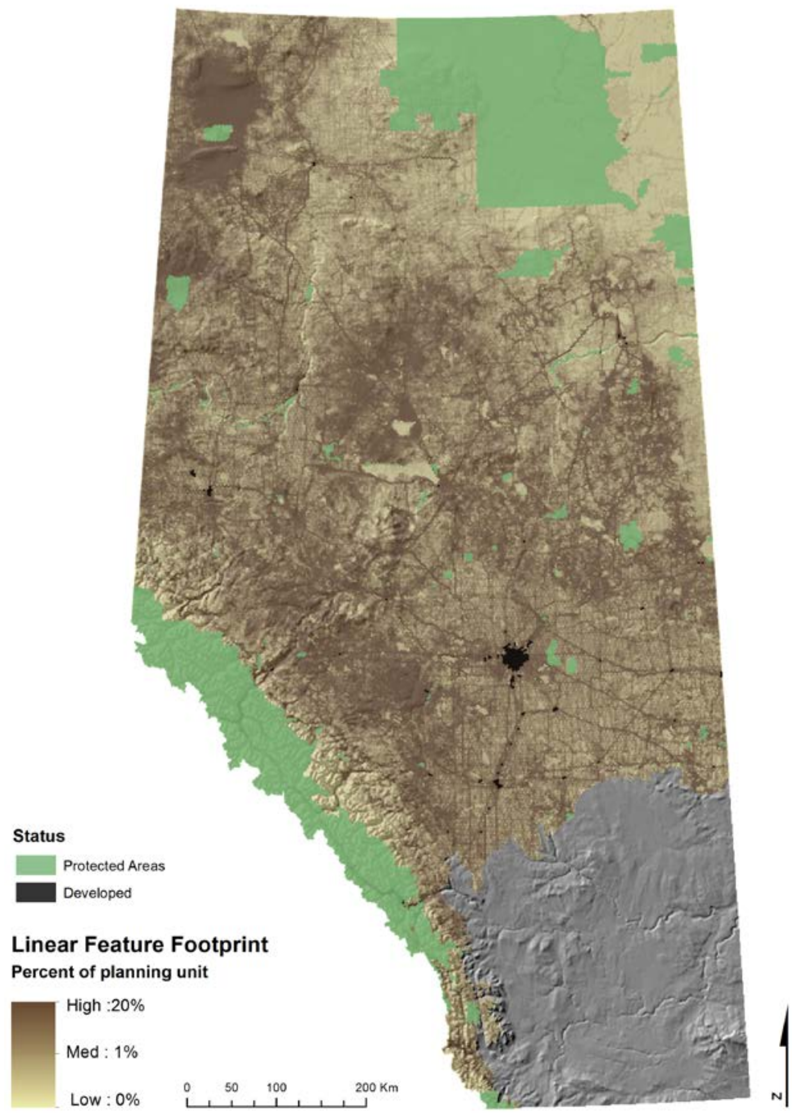
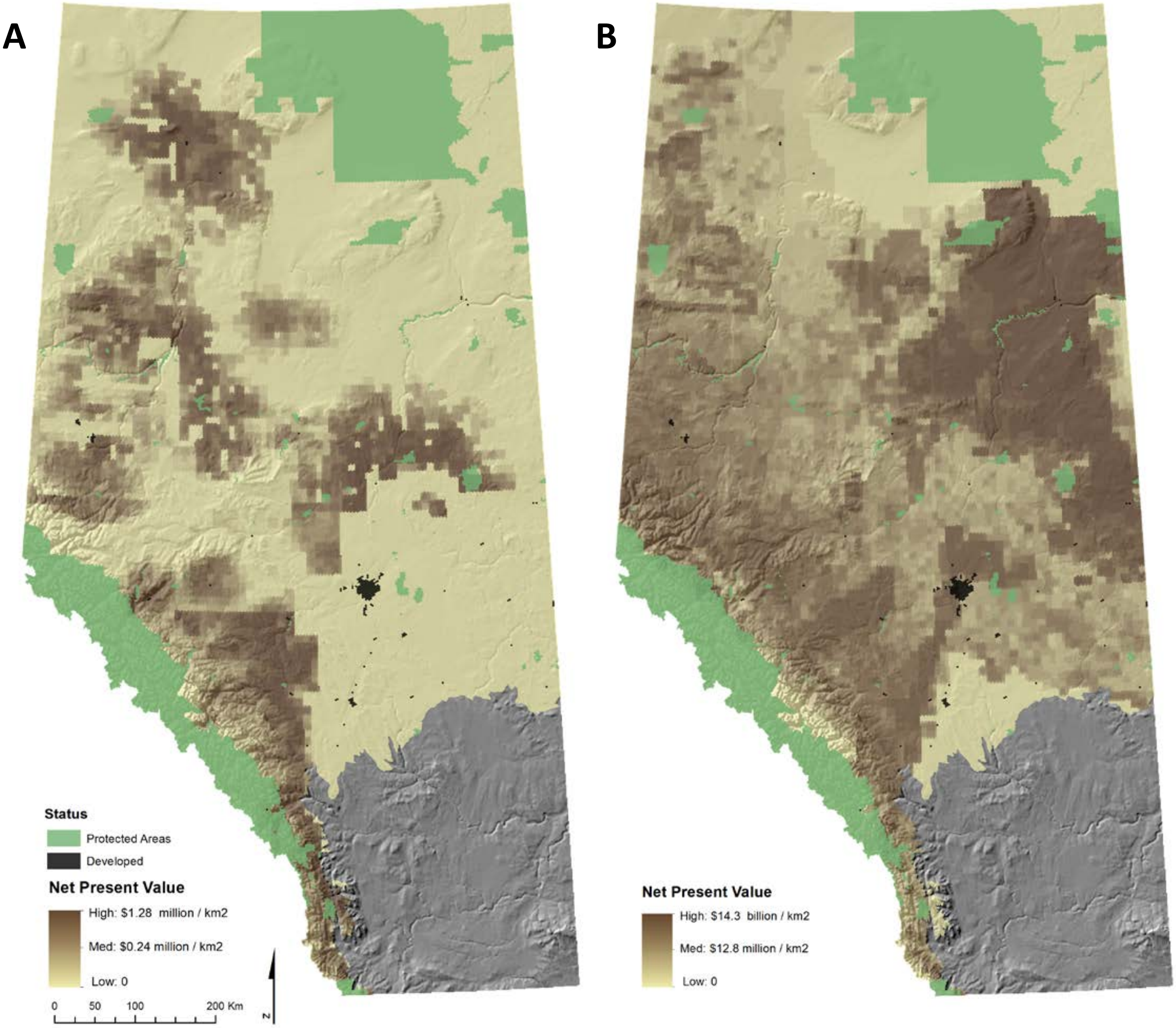


Figure 8| Percent linear features per planning unit in the study area.

A high density of linear features such as roads, pipelines, and seismic lines typically indicates high resource extraction or human presence, and can be a good overall measure of socio-economics (Figure 8). By using linear feature density as a cost function in Marxan, the likelihood of selecting planning units that have a

69 A. Ando, "Species Distributions, Land Values, and Efficient Conservation," *Science* 279, no. 5359 (March 27, 1998): 2126–28
70 Josie Carwardine et al., "Avoiding Costly Conservation Mistakes: The Importance of Defining Actions and Costs in Spatial Priority Setting.," *PloS One* 3, no. 7 (2008): e2586
71 Robin Naidoo et al., "Integrating Economic Costs into Conservation Planning.," *Trends in Ecology & Evolution* 21, no. 12 (2006): 681–87
72 Schneider *et al.*, *supra*



high density of linear features in the protected areas design is reduced. This method also increases the likelihood of selecting intact landscapes. ABMI's Human Footprint map (2010 v1.1) was used to calculate the area of roads, rail, transmission lines, pipelines, and seismic lines within each planning unit. Few linear features regenerate over time without active restoration. In many areas of Alberta active restoration of linear features needs to occur to reduce the overall development footprint and ensure the survival of important wildlife species such as caribou. On seismic lines, this restoration has been estimated to cost from $3,000 to $4,500 per kilometre of line.[73] By including seismic lines as a cost function, Marxan works to minimize them in the overall design while still ensuring that the biodiversity targets are met. This scenario therefore not only maximises intactness, it also identifies conservation networks that minimize the cost for restoration.

73 Cassidy Kay van Rensen, "Predicting Patterns of Regeneration on Seismic Lines to Inform Restoration Planning in Boreal Forest Habitats" (University of Alberta, 2014).

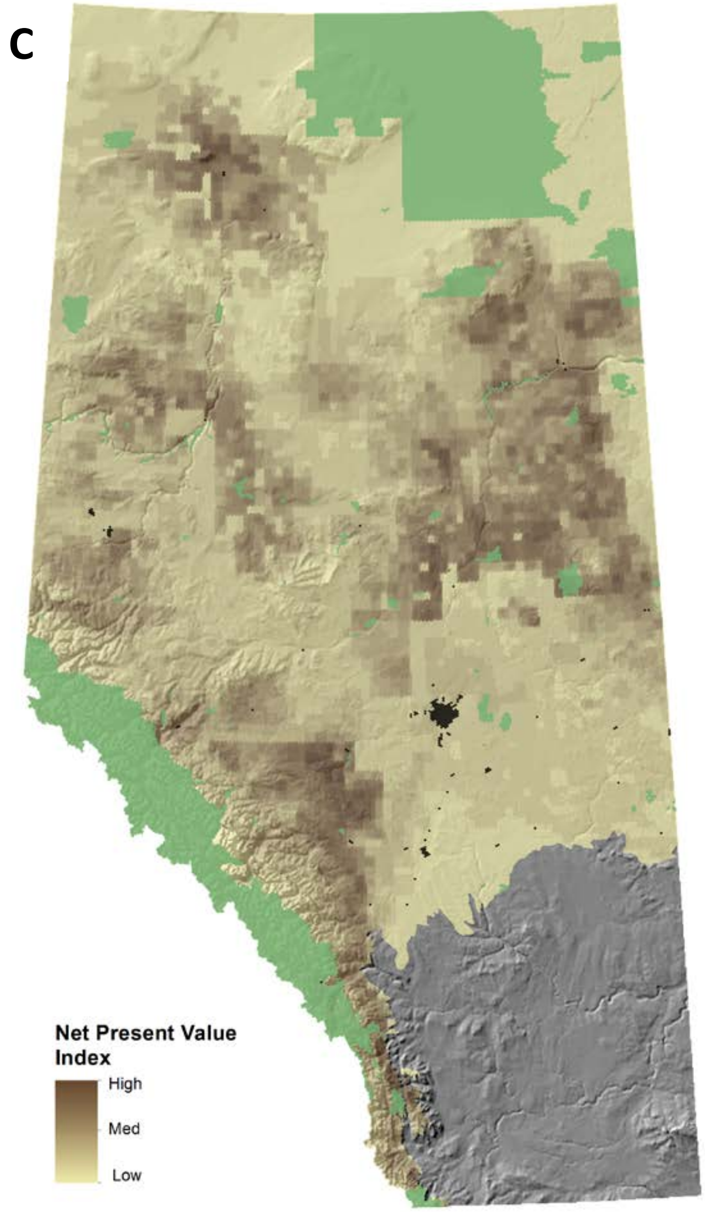


FIgure 9| Net present value (NPV) of each township in the study area, modeled by Grant Hauer of the University of Alberta by projecting expected resource flows, revenues, and costs over time.

Figure 9(A) shows the NPV of forestry resources in the study area

Figure 9(B) illustrates the NPV of the oil and gas sector in the study area

Figure 9(C) is a calculation of the NPV indev for each township where the separate NPV indices of both forestry and oil and gas are summed and weighted equally on the landscape. This ensures equal representation of the two industrial sectors in the Marxan analysis. This method was necessary to ensure a fair approach to the two important resource economies in Alberta. While the NPV value of the forestry sector represents only 1% of the total resource value of the land, the forestry industry is important in employing over 20,000 people in Alberta and sustaining many smaller communities in the province.

Net present value ("**NPV**") of resources such as conventional natural gas, conventional oil, bitumen, and forest products can indicate where past, current, and future resource extraction may occur. CPAWS Northern Alberta used the NPV modeled by Dr. Grant Hauer at the University of Alberta that projects expected resource flows, revenues, and costs over time at the township level for both the forestry[74] and oil and gas sectors (Figure 9).[75] The NPV values of the forestry sector only accounts for 1% of the total resource values of the land; therefore, to ensure equal representation of the two sectors in Marxan, CPAWS Northern Alberta created separate indices for the forestry sector and the oil and gas sector and summed them together. This scenario therefore minimizes the lost opportunity cost of a protected area design by identifying areas that have a lower value for resource development but that still meet biodiversity targets.

74 Grant Hauer et al., "Tradeoffs between Forestry Resource and Conservation Values under Alternate Policy Regimes: A Spatial Analysis of the Western Canadian Boreal Plains," *Ecological Modelling* 221, no. 21 (2010): 2590–2603

75 Grant Hauer, Wiktor Adamowicz, and Robert Jagodinski, "A Net Present Value Model of Natural Gas Exploitation in Northern Alberta: An Analysis of Land Values in Woodland Caribou Ranges," *Rural Economy: Project Report #10-01*, 2010.

Aspen forest - Ryan Peruniak

Gap analysis

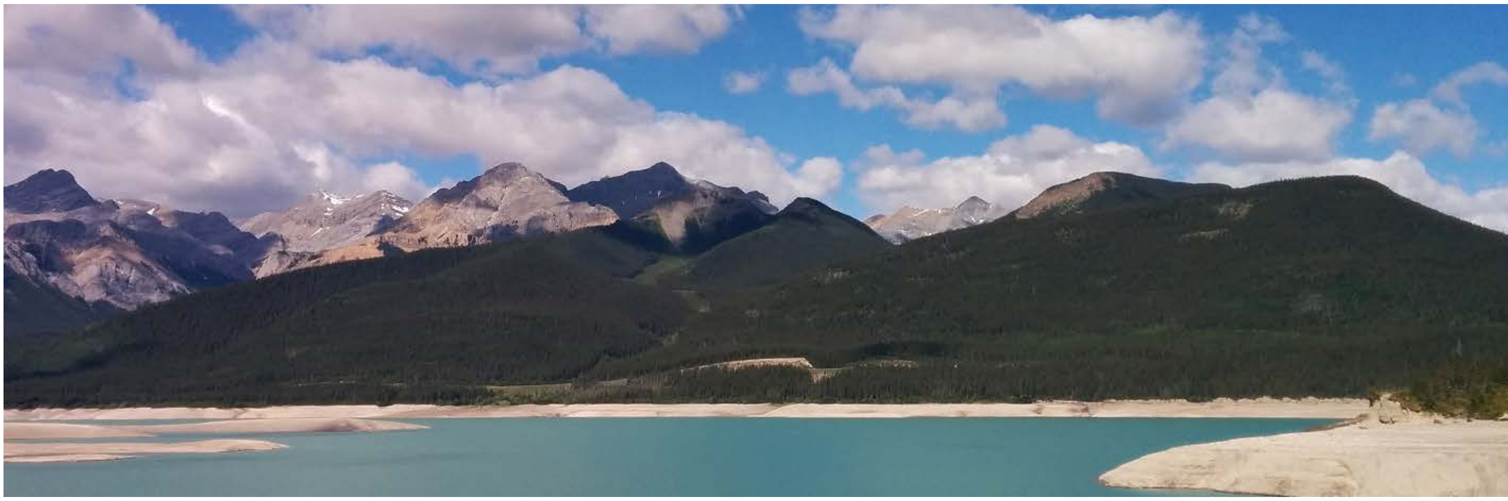
Historically, the location of protected areas has been selected not because of the conservation value of an area but because of its unsuitability for agriculture, forestry, or urban development.[76] These relatively 'easy' sites for conservation have resulted in an over-representation of steep slopes and high elevation in protected areas, and inadequate protection of many species, landscape features, and habitats. In Alberta, 15 out of the 21 Natural Subregions currently have less than 17% protection,[77] highlighting the need for better representation of landscape features in the province's protected areas network. A protected areas design therefore must identify what these gaps are and ensure that they are filled.

Marxan can account for protected and developed areas by locking planning units either in or out, ensuring that planning units are either always selected in the case of protected areas or never selected in the case of highly developed areas. CPAWS Northern Alberta considered a planning unit to be 'protected' if more than 50% of its area fell within a protected area, and considered it 'developed' if more than 50% had the 'developed' landcover class according to ABMI's wall to wall landcover map (v2010). If some or all of a conservation feature occurred within a protected planning unit, that amount contributed towards the overall target for that conservation feature and Marxan then worked to fill in the gaps to ensure representation of all the features.

"A protected areas design must identify what the gaps are and ensure that they are filled"

76 Margules and Pressey, *supra*

77 Government of Alberta, *State of Planning in Alberta Parks: 2014 Annual Report* (2014).



Abraham Lake - Alison Ronson

Calibration of the model

Protected area size and connectivity (BLM)

Connectivity of protected areas is an important aspect in conservation design in addressing the long-term survival of species through allowing the migration of wildlife and adaptation to a changing climate. Although Marxan does not explicitly address connectivity in a protected areas design, it does allow selected areas to be clumped together through a boundary length modifier ("BLM"), which indirectly affects protected area size and connectivity. When the BLM is increased, Marxan works to minimize the boundary length, or surface area, of the conservation design by clumping selected planning units. For each scenario, multiple BLM values were tested with the total cost of the conservation solution plotted against boundary length. The value that minimized the boundary length with only a modest increase in overall protected area size was selected.

Species penalty factor (SPF)

Within each scenario of the Conservation Blueprint, the same targets had to be met by all conservation features. Depending on the density and location of these conservation features, Marxan had a difficult time reaching the targets of some. The species penalty factor ("**SPF**") is a tool in Marxan that can be used to ensure that the conservation features always meet their targets. CPAWS Northern Alberta initially used a low SPF of 0.001 for all conservation features and then iteratively increased the SPF value for those features that could not reach their targets. The final SPF values therefore ranged between 0.001 and 100.

Annealing parameters

Marxan works by using a simulated annealing algorithm that runs through multiple iterations to find the 'best' solution that meets the biodiversity targets. Both the number of 'temperature' decreases and the number of iterations help to determine how close Marxan gets to an optimal solution. With very large datasets that have a wide spread in conservation features, such as the Conservation Blueprint, these values need to be increased to allow Marxan to better recognize the best sites to select. The number of 'temperature' decreases was therefore increased to 100,000. The number of iterations was increased to 200 million when there was no substantial improvement in score with increasing numbers of iterations. Marxan was then set to do 100 repetitions for nine runs, one for each "cost" scenario (no cost, minimizing linear features, and minimizing NPV) with three conservation target levels for each (20%, 50%, and 80%).

Maligne Lake - Danielle Pendlebury

Northern pintail- Ryan Peruniak

Conservation Value

As a final step in assessing areas of high conservation value in northern Alberta, CPAWS Northern Alberta combined the nine Marxan runs above to determine the Conservation Value of each planning unit.[78] CPAWS Northern Alberta used indices for irreplaceability, rarity, diversity, and richness for each planning unit to calculate its Conservation Value as:

Conservation Value = irreplaceability + rarity + diversity + richness

Irreplaceability

For each repetition in Marxan, a 'good' protected areas network is identified. One way to visualize the model outcomes is to look at the probability of selection for each planning unit, or the 'summed solutions' across 100 repetitions. This probability of selection can be considered as an 'irreplaceability' value, and can help to identify hotspots for biodiversity within the study area. The number of times a planning unit is selected is related to the uniqueness of its features, in that a planning unit that has rare or unique features will be 'irreplaceable' and always selected. Planning units that have high probabilities of selection therefore have high conservation value and should be prioritized for protection. Thus, the irreplaceability index was calculated as the probability of selection for each scenario and biodiversity target. It considered conservation priority, linear feature density, and NPV scenarios.

Indices for rarity, diversity, and richness

The rarity index was based on the rating of each at-risk species, with federally-listed *Endangered* species given the highest ranking and provincially-listed *Sensitive* species given the lowest ranking. The diversity index was calculated as the number of different conservation features found in each planning unit, and the richness index was calculated using the amount of each conservation feature per planning unit.

78 Sarah Loos, "Marxan analyses and prioritization of conservation areas for the Central Interior Ecoregional Assessment" *BC Journal of Ecosystems and Management* 12, no 1 (2011): 88-97

Chapter Three

Results and Discussion

The results of CPAWS Northern Alberta's Conservation Blueprint illustrates many things – where areas of high conservation value are located on the landscape, where the "cost" of protection to social and economic interests may influence protected areas planning, or what areas on the landscape are the most diverse, irreplaceable, or with the highest species richness.

The following maps, or scenarios, in this Conservation Blueprint illustrate the following:

1. Priority areas for conservation in northern Alberta (when selecting for 20, 50, or 80% protection of all conservation features);
2. Priority areas for conservation when linear disturbance and NPV are used as "cost" features on the landscape; and
3. Areas where Conservation Value is the highest, where Conservation Value refers to the irreplaceability of an area combined with its conservation feature richness, diversity, and rarity.

Each of these maps illustrate areas that were selected by Marxan in order to meet the targets for all of the conservation features, which included the coarse filter features, species ranges, and the species distribution models created for at-risk species in Alberta. The results of these at-risk species habitat preferences are therefore described first.

Cougar - Ryan Peruniak

Mapping potential habitat for at-risk species

A total of 177 at-risk or culturally important species showed significant habitat preferences using the 46 environmental predictor variables in MaxEnt (Appendix 4). These species distribution models provide a detailed potential distribution map for each species (Figure 10).

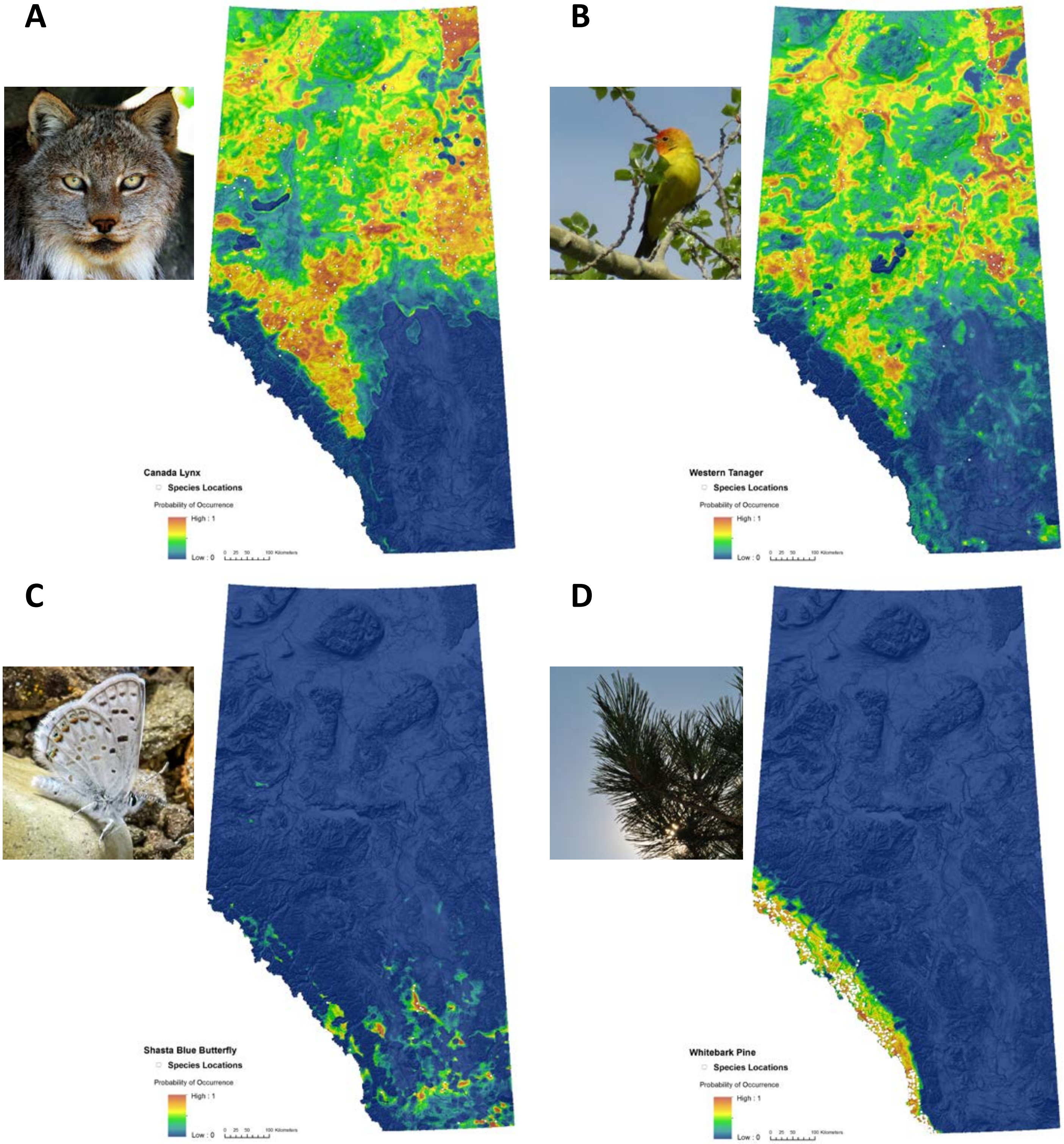
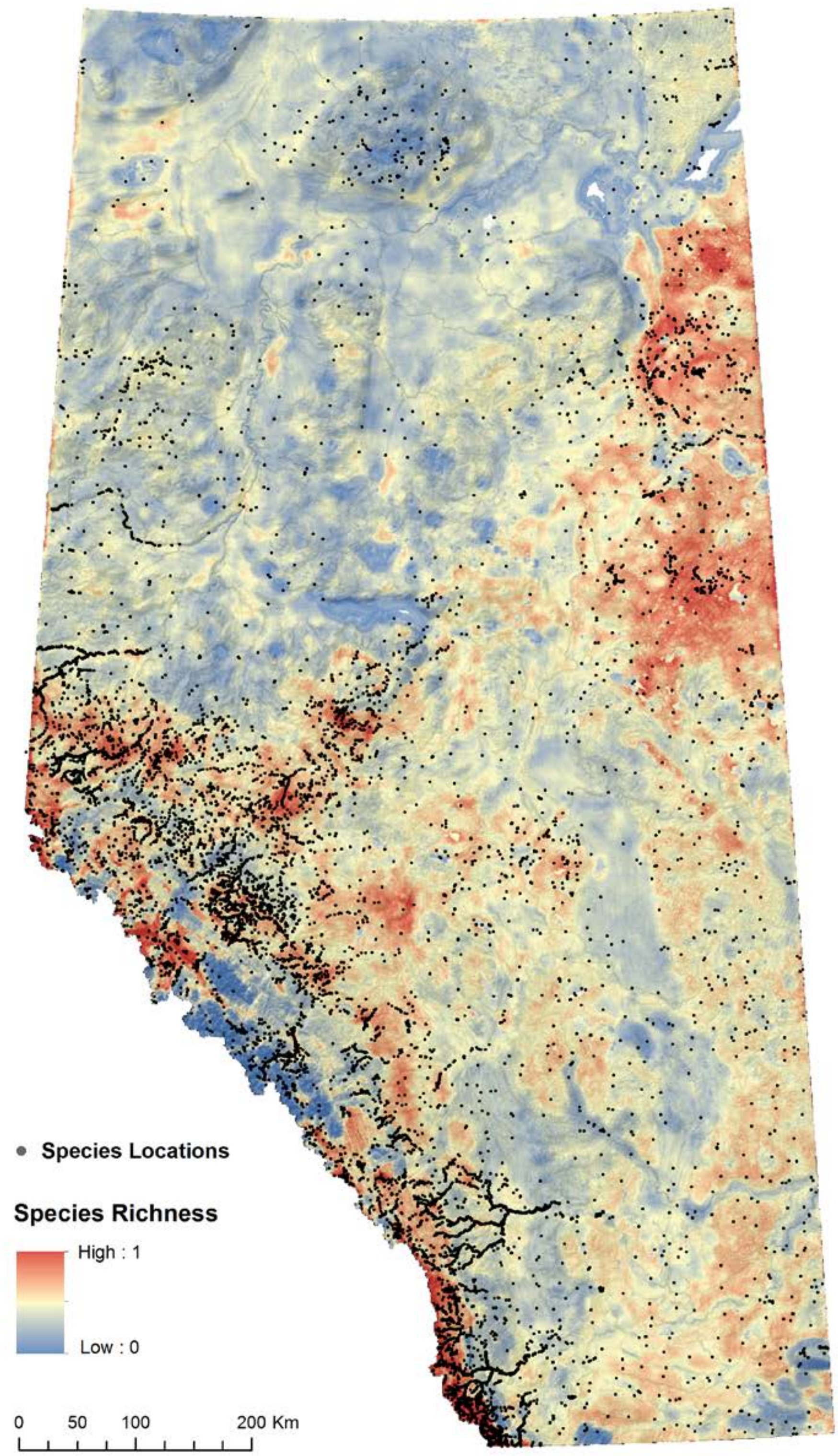


Figure 10| Examples of species distribution models for (A) lynx (Lynx canadensis) (B) western tanager (Piranga ludoviciana), (C) shasta blue butterfly (Icaricia shasta), and (D) whitebark pine (pinus albicaulis). The probability of occurrence for each species are mapped with blue being the least likely and red the most likly to find the species in that location. Image credits: (A,B,D) pixabay (C) Jaimee Morozoff.

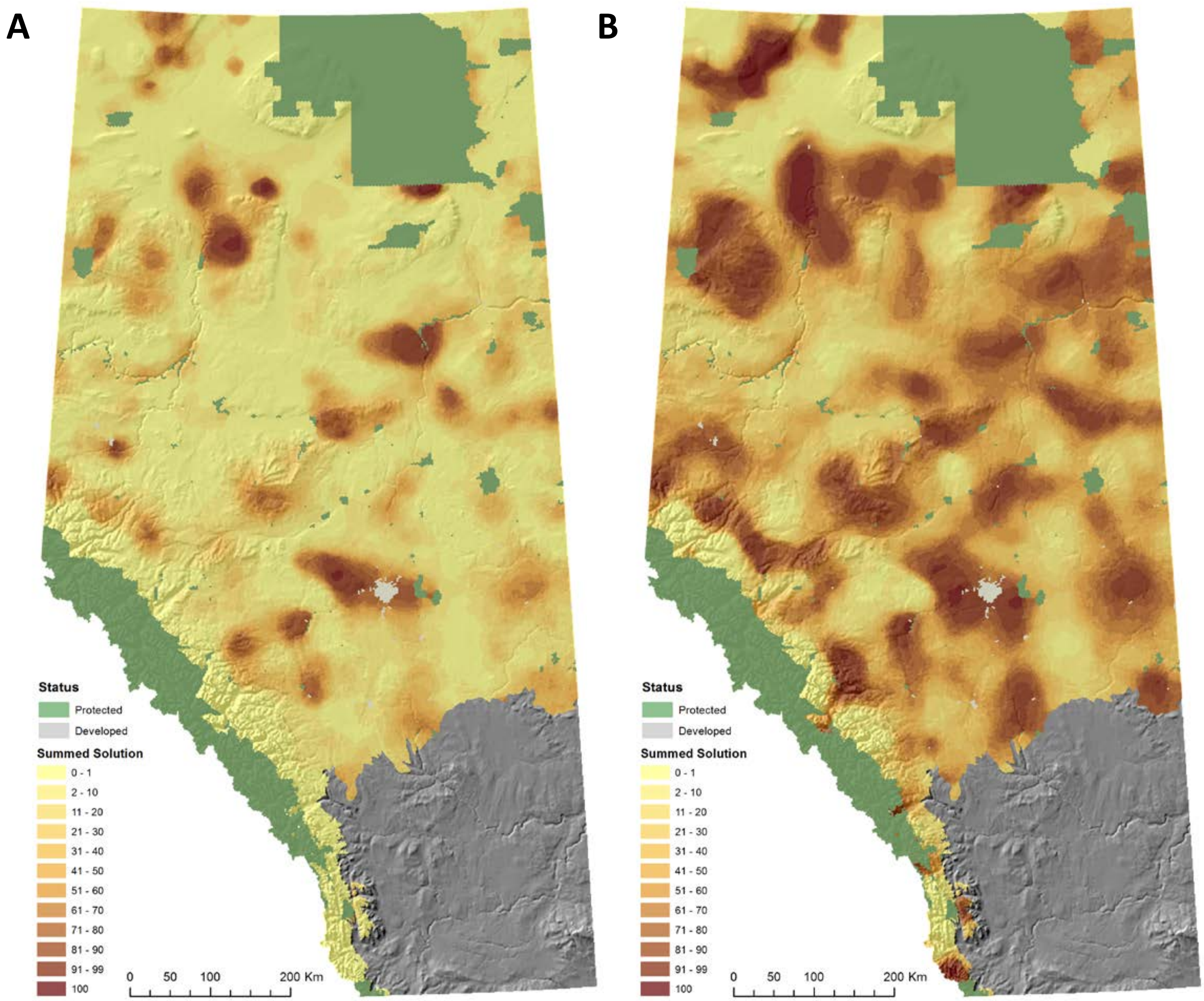
Figure 11| Fine filter conservation feature diversity.

This map illustrates the number of at-risk and culturally important species predicted to be in any one area, with red being the most number of species and blue being the least number of species. The species included were the 12 sensitive species ranges from AEP (Appendix 2) and the 177 species distribution models from MaxEnt (Appendix 4).

The black dots illustrate the species presence locations that were used to create the species distribution models. Although the models do correct for some of the bias around roads and cities, there is still bias away from areas that have poor sampling such as the Bighorn Wildland and northwestern Alberta.



Combined with the range maps provided through AEP, 189 species were included in the Marxan analysis, which included one amphibian, one gastropod, three fish, four butterflies, eight lichens, nine mammals, 40 birds, 47 mosses, and 76 vascular plants. CPAWS Northern Alberta mapped at-risk or culturally important species diversity using these species, showing a number of hotspots primarily in the Rockies, Foothills, and in the northeast of the province. Although the species distribution models correct for some bias in data collection for species locations, it is evident based on the lack of data in the Bighorn Wildland area of the province, near Nordegg and in northwestern Alberta that the sampling locations still result in some bias (Figure 11).



Priority conservation areas

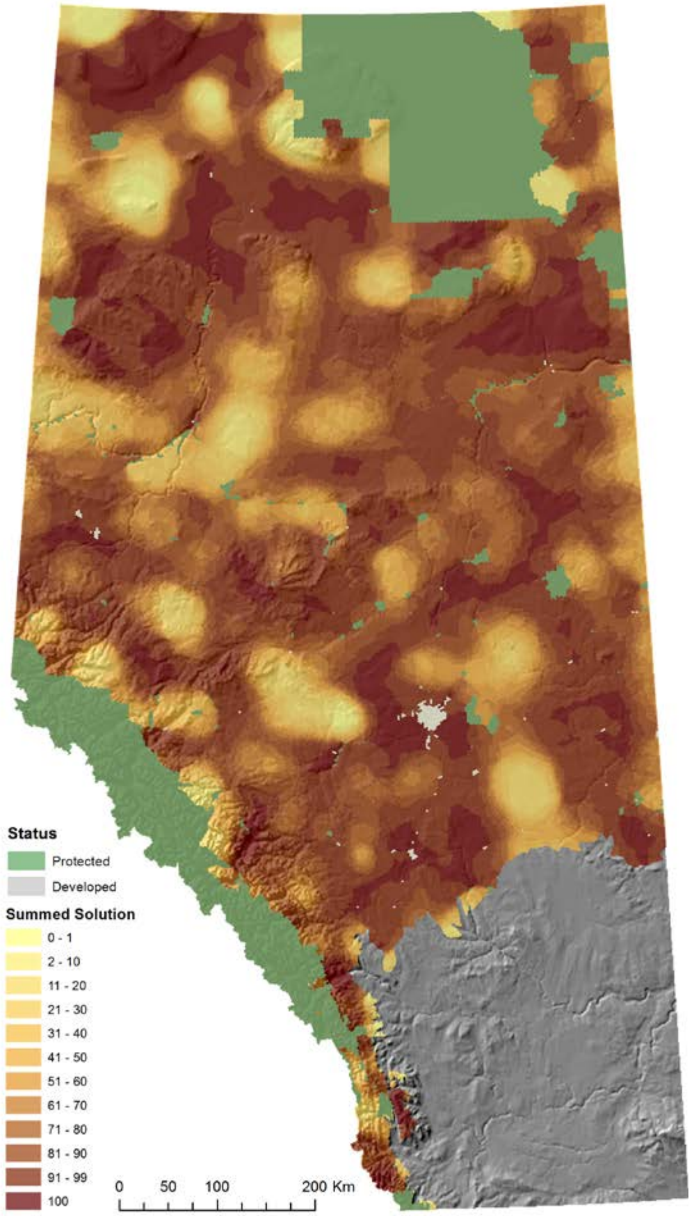
The Short-Term Perspective: 20% Protection of All Conservation Features

The CBD's Aichi Target 11 requires that all signatories to the CBD must achieve 17% protection of terrestrial and inland waters by the year 2020, and 10% of marine areas.[79] CPAWS released a report in July of 2014 titled *Protecting Canada: Is it in our nature?* which assessed Canada's and Alberta's progress towards the Aichi commitment.[80] Alberta was found to be lagging, with only 12.4% of its area protected, much of which includes the Rocky Mountains National Parks and Wood Buffalo National Park. If Alberta is to aid Canada in meeting Aichi Target 11, it must protect at least another 5% of its land base by 2020. And, this target is just the beginning towards setting the stage for a true commitment of *at least* 50% protection. Figure 12A shows priority areas for conservation if only 20% of conservation features are protected by 2020.

79 CBD Aichi Target 11, *supra*

80 CPAWS, *supra*

C



“If Alberta is to aid Canada in meeting Aichi Target 11, it must protect at least another 5% of its land base by 2020. And, this target is just the beginning towards setting the stage for a true commitment of *at least* 50% protection”

FIgure 12| Priority conservation areas for (A) 20% conservation targets, (B) 50% conservation targets, and (C) 80% conservation targets.

Each target level was set to run 100 times and the summed solution, or number of times the planning unit was selected, is shown. Dark brown illustrates the planning units that were selected the most and can be considered as ‘irreplaceable.’

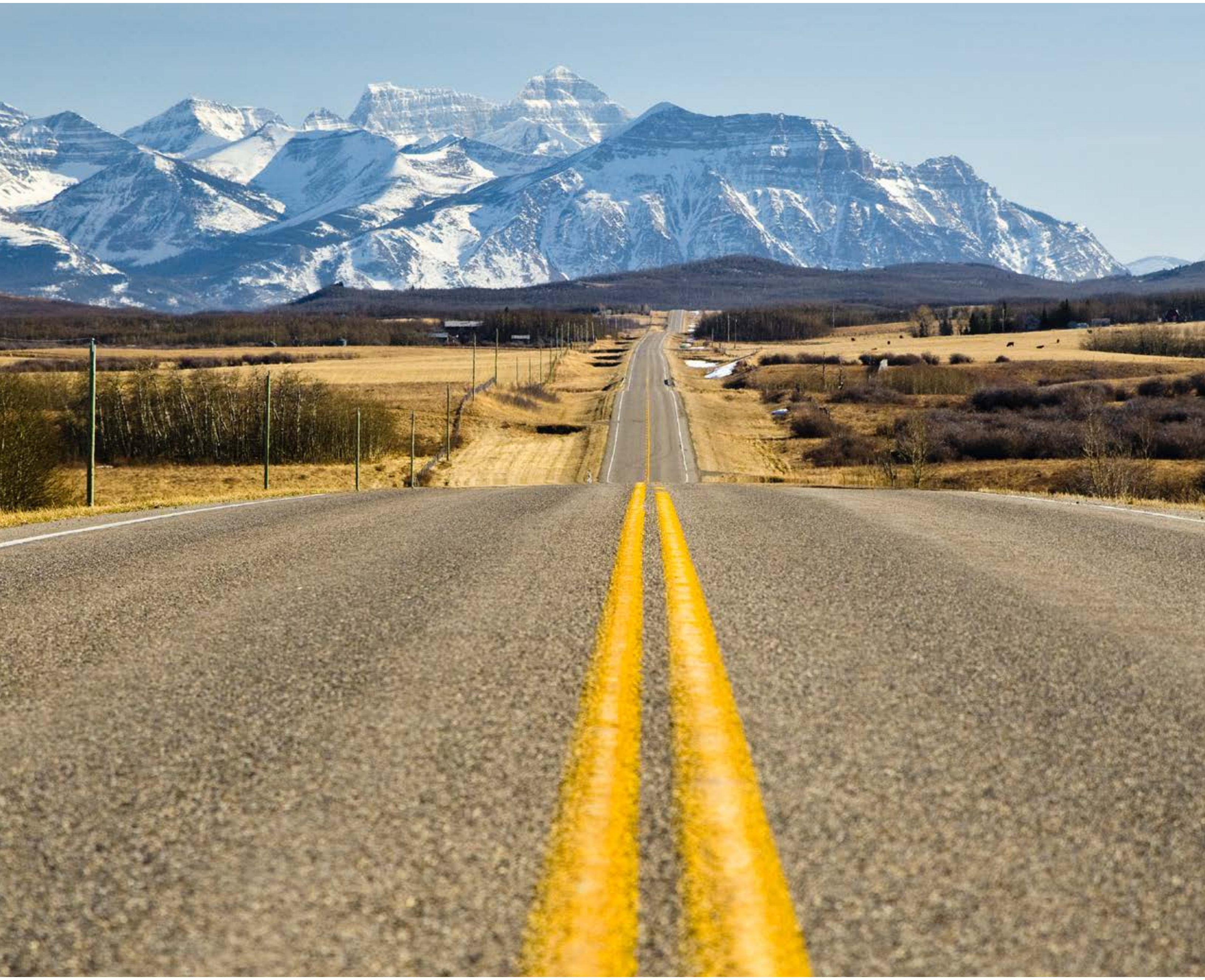
Nature Needs At Least Half: 50% Protection of All Conservation Features

In order to maintain biodiversity and ecological processes, many recent scientific studies have concluded that at least 50% of all representative landscapes requires protection.[81] For example, the International Boreal Conservation Science Panel released a report in 2013 stating that it is imperative that conservation be given top priority in planning for the future of Canada’s boreal forest, and recommending “at least 50% of an ecosystem or broad-scale landscape should be incorporated into a network of conservation areas that are free of industrial disturbance.”[82] Figure 12B shows the area required in northern Alberta if at least 50% of all conservation features are to be protected.

Protecting Alberta for Future Generations: 80% Protection of All Conservation Features

In some areas, protection of up to 75% is required in order to maintain biodiversity and ecological processes.[83] Figure 12C illustrates a level of 80% protection of all conservation features in northern Alberta.

81 See Noss *et al.*, *supra*, and Locke, *supra*
82 Badiou *et al., supra*
83 Noss *et al., supra* and Locke, *supra*



Linear features, such as roads, fragments the landscape and can lead to habitat loss - Ryan Peruniak

Protecting less than 100% of northern Alberta is an indication that the province is willing to sacrifice some of the biodiversity in the northern Natural Subregions of the province. Alberta has already seen massive habitat loss over the past century and, given the amount of disturbance currently existing on northern Alberta's landscape, many species have been pushed out of much of their remaining natural habitat. What is known is that a protected area network that has greater representation of landscape features and species habitat is healthier. What is not known, however, is how much protection is enough to ensure the long-term survival of all of biodiversity.[84,85] The selection of 100% habitat protection in the model for all species would have resulted in a map that shows the need for wall-to-wall conservation in the province. Anything less than this indicates that the province has made a decision to sacrifice biodiversity and healthy ecological processes in return for industrial development, recreation, or urban expansion.

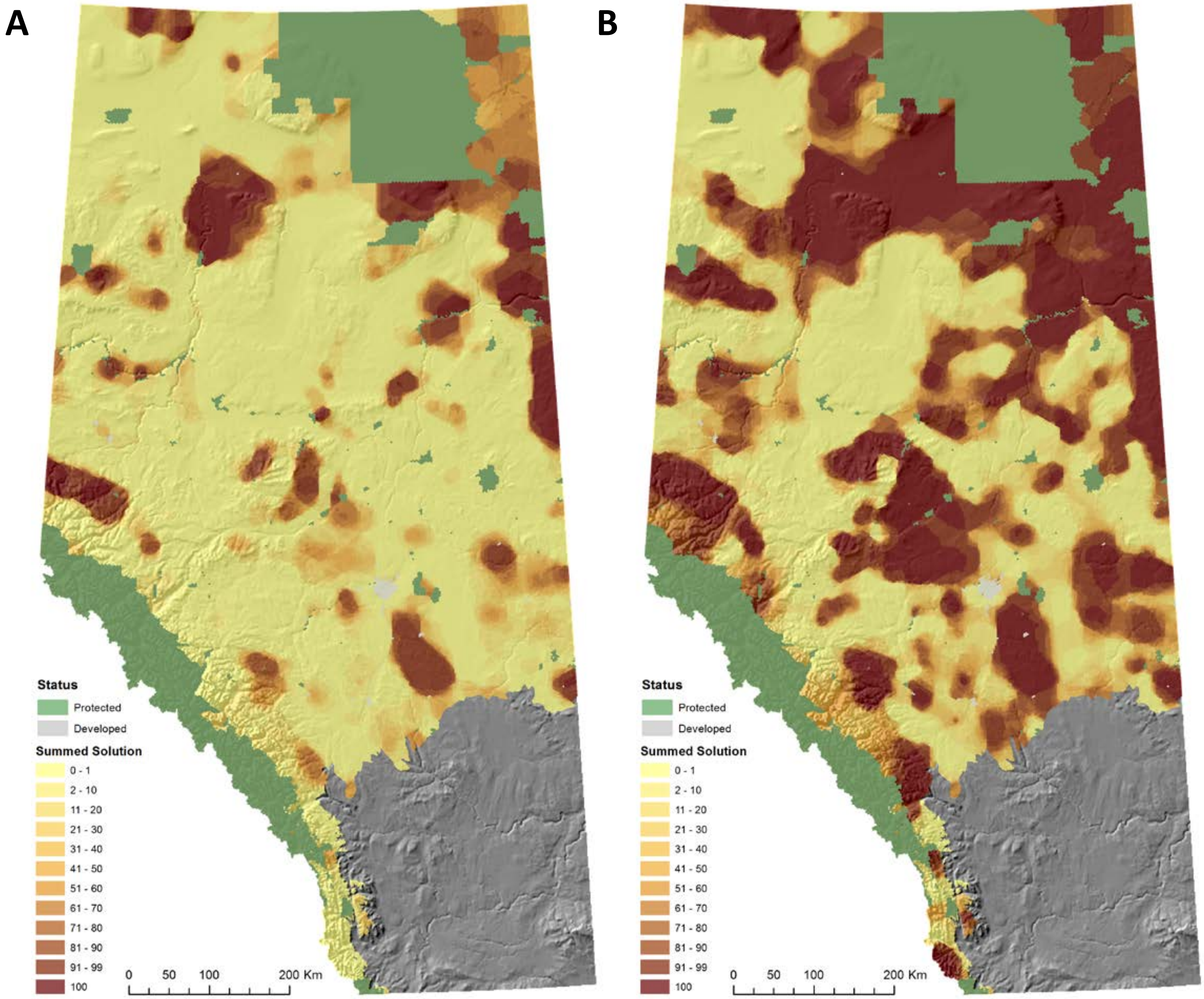
84 D.B. Gurd, T. Nudds, and D. Rivard, "Conservation of mammals in eastern North American wildlife reserves: how small is too small?" *Conservation Biology* 15 (2001): 1355-1363.

85 Svancara *et al., supra*

Cougar tracks - Ryan Peruniak

Disturbed Landscapes: Minimizing the Socio-Economic Cost of Protected Areas

Marxan is software that enables the modeller to minimize the socio-economic cost of protected spaces by taking into account the intactness of a landscape, the current disturbance level on a landscape, or the value of resources on the landscape. CPAWS Northern Alberta considered two "cost" scenarios: current existing linear disturbance on the landscape (roads, seismic lines, pipelines, transmission lines, and rail lines), and the value of resources to both the forestry and oil and gas industries in the province (the NPV). The following sections illustrate priority conservation areas when these "costs" are included in the model.



Alberta: A Land Divided and Fragmented

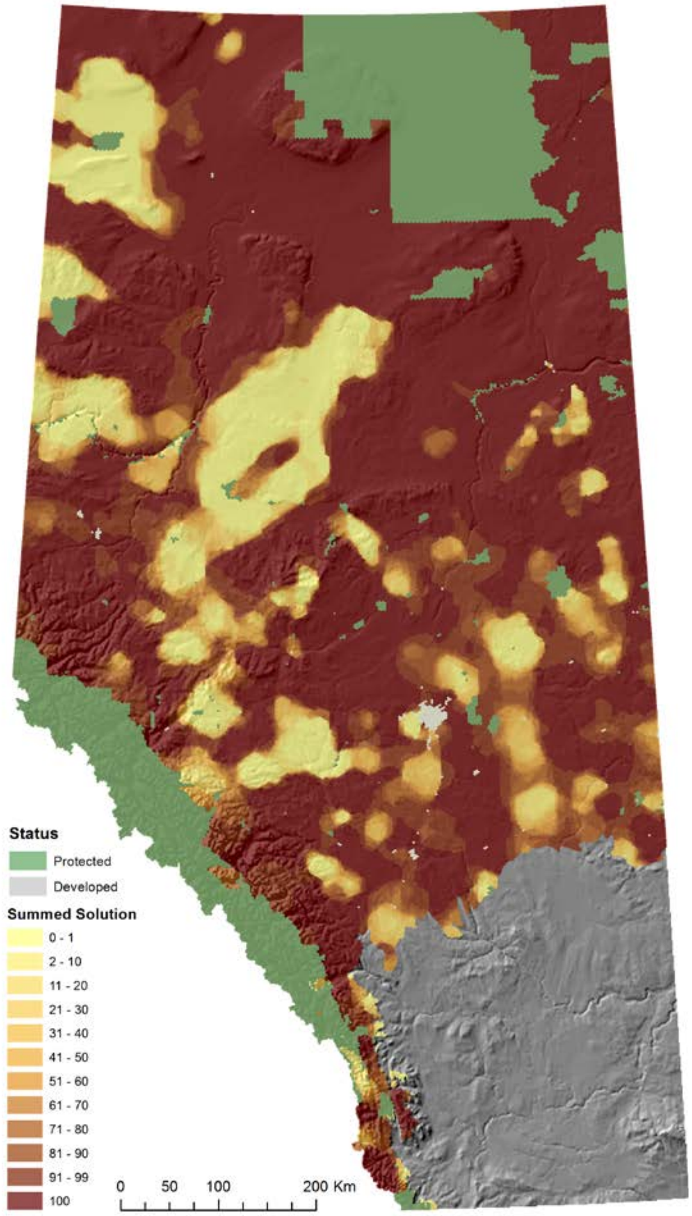
Alberta's landscape is highly fragmented. In some areas, linear and polygonal disturbance from roads, seismic lines, oil and gas pipelines and well pads, rail lines, and forestry cut blocks fragments up to 95% of the forest.[86] Seismic lines are considered one of the largest contributions to forest fragmentation in Alberta, with line densities as high as 10 km of line per square kilometer in some regions.[87] And, linear disturbance such as seismic lines continues to be placed on our landscape at a rate of 2,875km per year.[88] Linear disturbance is incredibly difficult to reclaim on a boreal landscape. For example, analysis has shown that, even after allowing for 35 years of growth, approximately 64% of conventional seismic lines (measuring 5 to

86 Environment Canada, *Critical Habitat Identification: Little Smoky (Alberta)* (2015), accessed Sept 2015 at http://www.sararegistry.gc.ca/document/doc2253pa3/appf3a_e.cfm#_006

87 P. Lee, and S. Boutin, "Persistence and developmental transition of wide seismic lines in the western Boreal Plains of Canada," *J. Environ. Manage*., 78 (2006), 240–250 [Hereinafter, Lee and Boutin]

88 Cassidy K. van Rensen *et al*., "Natural regeneration of forest vegetation on legacy seismic lines in boreal habitats in Alberta's oil sands region," *Biological Conservation* 184 (2015), 127-135.

C



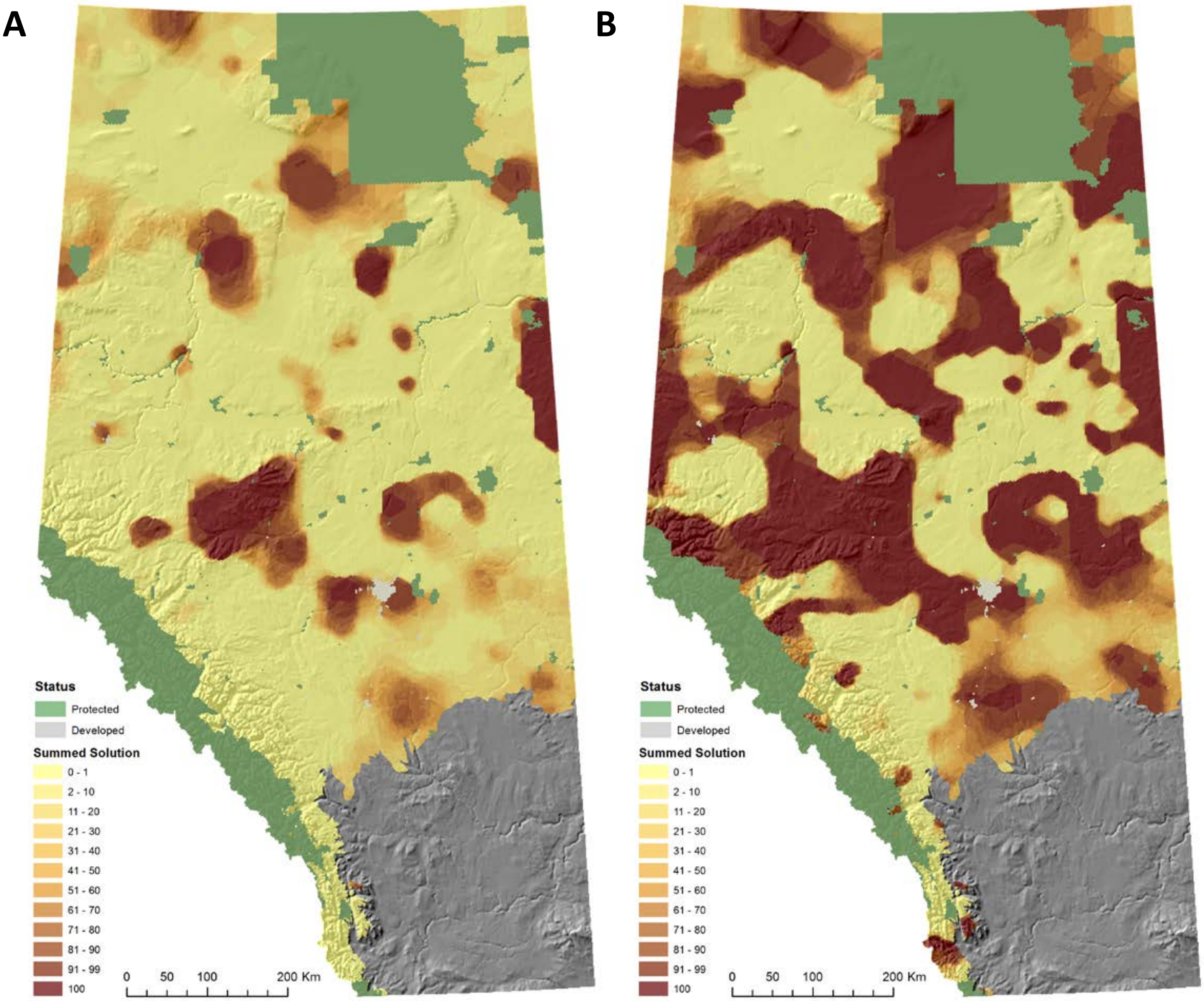
> “protected areas planners need to look at the current level of linear disturbance in northern Alberta, and protect those areas that are least impacted”

FIgure 13| Priority conservation areas when linear disturbance is minimized for (A) 20% conservation targets, (B) 50% conservation targets, and (C) 80% conservation targets.

Each target level was set to run 100 times and the summed solution, or number of times the planning unit was selected, is shown. Dark brown illustrates the planning units that were selected the most and can be considered as 'irreplaceable.'

8 meters wide) present in northeastern Alberta are covered only with grasses and herbs rather than native tree species.[89] Thus, to maximize the value of conservation on the landscape, protected areas planning needs to target areas with the highest conservation value as well as the highest level of intactness. Put in other words, protected areas planners need to look at the current level of linear disturbance in northern Alberta, and protect those areas that are least impacted. Figure 13 illustrates priority areas for conservation at 20% protection, 50% protection, and 80% protection of all conservation features when linear disturbance is included as a cost in the analysis.

89 Lee and Boutin, *supra*



Alberta: A Land of Resources

Natural resource extraction in northern Alberta has a major impact on the quality of wilderness in the province, which is well known for containing some of the largest reserves of oil, natural gas, and coal in the world. Forestry, oil and gas extraction, and mining activities lay claim to major tracts of land in this province. For example, the oil sands are located in three major areas in the province (the Cold Lake Oil Sands, Athabasca Oil Sands, and Peace River Oil Sands), underlying approximately 142,200km^2 of Alberta's boreal forest (which itself totals an area of about 381,000km^2).[90] Forestry tenures stretch from one border of the province to another, and result in a yearly average of 70,000 hectares of deforestation.[91]

90 Alberta Energy, *About Oil Sands: Facts and Statistics* (2015), accessed Sept 2015 at http://www.energy.alberta.ca/oil-sands/791.asp

91 Calculated from Government of Alberta, Environment and Sustainable Resource Development, *Sustainable Forest Management: Current facts and Statistics* (2011), accessed Sept 2015 at http://esrd.alberta.ca/lands-forests/forest-management/forest-management-facts-statistics/documents/AreaHarvested-CurrentFactsAndStatistics-2011.pdf

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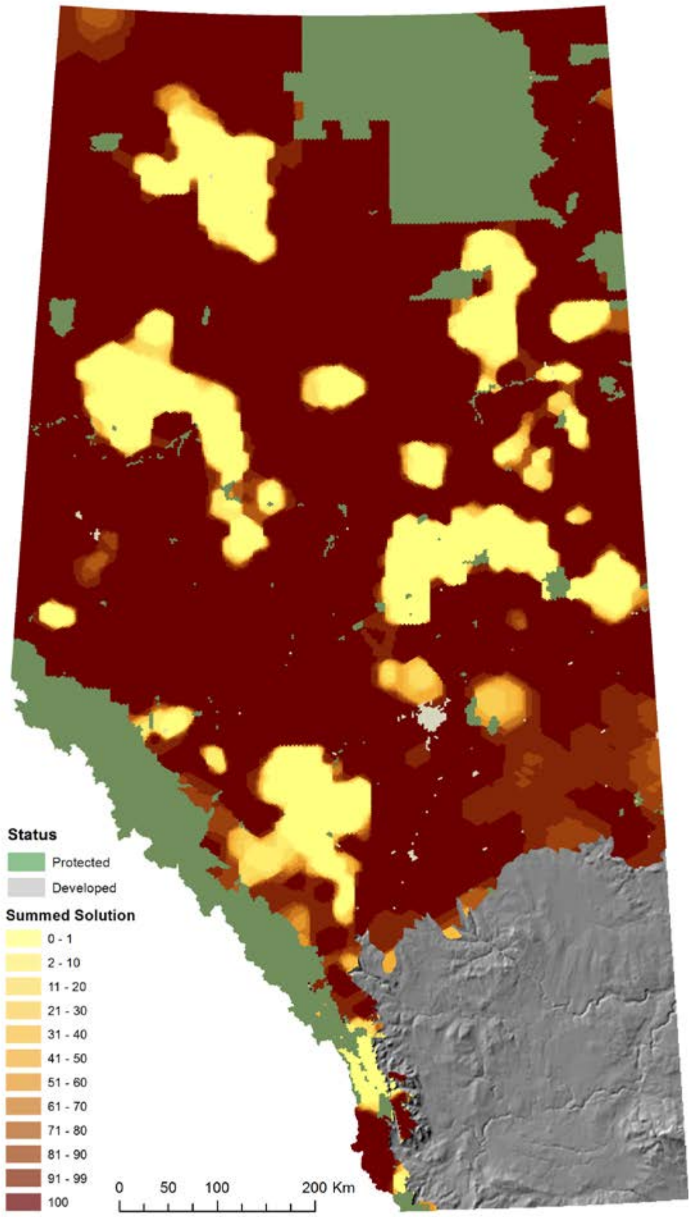


FIgure 14| Priority conservation areas when the net present value of forestry and oil and gas resources on the land is minimized for (A) 20% conservation targets, (B) 50% conservation targets, and (C) 80% conservation targets.

Each target level was set to run 100 times and the summed solution, or number of times the planning unit was selected, is shown. Dark brown illustrates the planning units that were selected the most and can be considered as 'irreplaceable.'

Using the NPV of forestry and oil and gas resources known to exist in the province, CPAWS Northern Alberta is able to present three scenarios for protected areas planning which minimize the "opportunity cost" of conservation on industry. Figure 14 demonstrates priority areas for conservation at 20% protection, 50% protection, and 80% protection of all conservation features when the cost to forestry and oil and gas NPV is minimized. In these scenarios, forestry NPV and oil and gas NPV have been weighted equally.

American white pelican- Ryan Peruniak

Conservation Value

As a final step in assessing areas of high conservation value in northern Alberta, indices for irreplaceability, rarity, diversity, and richness for each planning unit in the study area were used to calculate the Conservation Value for each planning unit as: *Conservation Value = irreplaceability + rarity + diversity + richness*.

Combining the irreplaceability values for each of the conservation targets and disturbance scenarios outlined above, along with the conservation feature richness, diversity, and rarity indices, CPAWS Northern Alberta has mapped the Conservation Value of each planning unit in the study area (Figure 15).

The Conservation Value map identifies priority areas based on multiple planning scenarios, presence of rare species, and amount and diversity of landscape features and species-at-risk. These identified priority areas for conservation form a connected biodiversity conservation network extending from the Rocky Mountain National Parks through the upland areas of the Swan Hills towards Birch Mountains Provincial Park and Wood Buffalo National Park. Another corridor connects Chinchaga to Wood Buffalo along the Peace River. Using this map, CPAWS Northern Alberta has identified six high priority areas for conservation in northern Alberta (Figure 16).

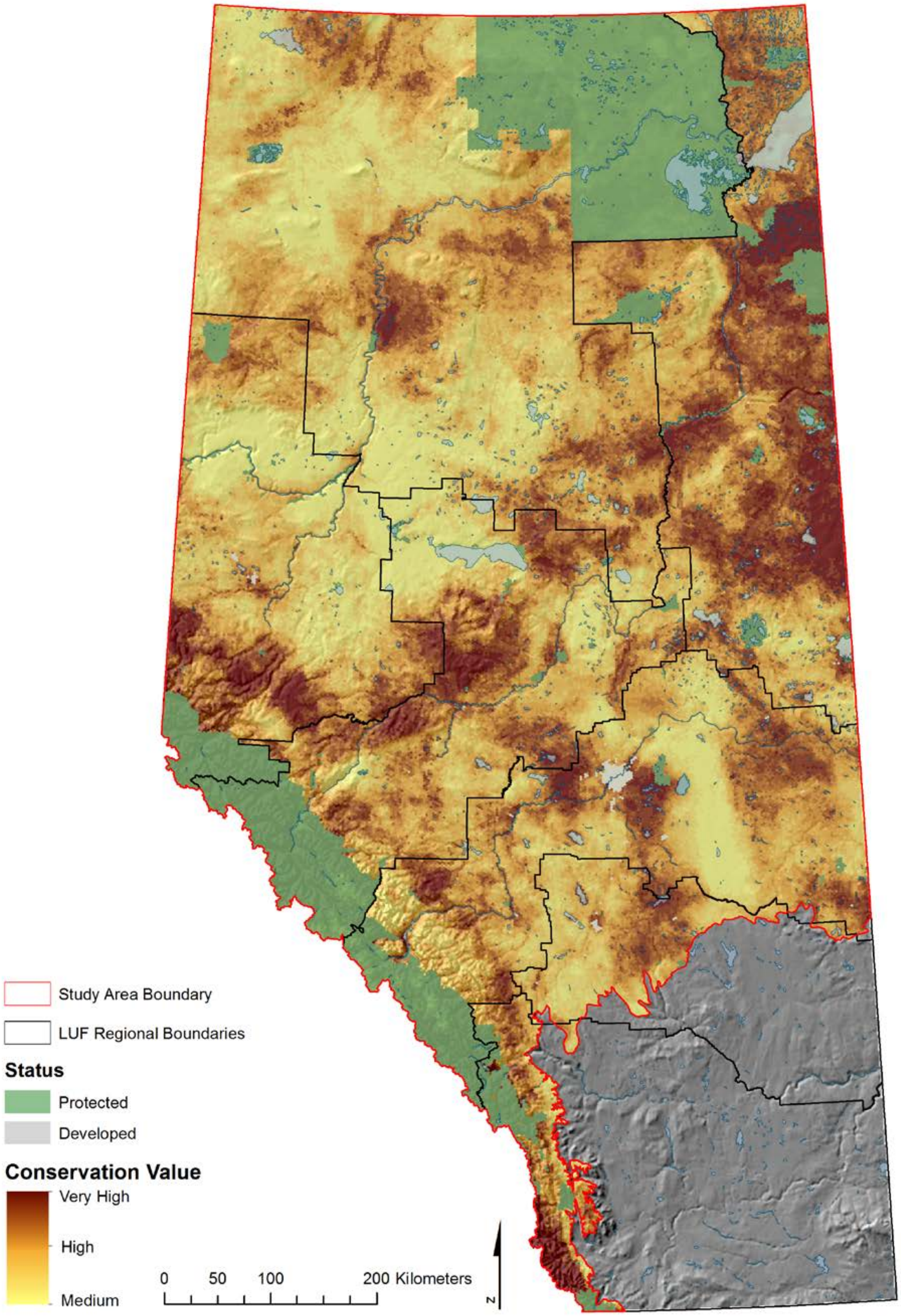


Figure 15| Conservation Value of the study area when Conservation Value = irreplaceability + rarity + diversity + richness of each conservation feature used in the Marxan analysis. In this figure, Conservation Value is shown in degrees of the colours yellow and brown. The colour yellow on the map indicates areas of medium Conservation Value; darker shades of yellow to brown illustrate areas of increasingly higher Conservation Value.

Highest Priority Areas for Conservation in Northern Alberta

The Conservation Value map provides a window into some, but not all, of the highest priority areas for conservation in the province. Below are brief descriptions of each highlighted area in Figure 16 detailing some of the important conservation features present which contribute to the high Conservation Value of these areas.

A. Bistcho - Cameron Hills

Located in northwestern Alberta, this area of the province provides habitat for over 35% of the sensitive and at-risk species included in the analysis, including the Bistcho and Yates caribou herds. It is also an area of astounding wetland diversity. Containing up to 25% of the open water landscape classes in grasslands, shrublands, mixedwood and coniferous forests, it is an important area for migratory birds and waterfowl.

B. Chinchaga - Cache Creek - Wolverine

The Chinchaga - Cache Creek - Wolverine area of the province stretches from the western border of Alberta into central-northern Alberta, and contains most of the range of the Chinchaga caribou herd. It is also a diverse landscape and, if protected, would help reach the province's goals of 17% of all terrestrial landscapes by 2020. For example, it contains 6% of the province's Dry Mixedwood Natural Subregion, of which only 1.5% is currently protected. Likewise, the area contains 8% of the province's Lower Boreal Highlands Natural Subregion, of which only 5.8% is currently protected. It is dominated by wetlands with swamps, fens, bogs, and marshes covering areas of Mixed Forest, Broadleaf Forest, and Grassland.

C. Kakwa - Little Smoky - Swan Hills

Located in the headwaters of the Athabasca and Peace Rivers, Kakwa - Little Smoky - Swan Hills represents an area that, if protected, would provide habitat for 68% of the sensitive and at-risk species included in our analysis. It contains over 25% of northern Alberta's grizzly bear habitat, over 10% of lynx habitat, and includes over 75% of the Little Smoky caribou range, which is estimated at this time to be at least 95% disturbed by industrial development. This area includes all landscape classes, and, if protected, would also contribute to the province's goal of protecting all Natural Subregions, as it contains 40% of the Upper Foothills Natural Subregion, and 30% of the Lower Foothills Natural Subregion, both of which are currently less than 3% protected. This area is home to osprey and great gray owls, and provides important waters for arctic grayling, native rainbow trout, and bull trout. It is also the only place in Alberta that provides habitat for the lace foamflower.

D. Athabasca Rapids

This diverse area of northeastern Alberta is rich in bogs and fens, containing all landscape classes in Alberta as well as 85% of all surficial geology classes. It covers 15% of the East Side Athabasca River caribou range, and 30% of the West Side Athabasca River caribou range. It is an important area for protecting the province's Central Mixedwood Natural Subregion, and provides habitat for 40% of the sensitive and at-risk species in the study area.

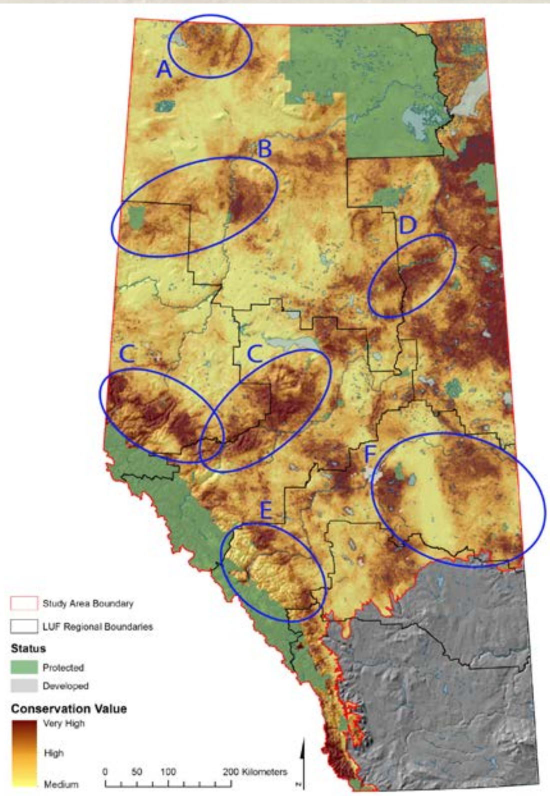
E. **Bighorn Wildland**

The Bighorn Wildland is a 5000km^2 area of alpine, subalpine and montane wilderness located just west of the Town of Nordegg. The Upper Foothills Natural Subregion of the Bighorn provides habitat to 65% of Alberta's sensitive and at-risk species, and contains almost 50% of mountain goat and bighorn sheep habitat in the province, as well as 20% of grizzly bear habitat. 23% of the province's Upper Foothills Natural Subregion is located here, meaning that protection of the Bighorn would ensure the province meets its goal of protecting this important Natural Subregion. Currently, only 2.7% of Alberta's Upper Foothills are protected. The Bighorn Wildland is also one of the more intact areas of the province, being mostly free from roads, pipelines, seismic lines, and industrial development. Promises to protect the area have been made many times since the 1970s but have have thus far gone unfulfilled, even while coal, oil and gas, forestry, and irresponsible recreational activities continue to pressure the Bighorn's wilderness .

F. **Beaver Hills - Parkland Dunes - Bodo Hills**

The Beaver Hills - Parkland Dunes - Bodo Hills area of the province contains small islands of public lands in the "white zone," an area dominated by private land ownership and development. However, some of the conservation features in this area are of the highest priority, providing habitat for many sensitive and at-risk species in the province. This includes many species of birds such as the grasshopper sparrow, northern pintail, American green-wing, great blue heron, swainson's hawk, piping plover, bobolink, bald eagle, and American white pelican. This is also one of the only areas in central Parkland that provides habitat for the province's sensitive amphibians such as the Plains Spadefoot and Great Plains Toad. Protecting this area would protect the province's Central Parkland Natural Subregion, which currently only has 0.9% protection.

Figure 16| Conservation Value of the study area illustrating highest priority areas for conservation: (A) Bistcho-Cameron Hills and (B) Chinchaga-Cache Creek-Wolverine, both in northwestern Alberta; (C) Kakwa-Little Smoky-Swan Hills in west central alberta; (D) Athabasca Rapids in northeastern Alberta; (E) the Bighorn Wildland in the Eastern Slopes of the Rocky Mountains; and (F) the Beaver Hills-Parkland Dunes-Bodo Hills in the predominantly "white area" of the North Saskatchewan region.



North Saskatchewan River - Marcus Becker

Chapter Four

Looking Forward

The Conservation Blueprint: Only the Beginning

This Conservation Blueprint is a comprehensive look at where Alberta needs to go in protected areas planning in order conserve our wilderness for future generations. The data is abundant, the model ran for days on end, and the maps illustrate many different scenarios for the province. However, this Conservation Blueprint is really a living, breathing document. It was impossible, for the purposes of this project, to include absolutely every stakeholder's interest on the landscape in the maps contained herein. Thus, the Conservation Blueprint is truly an iterative series of maps, capable of moving and working with changing times, people, and climates, both political and ecological.

The following sections set out different subject areas which can and will affect the Conservation Blueprint as CPAWS Northern Alberta continues working to protect northern wilderness.

Trumpeter swan - Ryan Peruniak

The Conservation Blueprint can "Zoom In" on species of interest such as caribou - Ted Simonett

"Zooming In" on Species or Areas

The flexibility of the Conservation Blueprint means that CPAWS Northern Alberta may use it as a tool at many different scales. The scenarios presented in this report are presented at a macro level, looking at the landscape of the province as from above. Working with regional managers, municipalities, or interested stakeholders, the Conservation Blueprint can be used to "zoom in" on any region or species of interest. For example, the Conservation Blueprint may be used by municipalities interested in protecting certain riparian areas, or by Aboriginal communities looking to maximize protection for culturally important species such as caribou, moose, or beaver.

Protecting Aboriginal Traditional Lands

In Alberta, 45 First Nations claim traditional territories in three historical treaty areas (Treaty 6, signed in 1876, Treaty 7, signed in 1877, and Treaty 8, signed in 1899).[92] Much of our province's First Nations' traditional territories occupy public lands, and to this day support traditional ways of life – hunting, trapping, fishing, and foraging. Many First Nations communities are already engaging in mapping exercises and land use planning to determine how best to protect their traditional territory, including both ecological and cultural values. For example, the Athabasca Chipewyan First Nation in northeastern Alberta has released reports on the ecological health of the lands and waters within their territory, including a document titled *Níh Boghodi: We are the stewards of our land*, focusing on a land use stewardship strategy for woodland and barren ground caribou and wood bison.[93] Many other First Nations are following suit within their own territories.

92 Government of Canada, Department of Aboriginal Affairs and Northern Development, *First Nations in Alberta* (September 15, 2010), accessed Sept2015 at http://www.aadnc-aandc.gc.ca/eng/1100100020670/1100100020675

93 Athabasca Chipewyan First Nation, *Níh Boghodi: We are the stewards of our land* (2012), accessed Sept 2015 at http://media.wix.com/ugd/75b7f5_03a0cb2d842038b4fdb975586e1c0ca3.pdf

Canoes at Elk Island National Park - Nadine and Jamie Burdon

CPAWS chapters across Canada work with Aboriginal communities to protect traditional lands and values. CPAWS Northern Alberta sees an opportunity, presented by this Conservation Blueprint, to do likewise by engaging with northern communities to enable Aboriginal management or co-management of protected areas and to develop traditional use protected areas in the province of Alberta. CPAWS Northern Alberta may be able to support the land use planning or calls for greater protection already occurring within Alberta's Aboriginal communities.

Managing Industrial Impacts and Reclamation

Alberta is a province rich in natural resources, and the economic viability of the province relies on natural resource extraction from the forestry, oil and gas, and minerals industries. CPAWS Northern Alberta's Conservation Blueprint is a tool that can be used in conjunction with resource development planning to determine priority areas for protection at the least cost to industrial development. Similarly, the Conservation Blueprint may be used by CPAWS with oil and gas and forestry companies to determine high priority areas for forest and habitat reclamation.

The Conservation Blueprint may also be a tool for guiding conservation on a working landscape through the mapping and identification of priority areas for resource harvesting deferrals. An example of where land use planning of this kind has already been used is through the negotiations between CPAWS and the forestry companies that are signatories to the Canadian Boreal Forest Agreement in the protection of boreal woodland caribou in Alberta.

Hikers in the Bighorn - Alison Ronson

Enabling Responsible Recreational Activity

Albertans love getting outside and connecting with nature. Proud of their natural heritage, Albertans are active hikers, campers, climbers and paddlers, hunters, anglers, and trappers. However, there is a dearth of protected, well-managed recreational lands in the province. Consequentially, many Albertans engage in random camping on public lands or use industrial access corridors to take themselves back into the bush, resulting in negative impacts to lands and waters[94] such as soil erosion and compaction, increased water sedimentation and turbidity, air and water pollution, diminished vegetative and wildlife biodiversity, and reduced habitat connectivity.[95]

The vast majority of Albertans understand the impacts their recreational activities have on the land, and have the desire to pass their natural heritage on, unimpaired, to their children. Working with recreational organizations, stewardship groups, and government to plot favourite recreational spots across the province is one next step that would inform protected areas planning in this province. Thus, the Conservation Blueprint may be used as a tool with protected areas planners and recreationalists to determine categories of protection and management on the landscape.

94 Alberta Environment and Parks, *Respect the Land: Shared resource, shared responsibility* (2013), accessed Sept 2015 at http://esrd.alberta.ca/recreation-public-use/recreation-on-public-land/documents/RespectTheLand-CampingPublicLand-2013.pdf

95 Douglas S. Ouren et al., United States Department of the Interior and United States Geological Survey. *"*Environmental Effects of Off-Highway Vehicles on Bureau of Land Management Lands: A Literature Synthesis, Annotated Bibliographies, Extensive Bibliographies, and Internet Resources." *Open-File Report 2007-1353* (2007), accessed Sept 2015 at https://www.cccofvt.org/wp-content/uploads/2009/02/usgsohvbiblioreport.pdf

Addressing Climate Change

The Intergovernmental Panel on Climate Change reports that each of the last three decades has been successively warmer at the Earth's surface than any preceding decade since 1850. Globally, this has resulted in atmospheric and ocean warming, diminished snow and ice levels, and sea level rises.[96] On a regional level, climate modelling predicts higher mean temperatures of approximately 2 to 4°C by 2050, which may result in a drier landscape, a change in the distribution of vegetative communities, and a higher frequency of forest fires.[97,98]

Cllimate change is a reality that must be faced by land use and protected areas planners if such planning is to ameliorate the more negative effects within this province. The Conservation Blueprint provides a modelling tool that may be used by CPAWS to inform protected areas planning under climate change scenarios by illustrating the highest priority areas and corridors needed to sustain Alberta's present levels of biodiversity under very different climate conditions.

Conclusion

This Conservation Blueprint is the culmination of many years of collective thinking, planning, and execution by CPAWS Northern Alberta and its Board of Directors and many volunteers. This report represents all that CPAWS stands for – an example of scientific evidence that can inform and educate Canadians on the need for protection and shared conservation solutions for their public lands and waters.

Within these pages, the Conservation Blueprint can be interpreted to provide numerous illustrations to stakeholders in conservation: as a solemn warning, a rational tool, and an aspirational, optimistic, and hopeful compass. The Conservation Blueprint is intended to inspire big, bold thinking for conservation on the Alberta landscape.

Albertans have an entrepreneurial spirit. When they put their minds to something, they can and often do accomplish it. This was proven in the twentieth century with the rapid development of the forestry and oil and gas industries in this province. Now, however, the province faces the consequences of unchecked industrial development in the form of a fragmented landscape and struggling wildlife populations. Still, there is hope, as the province of Alberta has an opportunity to protect the natural heritage so treasured by Albertans. Now is the time for the province to commit to meeting international protected areas targets such as Aichi Target 11, and to go further by adopting scientifically-sound conservation principles and committing to protecting at least half of the province's landscape for the benefit of all Albertans, for all time.

It is time for nature to be given the respect it is due. Opportunity is knocking at Alberta's door. As stated by Harvey Locke in the Foreword to this Conservation Blueprint: "We Albertans love Nature and it is time we showed it too."

"The Conservation Blueprint is intended to inspire big, bold thinking for conservation on the Alberta landscape"

96 Intergovernmental Panel on Climate Change. *Climate Change 2014: Synthesis Report. Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change*, edited by R.K. Pachauri and L.A. Meyer (Geneva, Switzerland: Intergovernmental Panel on Climate Change, 2014) 151 pp.

97 Richard R. Schneider *et al*. Potential effects of climate change on ecosystem distribution in Alberta. *Can. J. For. Res.* 39 (2009): 1001-1010.

98 C. Li *et al*. Influence of potential climate change on forest landscape dynamics of west-central Alberta. *Can. J. For. Res.* 30 (2000): 1905-1912.


Porcupine - Kevin Hasson

Glossary of Terms

AAFC .... Agriculture and Agri-Food Canada
ABMI .... Alberta Biodiversity Monitoring Institute
ACIMS .... Alberta Conservation Information Management Systems
AEP .... Alberta Environment and Parks
AUC.. area under the curve (a mathematical term used in MaxEnt results)

BLM... boundary length modifier

CBD .... United Nations *Convention on Biological Diversity*
CFS .... Canadian Forest Service
CMI .... Climate Moisture Index
Conservation Blueprint............ *Conservation Blueprint of Northern Alberta: Prioritizing areas for protected areas planning*
Conservation Value.................. *irreplaceability + rarity + diversity + richness*
COSEWIC .... Committee on the Status of Endangered Wildlife in Canada
CPAWS.................................... Canadian Parks and Wilderness Society
CWCS .... Canadian Wetland Classification System

DUC... Ducks Unlimited Canada

ENGOs..................................... environmental non-governmental organizations
EOSD .... Canadian Forestry Service's Earth Observation for Sustainable Development LC data set

FWMIS .... Fish and Wildlife Management Information Systems

GIS .... geographic information systems

IUCN.. International Union for Conservation of Nature

LUF .... government of Alberta's Land Use Framework, 2008

MaxEnt.................................... Maximum Entropy software

NPV .... net present value

P... mean annual precipitation
PET .... mean annual potential evapotranspiration

SDMs....................................... culturally important and species at-risk species distribution models
SPF .... species penalty factor

The Bruntland Report .... United Nations World Commission on Environment and Development publication, *Our Common Future*, 1987

Contributors

Harvey Locke

Harvey Locke is globally recognized as a leading conservationist, photographer, writer, and advocate for conservation, protected areas, and wilderness. A founder of the Yellowstone to Yukon Conservation Initiative, which aims to create connected spaces for wildlife movement from Yellowstone National Park in the United States to Canada's Yukon Territory, in 2013 he was named by CPAWS as the winner of the J.B. Harkin Award for conservation. In 2014 he received the Fred M. Packard International Parks Merit Award from the IUCN at the World Parks Congress.

Danielle Pendlebury

Danielle Pendlebury is CPAWS Northern Alberta's Conservation Coordinator. She holds a B.Sc.H. in Evolutionary Biology and a M.Sc. in Ecology from the University of Alberta. Her passion for the outdoors and curiosity about the environment has led her to work on a diverse range of research projects: from studying forest tent caterpillars in Alberta's boreal forest, assessing biodiversity in Honduras' cloud forests, to studying marine sponges in the Caribbean Sea and Pacific Ocean. Her research in Alberta as well as working as a guide in the Rockies fostered a desire to preserve the amazing wilderness in Alberta, and she has spent many years educating youth and the public about the state of our environment.

Alison Ronson

Alison Ronson is CPAWS Northern Alberta's Executive Director. She holds a B.Sc.H. in Environmental Sciences from Queen's University, a J.D. (*juris doctor*) from the University of Ottawa and an M.A. in International Affairs with a focus on Arctic Institutional Environmental Governance from Carleton University. She has experience working with a variety of conservation projects, including the promotion of wetland, reptile, and amphibian conservation in Ontario, the genetic study of song birds in western Canada, household waste management and vermicomposting in India, habitat, population, and feeding studies of Arctic sea birds, and the impact of climate change on Arctic soil and plant processes.

References

1. Public lands and waters refer to those lands and waters owned by either the federal government of Canada or by provincial governments across Canada.
2. The International Union for Conservation of Nature (IUCN) defines biodiversity as "the variability among living organisms from all sources including terrestrial, marine and other aquatic ecosystems, and the ecological complexes of which they are part; this includes diversity within species, between species, and of ecosystems." See IUCN, *About Biodiversity* (July, 2010), at http://iucn.org/iyb/about/
3. Government of Alberta, *Land-Use Framework* (2008), at https://landuse.alberta.ca/LandUse%20Documents/Land-use%20Framework%20-%202008-12.pdf
4. Badiou *et al., "Conserving the World's Last Great Forest is Possible:* Here's how,*" International Boreal Conservation Science Panel* (July 2013), accessed Sept 2015, http://borealscience.org/wp-content/uploads/2013/07/conserving-last-great-forests1.pdf, [Hereinafter, Badiou *et al.]*
5. Boreal Songbird Initiative*, Conservation Values of the Boreal Forest: Water,* accessed Sept 2015, http://www.borealbirds.org/conservation-values-boreal-forest
6. Dai, A., and K.E. Trenberth, "Estimates of freshwater discharge from continents: Latitudinal and seasonal variations," *Journal of Hydrometeorology* 3 (2002): 660-683
7. Badiou *et al, supra*
8. John Terborgh. "Foreword." In *Protecting the Wild: Parks and Wilderness, the Foundation for Conservation,* edited by George Wuerthner et al., xi-xvii. San Francisco: The Foundation for Deep Ecology in partnership with Island Press, 2015 [hereinafter, Terborgh]
9. Stuart L Pimm *et al.,* "The Future of Biodiversity," *Science* 269, no. 5222 (1995): 347–50
10. Terborgh, *supra*
11. Global Forest Watch, Canada: Alberta (August 2015) at http://www.globalforestwatch.org/country/CAN/1
12. SC 2002, c 29
13. RSA 2000, c W-10
14. See the Boreal Songbird Initiative at http://www.borealbirds.org/
15. Government of Alberta, Fish and Wildlife Division, "Status of the Grizzly Bear (Ursos arctos) in Alberta: Update 2010," *Alberta Wildlife Status Report No. 37 (2010), at* http://aep.alberta.ca/fish-wildlife/species-at-risk/species-at-risk-publications-web-resources/mammals/documents/SAR-StatusGrizzlyBearAlbertaUpdate2010-Feb2010.pdf
16. C R Margules and R L Pressey, "Systematic Conservation Planning.," *Nature* 405 (2000): 243–53 [Hereinafter, Margules and Pressey]
17. United Nations World Commission on Environment and Development. *Our Common Future.* Oxford: Oxford University Press, 1987 [hereinafter, Bruntland Report]
18. Bruntland Report*, supra*
19. United Nations, *Convention on Biological Diversity* (1992), accessed Sept 2015 at https://www.cbd.int/convention/text/
20. Aichi Target 11 states, "By 2020, at least 17 per cent of terrestrial and inland water areas and 10 per cent of coastal and marine areas, especially areas of particular importance for biodiversity and ecosystem services, are conserved through effectively and equitably managed, ecologically representative and well-connected systems of protected areas and other effective area-based conservation measures, and integrated into the wider landscape and seascape." United Nations Convention on Biological Diversity, *Strategic Plan for Biodiversity, 2011-2020, Target 11* (2015), accessed Sept 2015 at https://www.cbd.int/sp/targets/rationale/target-11/ [Hereinafter, CBD Aichi Target 11]
21. Locke, Harvey. "Nature Needs (at least) Half: A Necessary New Agenda for Protected Areas," in *Protecting the Wild: Parks and Wilderness, the Foundation for Conservation,* edited by George Wuerthner et al., 3-15. San Francisco: The Foundation for Deep Ecology in partnership with Island Press, 2015 [hereinafter, Locke]
22. International Union for Conservation of Nature, *What is a Protected Area?* (Nov 4, 2013), accessed Sept 2015 at https://www.iucn.org/about/work/programmes/gpap_home/pas_gpap/
23. Locke, *supra*
24. Government of Alberta*, Alberta's Plan for Parks* (2009), accessed Sept 2015 at http://www.albertaparks.ca/media/123436/p4p.pdf
25. Canadian Parks and Wilderness Society, *Protecting Canada: Is it in our nature? How Canada can achieve its international commitment to protect our land and freshwater* (2015), accessed Sept 2015 *at* http://cpaws.org/uploads/CPAWS_Parks_Report_2015-Single_Page.pdf [Hereinafter, CPAWS]
26. Government of Alberta, *Land Use Framework*, accessed July 2015 at https://landuse.alberta.ca/PlanforAlberta/LanduseFramework/Pages/default.aspx
27. Richard R Schneider *et al.,* "Achieving Conservation When Opportunity Costs Are High: Optimizing Reserve Design in Alberta's Oil Sands Region.," *PloS One* 6, no. 8 (2011) [Hereinafter, Schneider *et al.*]

28. Margules and Pressey, *supra*
29. The Canadian BEACONS Project, “The Canadian BEACONs Project”, accessed Aug 12, 2015 at http://www.beaconsproject.ca/rpu
30. Bruno A. Nhancale and Robert J. Smith, “The Influence of Planning Unit Characteristics on the Efficiency and Spatial Pattern of Systematic Conservation Planning Assessments,” *Biodiversity and Conservation* 20, no. 8 (2011): 1821–35
31. Marxan software can be downloaded at: http://www.uq.edu.au/marxan/index.html?page=77654&p=1.1.4.1 (as of Oct 1, 2015)
32. Ian R. Ball, Hugh P. Possingham, and M. Watts, “Marxan and Relatives: Software for Spatial Conservation Prioritisation,” *Spatial Conservation Prioritisation: Quantitative Methods and Computational Tools*, 2009, 185–95.
33. Jeff A. Ardron, Hugh P. Possingham, and Carissa J. Klein, “Marxan Good Practices Handbook,” (2008): 155.
34. MaxEnt software can be downloaded at: https://www.cs.princeton.edu/~schapire/maxent/ (as of Oct 1, 2015)
35. S.J. Phillips, R.P. Anderson, and R.E. Schapire, “Maximum entropy modelling of species geographic distributions.” *Ecological Modelling, 190 (2006): 231-259.*
36. C. Merow, M.J. Smith, and J.A. Silander Jr, “A practical guide to MaxEnt for modeling species’ distributions: what it does, and why inputs and settings matter.” *Ecography*, 36 (2013): 1058-1069.
37. J. Elith et al., “Novel Methods Improve Prediction of Species’ Distributions from Occurrence Data.” *Ecography,* 29, (2006): 129–51.
38. R software can be downloaded at https://cran.r-project.org/mirrors.html (as of Oct 1, 2015)
39. Reed F. Noss, “From Plant Communities to Landscapes in Conservation Inventories: A Look at the Nature Conservancy (USA),” *Biological Conservation* 41, no. 1 (1987): 11–37
40. Paul Beier and Brian Brost, “Use of Land Facets to Plan for Climate Change: Conserving the Arenas, Not the Actors,” *Conservation Biology* 24, no. 3 (2010): 701–10 [Hereinafter, Beier and Brost]
41. D. P. Faith and P. A. Walker, “Environmental Diversity: On the Best-Possible Use of Surrogate Data for Assessing the Relative Biodiversity of Sets of Areas,” *Biodiversity and Conservation* 5, no. 4 (1996): 399–415
42. Malcolm L. Hunter, George L. Jacobson, and Thompson Webb, “Paleoecology and the Coarse-Filter Approach to Maintaining Biological Diversity,” *Conservation Biology* 2, no. 4 (1988): 375–85
43. Beier and Brost, *supra*.
44. Natural Regions Committee (2006) Natural Regions and Subregions of Alberta: Alberta Environment, Edmonton, Alberta.
45. ABMI Wall-to-wall Land Cover Map Guide Version 2.1 (ABMIw2wLCV2010v1.0). Accessed on abmi.ca Sept 25, 2014
46. Ducks Unlimited Canada, *Learn About Wetlands,* accessed August 2015 at http://www.ducks.ca/learn-about-wetlands/
47. Alberta Merged Wetland Inventory downloaded January 28, 2015. Funding partners: Government of Alberta, Ducks Unlimited Canada, United States Forest Service (USFS), the PEW Charitable Trusts, United States Fish and Wildlife Service (North American Wetlands Conservation Act), Alberta Pacific Forest Industries Inc. (Al-Pac), Weyerhaeuser Company Ltd, Suncor Energy Foundation, Imperial Oil Resources, Lakeland Industry and Community Association (LICA), Shell Canada, EnCana Corporation, Canadian Boreal Initiative, Environment Canada (EC), Canadian Space Agency (CSA).
48. Mark G. Anderson and Charles E. Ferree, “Conserving the Stage: Climate Change and the Geophysical Underpinnings of Species Diversity,” *PLoS ONE* 5, no. 7 (2010): e115544
49. Alberta Parks. *Natural Regions and Subregions of Alberta, A Framework for Alberta’s Parks*. Edmonton: Alberta Tourism, Parks and Recreation (2015), 72pp.
50. Edward H. Hogg, “Temporal Scaling of Moisture and the Forest-Grassland Boundary in Western Canada,” *Agricultural and Forest Meteorology* 84, no. 1–2 (March 1997): 115–22
51. Stephen C. Zoltai, *Southern Limit of Coniferous Trees on the Canadian Prairies*, Northern Forest Research Centre, Canadian Forestry Service, Environment Canada, 1975. 24pp
52. Dale H. Vitt, Linda A. Halsey, and Stephen C. Zoltai, “The Bog Landforms of Continental Western Canada in Relation to Climate and Permafrost Patterns,” *Arctic and Alpine Research* 26, no. 1 (1994): 1–13
53. E. H. Hogg and P. A. Hurdle, “The Aspen Parkland in Western Canada: A Dry-Climate Analogue for the Future Boreal Forest?,” *Water, Air, and Soil Pollution* 82, no. 1–2 (1995): 391–400
54. W. K. Sly, “A Climatic Moisture Index for Land and Soil Classification in Canada,” *Canadian Journal of Soil Science* 50, no. 3 (1970): 291–301
55. Alberta Environment and Parks, *Wildlife Sensitivity Maps,* accessed October 2014 at http://esrd.alberta.ca/forms-maps-services/maps/wildlife-sensitivity-maps/default.aspx. Trumpeter Swan dataset updated on September 23, 2015.
56. Alberta Sustainable Resource Development and Alberta Conservation Association. “Status of the Woodland Caribou (*Rangifer tarandus caribou*) in Alberta: Update 2010.” Wildlife Status Report No. 30. Edmonton (2010). 88pp.
57. 1,119 species were recorded as having a status of ‘At Risk’, ‘May be at Risk’, or ‘Sensitive’ in the Alberta Wild Species General Status Listing, 2010: http://aep.alberta.ca/fish-wildlife/species-at-risk/wild-species-status-search.aspx accessed on February 3, 2015.

58. Personal communication, Scott Nielsen (Dec 12, 2014)
59. Personal communication, Scott Nielsen (Dec 12, 2014)
60. Jennie Pearce and Simon Ferrier, "Evaluating the Predictive Performance of Habitat Models Developed Using Logistic Regression," *Ecological Modelling* 133, no. 3 (2000): 225–45
61. Ming-Gang Zhang *et al.,* "Using Species Distribution Modeling to Improve Conservation and Land Use Planning of Yunnan, China," *Biological Conservation* 153 (2012): 257–64
62. Kerrie Wilson *et al.,* "Sensitivity Of Conservation Planning To Different Approaches To Using Predicted Species Distribution Data," *Biological Conservation* 22, no. 1 (2006): 99–112. [Hereinafter, Wilson *et al.*]
63. Wilson *et al*., *supra*
64. Jeff A Ardron, Hugh P Possingham, and Carissa J Klein, eds., *Marxan Good Practices Handbook*, Version 2 (Victoria, Canada: Pacific Marine Analysis and Research Association, 2010), pacmara.org.
65. Leona K. Svancara *et al.*, "Policy-Driven versus Evidence-Based Conservation: A Review of Political Targets and Biological Needs," *BioScience* 55, no. 11 (2005): 989, doi:10.1641/0006-3568(2005)055[0989:PVECAR]2.0.CO;2. [Hereinafter Svancara *et al.]*
66. Svancara *et al., supra*
67. Svancara *et al., supra*
68. R.F. Noss et al., "Bolder thinking for conservation," *Conservation Biology* 26 (2012): 1-4 [Hereinafter, Noss et al.]
69. A. Ando, "Species Distributions, Land Values, and Efficient Conservation," *Science* 279, no. 5359 (March 27, 1998): 2126–28
70. Josie Carwardine et al., "Avoiding Costly Conservation Mistakes: The Importance of Defining Actions and Costs in Spatial Priority Setting.," *PloS One* 3, no. 7 (2008): e2586
71. Robin Naidoo *et al.*, "Integrating Economic Costs into Conservation Planning.," *Trends in Ecology & Evolution* 21, no. 12 (2006): 681–87
72. Schneider *et al., supra*
73. Cassidy Kay van Rensen, "Predicting Patterns of Regeneration on Seismic Lines to Inform Restoration Planning in Boreal Forest Habitats" (University of Alberta, 2014).
74. Grant Hauer *et al.,* "Tradeoffs between Forestry Resource and Conservation Values under Alternate Policy Regimes: A Spatial Analysis of the Western Canadian Boreal Plains," *Ecological Modelling* 221, no. 21 (2010): 2590–2603
75. Grant Hauer, Wiktor Adamowicz, and Robert Jagodinski, "A Net Present Value Model of Natural Gas Exploitation in Northern Alberta: An Analysis of Land Values in Woodland Caribou Ranges," *Rural Economy: Project Report #10-01*, 2010.
76. Margules and Pressey, *supra*
77. Government of Alberta, *State of Planning in Alberta Parks: 2014 Annual Report* (2014).
78. Sarah Loos, "Marxan analyses and prioritization of conservation areas for the Central Interior Ecoregional Assessment" *BC Journal of Ecosystems and Management* 12, no 1 (2011): 88-97
79. CBD Aichi Target 11*, supra*
80. CPAWS, *supra*
81. See Noss *et al.*, *supra,* and Locke, *supra*
82. Badiou *et al., supra*
83. Noss *et al., supra and* Locke, *supra*
84. D.B. Gurd, T. Nudds, and D. Rivard, "Conservation of mammals in eastern North American wildlife reserves: how small is too small?" *Conservation Biology* 15 (2001): 1355-1363.
85. Svancara *et al., supra*
86. Environment Canada, *Critical Habitat Identification: Little Smoky (Alberta) (2015),* accessed Sept 2015 at http://www.sararegistry.gc.ca/document/doc2253pa3/appf3a_e.cfm#_006
87. P. Lee, and S. Boutin, "Persistence and developmental transition of wide seismic lines in the western Boreal Plains of Canada," *J. Environ. Manage.,* 78 (2006), 240–250 [Hereinafter, Lee and Boutin]
88. Cassidy K. van Rensen et al., "Natural regeneration of forest vegetation on legacy seismic lines in boreal habitats in Alberta's oil sands region," *Biological Conservation* 184 (2015), 127-135.
89. Lee and Boutin, *supra*
90. Alberta Energy, *About Oil Sands: Facts and Statistics (2015),* accessed Sept 2015 at http://www.energy.alberta.ca/oilsands/791.asp
91. Calculated from Government of Alberta, Environment and Sustainable Resource Development, *Sustainable Forest Management: Current facts and Statistics (2011),* accessed Sept 2015 at http://esrd.alberta.ca/lands-forests/forest-management/forest-management-facts-statistics/documents/AreaHarvested-CurrentFactsAndStatistics-2011.pdf
92. Government of Canada, Department of Aboriginal Affairs and Northern Development, *First Nations in Alberta (September 15, 2010),* accessed Sept2015 at http://www.aadnc-aandc.gc.ca/eng/1100100020670/1100100020675
93. Athabasca Chipewyan First Nation, *Níh Boghodi: We are the stewards of our land (2012),* accessed Sept 2015 at http://media.wix.com/ugd/75b7f5_03a0cb2d842038b4fdb975586e1c0ca3.pdf

94. Alberta Environment and Parks, *Respect the Land: Shared resource, shared responsibility* (2013), accessed Sept 2015 at http://esrd.alberta.ca/recreation-public-use/recreation-on-public-land/documents/RespectTheLand-CampingPublicLand-2013.pdf

95. Douglas S. Ouren *et al.,* United States Department of the Interior and United States Geological Survey. “Environmental Effects of Off-Highway Vehicles on Bureau of Land Management Lands: A Literature Synthesis, Annotated Bibliographies, Extensive Bibliographies, and Internet Resources.” Open-File Report 2007-1353 (2007), accessed Sept 2015 at https://www.cccofvt.org/wp-content/uploads/2009/02/usgsohvbiblioreport.pdf

96. Intergovernmental Panel on Climate Change. *Climate Change 2014: Synthesis Report. Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change,* edited by R.K. Pachauri and L.A. Meyer (Geneva, Switzerland: Intergovernmental Panel on Climate Change, 2014) 151 pp.

97. Richard R. Schneider et al. *Potential effects of climate change on ecosystem distribution in Alberta.* Can. J. For. Res. 39 (2009): 1001-1010.

98. C. Li *et al.* “Influence of potential climate change on forest landscape dynamics of west-central Alberta.” *Can. J. For. Res.* 30 (2000): 1905-1912.

Appendices

A1: List of coarse conservation features used in Marxan

Natural Subregions
- Alpine
- Athabasca Plain
- Boreal Subarctic
- Central Mixedwood
- Central Parkland
- Dry Mixedwood
- Kazan Uplands
- Lower Boreal Highlands
- Lower Foothills
- Montane
- Northern Mixedwood
- Peace River Parkland
- Peace-Athabasca Delta
- Subalpine
- Upper Boreal Highlands
- Upper Foothills

Surficial Geology
- Bedrock
- Coluvial Deposits
- Eolian Deposits
- Fluted Moraine
- Fluvial Deposits
- Glaciers
- Glaciofluvial Deposits
- Glaciolacustrine Deposits
- Ice-thrust Moraine
- Lacustrine Deposits
- Moraine
- Organic Deposits
- Preglacial Fluvial Deposits
- Stagnant Ice Moraine

Climate moisture index
- CMI = -18.03 to -8.16
- CMI = -8.16 to -4.21
- CMI = -4.21 to -2.24
- CMI = -2.24 to -1.25
- CMI = -1.25 to -0.27
- CMI = -0.27 to 0.72
- CMI = 0.72 to 2.69
- CMI = 2.69 to 3.67
- CMI = 3.67 to 4.66
- CMI = 4.66 to 6.63
- CMI = 6.63 to 8.61
- CMI = 8.61 to 10.58
- CMI = 10.58 to 13.54
- CMI = 13.54 to 16.50
- CMI = 16.50 to 22.42
- CMI = 22.42 to 34.26
- CMI = 34.26 to 69.78
- CMI = 69.78 to 206.93

Landscape Classes
- Bog
- Broadleaf Forest
- Broadleaf Forest Bog
- Broadleaf Forest Fen
- Broadleaf Forest Marsh
- Broadleaf Forest Open Water
- Broadleaf Forest Swamp
- Coniferous Forest
- Coniferous Forest Bog
- Coniferous Forest Fen
- Coniferous Forest Marsh
- Coniferous Forest Open Water
- Coniferous Forest Swamp
- Fen
- Grassland
- Grassland Bog
- Grassland Fen
- Grassland Marsh
- Grassland Open Water
- Grassland Swamp
- Marsh
- Mixed Forest
- Mixed Forest Bog
- Mixed Forest Fen
- Mixed Forest Marsh
- Mixed Forest Open Water
- Mixed Forest Swamp
- Open Water
- Rock/Rubble
- Shrubland
- Shrubland Bog
- Shrubland Fen
- Shrubland Marsh
- Shrubland Open Water
- Shrubland Swamp
- Snow/Ice
- Swamp

A2: Sensitive species ranges used in Marxan

Mountain Goat and Sheep
Grizzly Bear Zone 1 and 2
Caribou Yates Range
Caribou Bischto Range
Caribou Richardson Range
Caribou Slave Lake Range
Caribou Nipisi Range
Caribou Red Earth Range
Caribou Cold Lake Range
Caribou East Side Athabasca Range
Caribou Caribou Mountains Range
Caribou Chinchaga Range
Caribou West Side Athabasca Range
Caribou Jasper Range
Caribou West Cantral Range
Caribou Little Smoky Range
Great Blue Heron
Ferruginous hawk
Piping Plover
Trumpeter Swan
Prairie Falcon
Peregrine Falcon
Bald Eagle
American White Pelican
Sensitive Amphibian

A3: Environmental predictors used in species distribution models

Environmental Layer	Date	Description	Source
Elevation	1996	Mean elevation (in meters)	Natural Resources Canada
		Standard deviation of elevation	(Canada3D GTOPO30)
Natural Region	2005	Percentage of Boreal	Alberta Environment and
		Percentage of Canadian Shield	Parks
		Percentage of Parkland	
		Percentage of Foothills	
		Percentage of Rocky Mountain	
		Percentage of Grassland	
Landcover	2010	Percentage of water	ABMI wall to wall land
		Percentage of snow	cover (v2010)
		Percentage of rock	
		Percentage of exposed land	
		Percentage of shrubland	
		Percentage of grassland	
		Percentage of agriculture	
		Percentage of coniferous forest	
		Percentage of broadleaf forest	
		Percentage of mixedwood forest	
		Percentage of urban or industrial developments	
Wetlands	1998-2009	Percentage of bog	Alberta Environment and
		Percentage of fen	Parks Merged Wetland
		Percentage of marsh	Inventory
		Percentage of swamp	
		Percentage of open water	
Surficial Geology	1995	Percentage of Colluvial deposits	Alberta Geological
		Percentage of Bedrock	Survey
		Percentage of Eolian	
		Percentage of Fluted moraine	
		Percentage of Fluvial deposits	
		Percentage of Glaciers	
		Percentage of Glaciofluvial deposits	
		Percentage of Glaciolacustrine deposits	
		Percentage of Ice-trust moraine	
		Percentage of Lacustrine deposits	
		Percentage of Moraine	
		Percentage of Organic Deposits	
		Percentage of Preglacial Fluvial deposits	
		Percentage of Stagnant Ice Moraine	
Climate	1961-1990	Mean annual temperature (°C)	ClimateAB (M. Mbogga,
		Mean warmest month temperature (°C)	C. Hansen, T. Wang, and
		Mean coldest month temperature (°C)	A. Hamann "A comprehensive
		Mean annual precipitation (mm)	set of interpolated climate
		Annual heat:moisture index (MAT+10)/(MAP/1000)	data for Alberta." Government
		Degree-days below 0°C, chilling degree-days	of Alberta, Publication
		Degree-days above 5°C, growing degree-days	No: Ref T/235)
		Frost-free period	

A4: Species modeled in MaxEnt

Taxon	Common Name	Scientific Name	Equal training sensitivity and specificity value	AUC
Birds	Grasshopper Sparrow	*Ammodramus savannarum*	0.165	0.988
Birds	Northern Pintail	*Anas acuta*	0.319	0.915
Birds	American Green-winged Teal	*Anas crecca*	0.42	0.901
Birds	Lesser Scaup	*Aythya affinis*	0.42	0.825
Birds	Upland Sandpiper	*Bartramia longicauda*	0.31	0.928
Birds	American Bittern	*Botaurus lentiginosus*	0.421	0.887
Birds	Swainson's Hawk	*Buteo swainsoni*	0.449	0.985
Birds	Chestnut-collared Longspur	*Calcarius ornatus*	0.269	0.965
Birds	Brown Creeper	*Certhia americana*	0.383	0.895
Birds	Black Tern	*Chlidonias niger*	0.398	0.828
Birds	Common Nighthawk	*Chordeiles minor*	0.421	0.876
Birds	Northern Harrier	*Circus cyaneus*	0.429	0.951
Birds	Olive-sided Flycatcher	*Contopus cooperi*	0.341	0.874
Birds	Western Wood-pewee	*Contopus sordidulus*	0.354	0.829
Birds	Bobolink	*Dolichonyx oryzivorus*	0.513	0.994
Birds	Pileated Woodpecker	*Dryocopus pileatus*	0.396	0.816
Birds	Least Flycatcher	*Empidonax minimus*	0.446	0.739
Birds	Rusty Blackbird	*Euphagus carolinus*	0.406	0.825
Birds	Common Yellowthroat	*Geothlypis trichas*	0.432	0.789
Birds	Sandhill Crane	*Grus canadensis*	0.341	0.835
Birds	Barn Swallow	*Hirundo rustica*	0.399	0.898
Birds	Baltimore Oriole	*Icterus galbula*	0.324	0.912
Birds	Osprey	*Pandion haliaetus*	0.347	0.982
Birds	Black-backed Woodpecker	*Picoides arcticus*	0.309	0.966
Birds	Western Tanager	*Piranga ludoviciana*	0.398	0.805
Birds	Horned Grebe	*Podiceps auritus*	0.416	0.9
Birds	Pied-billed Grebe	*Podilymbus podiceps*	0.338	0.885
Birds	Sora	*Porzana carolina*	0.432	0.785
Birds	Brewer's Sparrow	*Spizella breweri*	0.425	0.964
Birds	Forster's Tern	*Sterna forsteri*	0.19	0.982
Birds	Great Gray Owl	*Strix nebulosa*	0.515	0.985
Birds	Sharp-tailed Grouse	*Tympanuchus phasianellus*	0.223	0.975
Butterflies	Sheridan’s Hairstreak	*Callophrys sheridanii*	0.377	0.999
Butterflies	Lorquin's Admiral	*Limenitis lorquini*	0.334	0.999
Butterflies	Boisduval's Blue	*Plebejus icarioides*	0.47	0.999
Butterflies	Shasta Blue	*Icaricia shasta*	0.202	0.992
Fish	Rainbow Trout	*Oncorhynchus mykiss*	0.442	0.848
Fish	Bull Trout	*Salvelinus confluentus*	0.422	0.867
Fish	Arctic Grayling	*Thymallus arcticus*	0.359	0.869
Gastropods	Two-ridge Rams-horn	*Helisoma anceps*	0.377	0.867
Lichens	Spangled Horsehair Lichen	*Bryoria simplicior*	0.426	0.989
Lichens	Yellowhorn Pixie Lichen	*Cladonia bacilliformis*	0.248	0.951
Lichens	Cold-water Stippleback Lichen	*Dermatocarpon rivulorum*	0.282	0.999
Lichens	Fringed Rosette Lichen	*Physcia tenella*	0.265	0.951
Lichens	Hyphenated Ramalina Lichen	*Ramalina farinacea*	0.452	0.964
Lichens	Fan Ramalina Lichen	*Ramalina sinensis*	0.155	0.974
Lichens	Snow Foam Lichen	*Stereocaulon rivulorum*	0.4	0.996
Lichens	Fishbone Beard Lichen	*Usnea filipendula*	0.345	0.934
Mammals	Moose	*Alces alces*	0.473	0.708
Mammals	Pronghorn	*Antilocapra americana*	0.303	0.983
Mammals	Beaver	*Castor canadensis*	0.43	0.776
Mammals	Canada Lynx	*Lynx canadensis*	0.439	0.801

Taxon	Common Name	Scientific Name	Equal training sensitivity and specificity value	AUC
Mammals	Fisher	*Martes pennanti*	0.4	0.838
Mammals	American Badger	*Taxidea taxus*	0.384	0.965
Mosses	Short-tooth Hump Moss	*Amblyodon dealbatus*	0.093	0.988
Mosses	Snow Rock Moss	*Andreaea nivalis*	0.32	0.998
Mosses	Little Groove Moss	*Aulacomnium androgynum*	0.088	0.997
Mosses	Cold Ragged Moss	*Brachythecium frigidum*	0.345	0.997
Mosses	Woodsy Ragged Moss	*Brachythecium hylotapetum*	0.181	0.998
Mosses	Bryobrittonia longipes	*Bryobrittonia longipes*	0.245	0.983
Mosses	Brown Shield Moss	*Buxbaumia aphylla*	0.286	0.984
Mosses	Cirriphyllum cirrosum	*Cirriphyllum cirrosum*	0.264	0.994
Mosses	Dichelyma falcatum	*Dichelyma falcatum*	0.535	0.997
Mosses	Awl-leaved Forklet Moss	*Dicranella subulata*	0.407	0.994
Mosses	Fragile Broom Moss	*Dicranum tauricum*	0.145	0.997
Mosses	False Beard Moss	*Didymodon fallax*	0.244	0.981
Mosses	Spreading Fringe Moss	*Dryptodon patens*	0.132	0.999
Mosses	Lime Entodon Moss	*Entodon concinnus*	0.285	0.998
Mosses	Entodon schleicheri	*Entodon schleicheri*	0.207	0.999
Mosses	Grimmia anomala	*Grimmia anomala*	0.458	0.999
Mosses	Grimmia mollis	*Grimmia mollis*	0.31	0.998
Mosses	Sun Grimmia Moss	*Grimmia montana*	0.206	0.999
Mosses	Grimmia torquata	*Grimmia torquata*	0.148	0.994
Mosses	Nevada Curl Moss	*Homalothecium nevadense*	0.262	0.998
Mosses	Claw Brook Moss	*Hygrohypnum ochraceum*	0.132	0.998
Mosses	Jaffueliobryum wrightii	*Jaffueliobryum wrightii*	0.428	0.997
Mosses	Nerved Leske's Moss	*Leskeella nervosa*	0.303	0.996
Mosses	Ambiguous Leafy Moss	*Mnium ambiguum*	0.219	0.992
Mosses	Dwarf Mouse-tail Moss	*Myurella tenerrima*	0.159	0.986
Mosses	Feathery Neckera Moss	*Neckera pennata*	0.17	0.989
Mosses	Oligotrichum hercynicum	*Oligotrichum hercynicum*	0.136	0.998
Mosses	Flat-brocade Moss	*Platygyrium repens*	0.316	0.901
Mosses	Mountain Hair Moss	*Pogonatum dentatum*	0.345	0.993
Mosses	Urn Hair Moss	*Pogonatum urnigerum*	0.146	0.995
Mosses	Pohlia drummondii	*Pohlia drummondii*	0.334	0.997
Mosses	Pseudoleskea atricha	*Pseudoleskea atricha*	0.501	0.999
Mosses	Patent Leskea Moss	*Pseudoleskea patens*	0.192	0.997
Mosses	Racomitrium fasciculare	*Racomitrium fasciculare*	0.132	0.997
Mosses	Yellow-green Rock Moss	*Racomitrium heterostichum*	0.209	0.997
Mosses	Slender Rock Moss	*Racomitrium sudeticum*	0.319	0.998
Mosses	Large-leaved Leafy Moss	*Rhizomnium magnifolium*	0.306	0.988
Mosses	Naked Leafy Moss	*Rhizomnium nudum*	0.129	0.998
Mosses	Ontario Rose Moss	*Rhodobryum ontariense*	0.09	0.998
Mosses	Seligeria donniana	*Seligeria donniana*	0.407	0.995
Mosses	Yellow Dung Moss	*Splachnum luteum*	0.304	0.942
Mosses	Red Dung Moss	*Splachnum rubrum*	0.35	0.926
Mosses	Splachnum vasculosum	*Splachnum vasculosum*	0.383	0.975
Mosses	Tayloria lingulata	*Tayloria lingulata*	0.137	0.997
Mosses	Timmia norvegica	*Timmia norvegica*	0.226	0.996
Mosses	Tortella inclinata	*Tortella inclinata*	0.132	0.997
Mosses	Ulota curvifolia	*Ulota curvifolia*	0.332	0.998
Vascular plants	Marsh Alkali Aster	*Almutaster pauciflorus*	0.464	0.989
Vascular plants	Jones' Columbine	*Aquilegia jonesii*	0.381	0.999
Vascular plants	Lemmon's Rockcress	*Arabis lemmonii*	0.206	0.996

Taxon	Common Name	Scientific Name	Equal training sensitivity and specificity value	AUC
Vascular plants	Long-leaved Arnica	*Arnica longifolia*	0.28	0.999
Vascular plants	Triangle Moonwort	*Botrychium lanceolatum*	0.108	0.989
Vascular plants	Northwestern Moonwort	*Botrychium pinnatum*	0.152	0.96
Vascular plants	Tasseled-flowered Brickelbush	*Brickellia grandiflora*	0.256	0.999
Vascular plants	Arctic Harebell	*Campanula uniflora*	0.116	0.995
Vascular plants	Capitate Sedge	*Carex capitata*	0.415	0.997
Vascular plants	Glacier Sedge	*Carex glacialis*	0.483	0.999
Vascular plants	Hudson Bay Sedge	*Carex heleonastes*	0.34	0.935
Vascular plants	Arctic Harefoot Sedge	*Carex lachenalii*	0.102	0.993
Vascular plants	Few-seeded Sedge	*Carex oligosperma*	0.142	0.992
Vascular plants	Payson's Sedge	*Carex paysonis*	0.3	0.999
Vascular plants	Short-stalked Sedge	*Carex podocarpa*	0.097	0.997
Vascular plants	Cypresslike Sedge	*Carex pseudocyperus*	0.578	0.988
Vascular plants	Swollen Beaked Sedge	*Carex rostrata*	0.419	0.841
Vascular plants	Quill Sedge	*Carex tenera*	0.422	0.939
Vascular plants	Iowa Golden Saxifrage	*Chrysosplenium iowense*	0.254	0.893
Vascular plants	Pink Lady's-slipper	*Cypripedium acaule*	0.145	0.991
Vascular plants	Long-stalked Whitlow-grass	*Draba juvenilis*	0.366	0.996
Vascular plants	Macoun's Whitlow-grass	*Draba macounii*	0.181	0.997
Vascular plants	Wind River Whitlow-grass	*Draba ventosa*	0.145	0.997
Vascular plants	Northern Wood Fern	*Dryopteris expansa*	0.163	0.958
Vascular plants	Scribner's Wild Rye	*Elymus scribneri*	0.306	0.999
Vascular plants	Talus Willowherb	*Epilobium clavatum*	0.406	0.996
Vascular plants	Glaucous Willowherb	*Epilobium glaberrimum*	0.373	0.854
Vascular plants	Pale Fleabane	*Erigeron pallens*	0.323	0.995
Vascular plants	Taproot Fleabane	*Erigeron radicatus*	0.433	0.994
Vascular plants	Barren Ground Fleabane	*Erigeron trifidus*	0.133	0.996
Vascular plants	Sheathed Cotton-grass	*Eriophorum callitrix*	0.471	0.998
Vascular plants	Rough Fescue	*Festuca altaica*	0.059	0.995
Vascular plants	Small-flowered Fescue	*Festuca minutiflora*	0.452	0.998
Vascular plants	Carolina Crane's-bill	*Geranium carolinianum*	0.336	0.993
Vascular plants	Tall Manna Grass	*Glyceria elata*	0.093	0.99
Vascular plants	Clammy Hedge Hyssop	*Gratiola neglecta*	0.166	0.982
Vascular plants	Western Oak Fern	*Gymnocarpium disjunctum*	0.239	0.997
Vascular plants	Porcupine Needle Grass	*Hesperostipa spartea*	0.417	0.982
Vascular plants	Larger St. John's-wort	*Hypericum majus*	0.095	0.98
Vascular plants	Two-flowered Rush	*Juncus biglumis*	0.287	0.997
Vascular plants	Narrow-panicled Rush	*Juncus brevicaudatus*	0.306	0.98
Vascular plants	Thread Rush	*Juncus filiformis*	0.608	0.998
Vascular plants	Veiny Vetchling	*Lathyrus venosus*	0.382	0.892
Vascular plants	Alpine Azalea	*Loiseleuria procumbens*	0.193	0.999
Vascular plants	Elegant Stitchwort	*Minuartia elegans*	0.256	0.998
Vascular plants	Five-Stamen Bishop's-cap	*Mitella pentandra*	0.467	0.995
Vascular plants	Alkali Muhly	*Muhlenbergia asperifolia*	0.494	0.962
Vascular plants	Purple Sweet Cicely	*Osmorhiza purpurea*	0.196	0.998
Vascular plants	Dwarf Poppy	*Papaver pygmaeum*	0.311	0.999
Vascular plants	Hairy Butterwort	*Pinguicula villosa*	0.143	0.992
Vascular plants	Whitebark Pine	*Pinus albicaulis*	0.389	0.961
Vascular plants	Alaskan Rein Orchid	*Piperia unalascensis*	0.361	0.999
Vascular plants	White Bog Orchid	*Platanthera dilatata*	0.371	0.95
Vascular plants	Eastern Cottonwood	*Populus deltoides*	0.441	0.995
Vascular plants	Blunt-leaved Pondweed	*Potamogeton obtusifolius*	0.229	0.927
Vascular plants	Robbin's Pondweed	*Potamogeton robbinsii*	0.276	0.992

Taxon	Common Name	Scientific Name	Equal training sensitivity and specificity value	AUC
Vascular plants	Straight-leaved Pondweed	*Potamogeton strictifolius*	0.342	0.875
Vascular plants	Drummond's Cinquefoil	*Potentilla drummondii*	0.414	0.998
Vascular plants	Diverse-leaved Cinquefoil	*Potentilla multisecta*	0.114	0.997
Vascular plants	Greenland Primrose	*Primula egaliksensis*	0.332	0.992
Vascular plants	Bristly Buttercup	*Ranunculus pensylvanicus*	0.511	0.982
Vascular plants	Alder-leaved Buckthorn	*Rhamnus alnifolia*	0.35	0.985
Vascular plants	Sitka Mistmaiden	*Romanzoffia sitchensis*	0.124	0.998
Vascular plants	Widgeon-grass	*Ruppia cirrhosa*	0.117	0.988
Vascular plants	Athabasca Willow	*Salix athabascensis*	0.401	0.9
Vascular plants	Under-green Willow	*Salix commutata*	0.28	0.99
Vascular plants	Northern Pitcher Plant	*Sarracenia purpurea*	0.46	0.992
Vascular plants	Spreading Stonecrop	*Sedum divergens*	0.409	0.996
Vascular plants	Northern Blue-eyed-grass	*Sisyrinchium septentrionale*	0.13	0.967
Vascular plants	Narrow-leaved Meadow-sweet	*Spiraea alba*	0.507	0.997
Vascular plants	Buttercup-leaved Mock Brookfoar	*Suksdorfia ranunculifolia*	0.268	0.999
Vascular plants	Purple Meadow-rue	*Thalictrum dasycarpum*	0.495	0.968
Vascular plants	Lace Foamflower	*Tiarella trifoliata*	0.485	0.999
Vascular plants	Oval-leaved Bilberry	*Vaccinium ovalifolium*	0.144	0.997
Vascular plants	Alpine Bilberry	*Vaccinium uliginosum*	0.347	0.984
Vascular plants	Columbian Watermeal	*Wolffia columbiana*	0.333	0.999

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