OUR LAND IS OUR FUTURE

Hà t_átgi hà khustìyxh sìti

A Conservation Area Design for the Territory of the Taku River Tlingit First Nation

Round River is an ecologically oriented research and education organization whose goal is the formulation and carrying out of conservation strategies that preserve and restore wildness. By wildness, we have in mind landscapes that are relatively self-maintaining, with full vegetation and faunal assemblages present, and where the human communities are in a close and sustainable relationship with the local ecosystem. Flourishing, and intact, we view wild landscapes as important in, and of, themselves; for cultural reasons, and as indicators of ecological health. Round River works to ensure the integrity of wild lands and waters for generations yet to come. We employ the principles of conservation biology to formulate strategies to provide our partner organizations and communities confidence in their decisions and to provide a well founded scientific basis for their long-term conservation planning efforts.

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Nakina River Grizzly Bear *Dennis Sizemore*

Published with assistance from the Brainerd Foundation, Bullitt Foundation, Kongsgaard-Goldman Foundation, Gordon and Betty Moore Foundation, David and Lucille Packard Foundation, Rockefeller Brothers Fund, Tides Foundation, Weeden Foundation and the Wilburforce Foundation.

Design and production/Trent Alvey Design. Cartography/Rick Tingey. Printing/Western Printers and Lithographers Ltd, Vancouver. Cover printed on Reincarnation Matte 100% recycled (50% pcw and 50% post commercial waste, process chlorine free). Insides printed on New Life Opaque 30% post consumer waste.

Additional copies may be obtained by contacting the Land and Resources Office of the Taku River Tlingit First Nation or Round River Conservation Studies. The report may be downloaded from the web sites of the Taku River Tlingit First Nation (www.trtfn.com), Round River Canada (www.roundrivercanada.org), or Round River Conservation Studies (www.roundriver.org).

Canadian Lynx tracks

A Conservation Area Design for the Territory of the Taku River Tlingit First Nation: Preliminary Analyses and Results

Report prepared for

The Taku River Tlingit First Nation

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GIS Analyses:
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November, 2003

Cite as: Heinemeyer, K., T. Lind, and R. Tingey. 2003. A Conservation Area Design for the Territory of the Taku River Tlingit First Nation: Preliminary Analyses and Results. A report prepared for the Taku River Tlingit First Nation. Round River Conservation Studies, Salt Lake City, Utah 84103. 98 pp.

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Acknowledgements

This Conservation Area Design (CAD) has been made possible through the direction of the Taku River Tlingit First Nation (TRTFN). In particular, the TRTFN leaders Bryan Jack, John Ward and TJ Esquiro have consistently and strongly supported the CAD development and the incorporation of conservation science into the Nation's land planning efforts. Many TRTFN citizens contributed their ecological knowledge, including Jackie Williams, Bryan Jack, Andrew Williams, Terry Jack, Harry Carlick, Richard Carlick, Greta Thorlakson, Douglas Jack and Richard Johnson. The TRTFN Citizen's Caucus and the TRTFN Fisheries, GIS, Natural Resources and Administrative staff was also supportive and helpful throughout the development of the CAD. In addition, several unmentioned citizens contributed their knowledge in formal and informal conversations. A strong and effective partnership between the TRTFN and Round River Conservation Studies (RRCS) facilitated this process. This partnership was aided by the efforts of our associates: Convergence Communications, Dovetail Consulting, Round River Canada, Nature Conservancy Canada and the Transboundary Watershed Alliance.

The spatial analyses and mapping work for the CAD was lead by Rick Tingey and Tom Lind of RRCS. Additionally, helpful and insightful conversations with Richard Jeo and Dennis Sizemore provided guidance throughout project.

While not documented in this report, a large field research effort directly and indirectly supported this effort. Doug Milek of RRCS and Jerry Jack of the TRTFN have led the field team through much of this work. The field crew has included: Phil Tizya, Rick Tingey, Nick Larson, Lance Craighead, Bryan Aber, Sara Jaward and Mandy Kellner. Additionally, Phil Timpany and other local Atlin residents generously provided key insights into the ecology of the region, as well as logistical assistance with the field studies. Phil has been particularly generous with his time and the sharing of his extensive knowledge of the Territory and its wildlife. Atlin Air and Discovery Air provided flight services and Helen Kennedy provided expediting assistance.

Many people provided comments and suggestions that improved the content and reporting of the CAD. Several peer-reviewers provided suggestions on the focal species habitat models; they include: Phil Timpany, Lance Craighead, Jean Carey, Rick Ward, Rick Florkiewicz, Rick Keim, Grant MacHutchon and Wayne McCrory. Report editing was provided by Dennis Sizemore, Julian Griggs, Bryan Evans and Barbara Dugleby. In particular, Barbara provided assistance in organization and editing; her helpful suggestions and her time are greatly appreciated.

Financial support for the CAD development was provided by the Brainerd Foundation, Bullitt Foundation, Kongsgaard-Goldman Foundation, Gordon and Betty Moore Foundation, David and Lucille Packard Foundation, Rockefeller Brothers Fund, Tides Foundation, Weeden Foundation and the Wilburforce Foundation. Particular mention is required for the sustained and rallying efforts of Don Weir, Bill Mitchell, Scott Rehmus and Mike Magee.

Dall Sheep

Executive Summary

This report synthesizes work done by Round River Conservation Studies (RRCS) to develop a Conservation Areas Design (CAD) for the Territory of the Taku River Tlingit First Nation (TRTFN). The CAD presented in this document is a work in progress, as additional field studies, analysis procedures and peer-review will continue over the next two years. The CAD includes analyses across approximately 4 million ha in northwest British Columbia, Canada. The TRTFN CAD provides a conservation science foundation for TRTFN land planning efforts, and was motivated partly by the lack of any similar assessments for this region in NW British Columbia. The Territory is approximately 95% wilderness, and presently supports low human population numbers, limited industrial developments and vast, relatively unaltered ecosystems. The remoteness of the region has been fundamental to the maintenance of healthy, viable ecosystems supporting northern biodiversity, including large mammal predator-prey systems, wild-run salmon/grizzly bear systems, and natural disturbance regimes. The Territory includes the entirety of the British Columbia portions of the Taku, Whiting, Atlin, and Tagish River watersheds, as well as the portions of Swift, Jennings, and Teslin Lake drainages.

Flannegan's Slough on the Lower Taku River.

The remoteness of the region translates into a scarcity of regional scientific data. The lack of these data was compensated for by using the traditional and indigenous ecological knowledge (TIEK) of the TRTFN in the development of the CAD. By combining the TRTFN TIEK with other sources of data, with our own field investigations and with the analyses methods and theoretical understandings of conservation biology, a CAD was produced that represents a powerful combination of these forms of ecological knowledge. We used a combination of methods, including the development of habitat models for multiple focal species, coarse-filter ecological community classification and representation analyses, regional connectivity analyses, and spatial optimization procedures.

We selected five terrestrial focal species: grizzly bear, moose, woodland caribou, thinhorn sheep and mountain goat, and developed habitat suitability models for each. Additionally, six species of freshwater salmonids were utilized: the five anadromous species (sockeye, Chinook, chum, coho, pink) and steelhead. We predicted the occurrence and distribution of 201 ecological communities through the development of an ecological landscape unit model that uses biogeoclimatic classification (BEC), vegetative cover, forest age class, and topographic variables to predict unique ecological communities. Special elements included 120 fish and wildlife occurrences compiled by the Conservation Data Centre, by TRTFN Natural Resources Dept. and RRCS from a variety of data sources, including field surveys. Due to the scarcity of data, we used special element analyses only in a limited extent to check the representation of these elements in the potential CAD scenarios.

Using a simulated annealing algorithm, 26 different site selection scenarios were produced. Each scenario incorporated a different level of representation for focal species habitats, ecological communities and anthropogenic habitat impacts. These scenarios provided an index of conservation value across the Territory, which we translated into a conservation density surface. A kernel density estimator was utilized to identify high value areas, and to provide information about the relative amount of conservation values within potential core areas. We assessed regional connectivity patterns through predictions of potential movement paths or movement corridors for grizzly bear across the Territory. Over 2500 least-cost paths were used to provide a connectivity surface identifying high value linkage habitats. The resulting connectivity areas identified linkages across the Territory, with most core areas having multiple connectivity areas linking them to multiple adjacent core areas.

The core and connectivity areas create a suite of habitats providing for the conservation of biodiversity and ecological processes across the Territory, and form the basis for the recommended CAD. The combination of the core and connectivity areas represents approximately 55% of the Territory. Focal species seasonal and annual predicted habitats are well represented, with representation levels ranging from 44% to 76%. Nearly all (99.2%) of the rivers and streams sustaining salmon are within the recommended CAD, as are 100% of the stream reaches identified to support spawning. In addition, the CAD represents 30% of the distribution of all but 3 ecological communities. In addition to the core and connectivity areas, we recommend the establishment of special management areas that have known critical values for sensitive species or habitats. The landscapes and habitats falling outside of the recommended CAD and special management areas remain critical to the overall integrity and resiliency of the ecological processes and biodiversity of the Territory. Therefore, all the lands within the Territory must be carefully managed to ensure the maintenance of ecological values.

Continued advancement of the TRTFN CAD will help ensure proper management for the long-term viability and robustness of the ecological systems of the Territory. We make several recommendations for the advancement and improvement of the TRTFN CAD. These include increasing the baseline data and information sources and, most importantly, establishing a long-term ecological and environmental monitoring regime.

Grey Wolf

1. Introduction and Background

1.1 Project Background and Objectives

This report summarizes work done by Round River Conservation Studies (RRCS), in partnership with the Taku River Tlingit First Nation (TRTFN), to develop a Conservation Areas Design (CAD) for the traditional Territory of the TRTFN. The TRTFN CAD was initiated in 1999 to provide a conservation science foundation for a community mandated TRTFN land planning effort. Land planning had been initiated by the TRTFN in response to concerns regarding the management of their lands and natural resources. Over the centuries the Taku River Tlingit, have demonstrated their ability as effective care takers of their lands and its resources. Their commitment to responsible stewardship has continued, as evidenced by their Constitution (Taku River Tlingit 1993), their legal battles over improper development (see Hart & Lucas 1996; Taku River Tlingit 2000, 2002) and the current development of a Conservation Area Design for their community-based land planning.

The development of the CAD was motivated partly by the lack of any similar assessments for this region on NW British Columbia. The region has low human population numbers, limited industrial developments, and vast, relatively unaltered ecosystems. In general, there has been very little investment in monitoring and research focused on the natural resources of the region, and thus little available scientific data documenting the region's provincial, national, and international significance towards biodiversity maintenance. Furthermore, the provincial government of British Columbia was not readily forthcoming with additional data sets even after several requests by the TRTFN. The lack of regional scientific data was compensated for by using the traditional and indigenous ecological knowledge (TIEK) of the Taku River Tlingit in the development of the CAD. By combining the TRTFN TIEK with other sources of data, with our own field investigations and with the analyses methods and theoretical understandings of conservation biology, a CAD was produced that represents a powerful combination of these forms of ecological knowledge.

The CAD presented in this document is a work in progress, as additional field studies, analysis procedures and peer-review will continue over the next two years.

1.2 Landscape-Scale Conservation Planning: Background and Approach

Across British Columbia, managers and scientists are increasingly using landscape-scale analyses to gain insights into the dynamics and conservation of the Province's vast landscapes. This follows a world-wide trend of recognizing the need to think about, and manage for, the maintenance of functioning ecosystem processes and populations across appropriately large regions (Hawkins & Selman 2002; Howard et al. 2000; Jepson et al. 2002; Pfab 2002; Soulé & Terborgh 1999; Wisdom et al. 2002). Planning for the maintenance of landscape functions and species across broad regions is particularly important in regions such as northern British Columbia, where ecosystem richness and productivity are maintained through large-scale disturbance regimes (Bunnell 1995; Segerstrom 1997) and other natural processes (Pringle 2001). Additionally, in systems with relatively low productivity (e.g., boreal forests), some species, particularly large mammal species (e.g., grizzly bear, caribou, and wolf), have evolved life-history strategies that require extensive landscapes to meet seasonal and annual life requisites for food and breeding. Additionally, maintaining ecologically effective populations of these species also may be key to the maintenance of community dynamics and complexity over the long term (Berger et al. 2001; Soulé et al. 2003).

While the need for biodiversity conservation and planning has long been recognized, few areas are actually managed primarily for this purpose. World wide, only about 3% of the terrestrial land base has been designated for biodiversity management (McNeely 1994). Moreover, the location, size and juxtaposition of these existing biodiversity reserves are often based on political factors rather than consideration of the needs for conservation. For example, most protected areas in Canada and the United States are located in alpine or sub-alpine zones and are usually too small and isolated to maintain viable populations of certain species, particularly wide-ranging animals such as carnivores (Newmark 1995). Within British Columbia's own protected area system, 75% of the parks are less than 1000 hectares in size with the majority in alpine or sub-alpine zones resulting in the lower elevation, more productive ecosystems, being grossly underrepresented (Lewis & Westmacott 1996; Sanjayan & Soulé 1997).

Gaps in ecosystem representation are by no means a purely U.S. or Canadian phenomenon. Lack of protection for the full suite of biodiversity is increasingly recognized in many countries and regions, as is the small size of many protected areas. For instance, investigations in Indonesia have shown many ecological communities to be under-represented and under-protected (Jepson et al. 2002). Furthermore, re-assessment of the reserve system in southeast Mexico has revealed major ecosystem types also to be under-represented, and important connectivity considerations to be lacking (Galindo-Leal et al. 2000). The existing protection of Africa's biodiversity has also recently received critical attention by several researchers and conservation biologists (e.g., Brooks et al. 2001; Fairbanks et al. 2001; Heydenrych et al. 1999; Howard et al. 2000).

Worldwide, conservation scientists have become increasingly engaged in assisting conservation organizations and governments striving to meet their regional conservation missions. Measuring success at maintaining long term ecological functions and biodiversity in any region has proven difficult and elusive. Therefore, to provide more tangible measures of success scientists have proposed sets of conservation and management goals. Noss (1992) and Noss and Cooperrider (1994) stated four goals of regional conservation to be satisfied to achieve the overarching mission of maintaining biodiversity and ecological integrity, into perpetuity. These goals are:

1. Represent, in a system of protected areas, all native ecosystem types and seral stages across their natural range of variation.

2. Maintain viable populations of all native species in natural patterns of abundance and distribution.

3. Maintain ecological and evolutionary processes, such as disturbance regimes, hydrological processes, nutrient cycles, and biotic interactions.

4. Design and manage the system to be resilient to short-term and long-term environmental change and to maintain the evolutionary potential of lineages.

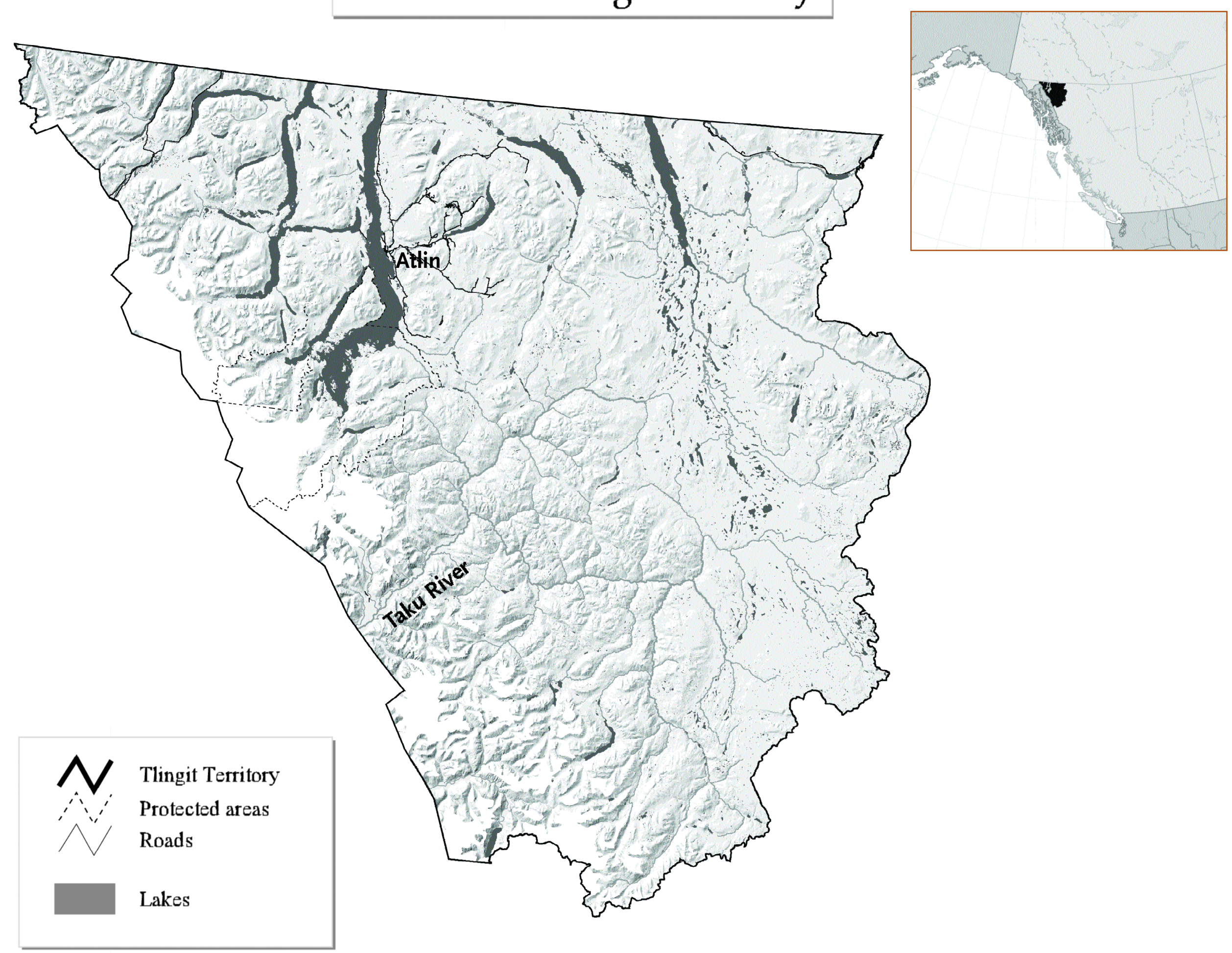
These four goals are often cited and have become central to most regional conservation strategies and conservation area designs endorsed and/or developed by government agencies and conservation organizations. For example, the BC provincial government (1993) stated that the first goal of its protected area strategy is "to protect viable, representative examples of natural diversity in the province, representative of the major terrestrial, marine and freshwater ecosystems, the characteristic habitats, hydrology and landforms ... of each ecosection". Further, the provincial government recommended in its Forest Practices Code (British Columbia 1995) that an ecosystem management approach be adopted to provide adequate habitat and to sustain genetic and functional diversity in perpetuity for all native species across their historic ranges, along with the maintenance of ecological processes. The BC government has increasingly embraced regional, science-based planning as the foundation for its land management. In the central and north coast regions of BC, where conflict between the timber industry and environmental concerns has stalled land use decisions, the BC government, timber industries and environmental organizations have agreed to jointly cooperate and support a regional-scale, science-based conservation area design developed by a coalition independent scientists, that includes RRCS biologists and GIS analysts (www.citbc.org). In northeastern BC, the establishment of the Muskwa-Kechika Management Area (MKMA) by three Land and Resource Management Planning Tables is an internationally applauded example of BC government's attempt to recognize and pursue landscape-scale conservation objectives and planning (www.muskwa-kechika.com). A conservation area design, com-missioned by the BC Government, is presently being developed by Nature Conservancy Canada and RRCS for the 6.4 million ha MKMA, to assist managers in maintaining its ecological integrity and native biodiversity (www.luco.gov.bc.ca).

The private sector in British Columbia is also getting into the act. Bunnell and Johnson (1998), in a report for MacMillan Bloedel, state that sustaining ecosystem health and biological diversity are two new broad objectives for this logging company. Non-government organizations have also embraced landscape-scale conservation planning as the most effective form of biodiversity conservation both within British Columbia and internationally. For example, Greenpeace Canada, Sierra Club of BC and Raincoast Conservation Society were the organizations that commissioned the Central Coast CAD (Jeo et al. 1999; Sanjayan et al. 2000). Also, The Nature Conservancy, the largest international conservation organization, has in its mission statement the explicit goal of ensuring the long-term survival of all viable native species and community types through the design and conservation of portfolios of sites within ecoregions.

2. Taku River Tlingit Territory Description

The Taku River Tlingit Territory is located in northwestern British Columbia, and extends well into the Yukon Territory. This present work covers the portion of the Territory within BC, an area of approximately 4 million hectares, including the entirety of the Taku and Whiting River watersheds, as well as the portions of Tagish, Atlin and Teslin Lake drainages (Map 1). Throughout this report, this BC portion of the TRTFN Territory is referred to as the "Territory". The Territory is bordered on the west by the Canada-US border. The southern boundary follows the southern edge of the Whiting and the Taku River watersheds, while the eastern boundary includes all the south-eastern portion of the Taku River watershed and most of the Teslin watershed, excluding the Jennings River and its reaches.

Map 1, Study Area:
Taku River Tlingit Territory



2.1 Present Human Landscape

Within the Territory, there currently exists one human settlement, Atlin, which is located along the eastern shore of Atlin Lake. The town is accessed by a 100 km road connecting it to the Alaska Highway in the Yukon. The population of Atlin, approximately 450 year-around residents, is comprised of Taku River Tlingit and non-native citizens. Atlin was originally a Tlingit village, with non-native immigrants settling there during the gold rushes of the late 1800's (Smith & Dickenson 1997). Some dirt roads radiate out from Atlin, to the east and south, primarily built to access placer gold mines along tributaries to Atlin, Surprise and Gladys Lakes (Map 1). Other access roads into the margins of the Territory include the road to the Golden Bear Mine in the extreme southeast corner of the Taku River watershed. This mine reached is no longer in production and the road is closed to legal public use. Access to the majority of the Territory is limited primarily to float-planes and helicopters. Other access includes by boat up the Taku River from Juneau, Alaska and by foot on a network of traditional Tlingit trails.

Present and historic uses of the Territory by the Taku River Tlingit are described in a wide variety of documents, and summary of this information is not attempted here.

2.2 Physical and Ecological Profile of the Territory

The TRTFN Territory has high ecosystem diversity for a northern landscape, ranging from ecosystems with strong coastal influences, through transition communities to the interior boreal ecosystems with continental and arctic influences. The Territory boasts of some of the richest habitats in the Province along the coastally-influenced lower Taku River, as well as vast, interior boreal landscapes with complex lake and stream systems that form the headwaters of the Yukon River.

An accepted system for describing ecosystems of British Columbia is the Biogeoclimatic Ecosystem Classification (BEC) system (Pojar et al. 1987), which delineates areas into "biogeoclimatic zones" according to climate, elevation, soils and potential climax vegetation. Using this system, the Territory contains 7 biogeoclimatic zones (Map 2). These range from Coastal Western Hemlock (CWH) and the Mountain Hemlock (MH) zones along the coastally influenced lower Taku River to Englemann spruce-subalpine fir (ESSF) and sub-boreal spruce (SBS) transition zones to alpine tundra (AT), spruce-willow-birch (SWB) zone at higher elevations and the black and white spruce (BSWS) zone at lower elevations in the interior landscapes. The following descriptions are modified for the Territory boundaries from Horn and Tablyn (2001).

2.2.1 Coastal Ecosystems

The Territory supports two coastally influenced broad ecosystem types or zones (Coastal Western Hemlock and Mountain Hemlock biogeoclimatic zones) in the lower Taku and Whiting River drainages, close to the Alaska border. The forested portions of these zones are considered coastal temperate rainforest, and are characterized by old-growth conifer stands with a complex structure, often including very large, old trees. Trees reaching 500 years of age are generally common in these types of northern coastal rainforests, as the wet coastal climate results in a low frequency of fire. For the most part, forests are replaced in piecemeal fashion by the death and replacement of individual trees, although occasionally large-scale disturbances such as wind throw and landslides also occur. In these areas, western hemlock and Sitka spruce are the dominant tree species, though in very wet sites, lodgepole pine and yellow cedar tend to dominate in bog-like habitats. On the active floodplains of larger rivers, hemlock and spruce are dominant on higher benches. Deciduous forests with alder and willow dominate areas with elevated water tables and those directly adjacent to rivers. These coastally influenced areas of the Territory tend to be forested, with localized non-forested bogs, fens, marshes and avalanche tracks.

The Mountain Hemlock zone is found at higher elevations in these coastally influenced regions of the Territory. Subalpine forest dominates this zone, where the snow-free season is short and the soils rarely dry out. Low-lying clouds are also often present, providing a significant amount of additional moisture to the system. Mountain hemlock and amabilis fir are the most common species, with yellow cedar occurring in more coastally-influenced areas and occasional subalpine fir in drier, colder areas. The lower elevations of the subalpine forest are continuously forested, except where dissected by avalanche tracks, as is often the case. Upper elevations have clumps of trees interspersed with subalpine meadows and wetlands.

2.2.2 Transitional Ecosystems

As weather systems move inland from the coast, they are limited to moving up valleys, and gradually lose their warmth, creating an area of transition between the warm, wet coast and cold, dry interior. This "transition region" supports two biogeoclimatic zones or ecosystems. The Sub-Boreal Spruce (SBS) occurs at lower elevations and the Englemann Spruce-Subalpine Fir (ESSF) occurs at higher elevations. These zones occur along the low-elevation valleys of the Taku River and its tributaries and the transitional streams west of Atlin Lake feeding into the Yukon River headwaters. Dominant tree species in the northern SBS are hybrid (Roche) spruce, subalpine fir, black cottonwood, paper birch and, less commonly, lodgepole pine and trembling aspen.

As one increases in elevation, the forests undergo a gradual transition to Engelmann Spruce - Subalpine Fir (ESSF). The ESSF in the Territory is the wettest and snowiest extreme of the ESSF in the province. The dominant tree species shifts from hybrid spruce at lower elevations to subalpine fir with more heather in the understory and subalpine herbs and dwarf shrubs in forest openings. Continuous forest gives way to subalpine parkland at higher elevations. Avalanche tracks are common and are dominated by Sitka alder.

2.2.3 Interior Boreal Ecosystems

The interior portions of the Territory have a climate that is more continental with arctic influences, and the landscape is dominated by rolling mountains and wide plateaus. These vast interior landscapes support two boreal biogeoclimatic zones or ecosystems, with Boreal Black and White Spruce (BWBS) occurring at lower elevations and Spruce-Willow-Birch (SWB) occurring at higher elevations. Arctic air masses move through these interior regions of the Territory during the winter, resulting in long, cold winters, cold soil temperatures, and a short growing season. The forests exist as a patchwork of slow-growing forests, deciduous scrub, and wetlands of varying ages and successional stages. In the BWBS, white spruce and black spruce, subalpine fir, lodgepole pine, and aspen are the major tree species. Shrub species include soopolallie, highbush cranberry, and Labrador tea. Wetlands are common but, for the most part, are not extensive (with the exception of the Teslin Basin). Grassland communities are also present in some areas. The Spruce-Willow-Birch (SWB) zone occurs above the BWBS. This zone is mostly forested by white spruce and subalpine fir, with lodgepole pine, aspen and black spruce occurring in variable amounts at lower elevations. At higher elevations subalpine fir is dominant. In the subalpine area, the vegetation mainly consists of deciduous shrubs such as willow and scrub birch.

2.3 Wildlife in the Territory

The remoteness of the region has been fundamental to the maintenance of healthy, viable ecosystems supporting northern biodiversity, including large mammal predator-prey systems, wild-run salmon/grizzly bear systems, and natural disturbance regimes (e.g., fire and flood). Because of the lack of development, there have been few natural resource conflicts in the Territory, and, as is often the case, the lack of conflict has translated into a lack of investment by governments in researching and monitoring the natural resources of the region. Basic western science-based knowledge of key wildlife species population distribution, historical and current population trends and regional habitat relations is limited. There is some provincial monitoring of key game species, including moose and woodland caribou, but little or no monitoring information is available for other species, including stone sheep, mountain goat, grizzly bear, black bear or wolf.

While there is little existing scientific documentation of the Territory, several general patterns for biodiversity and wildlife distributions can be assumed. It is likely that the more coastally-influenced systems, such as those found on the lower Taku River would support the widest array of biodiversity, given the productive and rich ecology of the region. While some of the most socially and culturally valued species, including moose and grizzly bear likely reach their highest densities associated with the Taku River, particularly the coastally-influenced lower Taku River, they are found distributed widely (though likely at lower densities) across the Territory. Other socially and culturally important species, such as the woodland caribou, Stone's sheep and Dall's sheep are found only in portions of the Territory that support appropriate habitats. While research to document the extent of these limited distributions is generally lacking, interviews with TRTFN elders and hunters, as well as other Atlin residents, have provided information on historic and current distributions of some of these species.

In 1999, the BC Province began a radio-telemetry research project associated with the proposed Tulsequah Chief mine and road. This project included radio-tagging grizzly bear, moose, woodland caribou, sheep and goat; all in the general vicinity of the proposed road. This project was an attempt to understand the potential impacts a proposed road and associated its use may have on key wildlife species. Data and reports of that research project have been generally unavailable, though multiple requests for data and information have been submitted by the TRTFN.

2.3.1 Rare Wildlife Species

The Conservation Data Centre estimates that approximately 20 fish and wildlife species found in the Territory are of special management concern in BC due to declining populations (red or blue-listed species at risk). The provincial government has recommended that the habitat needs of three species at risk – grizzly bear, fisher and trumpeter swan – be specifically addressed at the strategic planning level in the Atlin – Taku Planning Area (Horn & Tamblyn 2001). Fisher are blue-listed in the Province, but are known to be in the Territory in only a limited number of drainages of the Taku River. These include Yeth Creek and the Nakina River, as documented by local trappers and TRTFN. Even in these areas, they are quite rare, there are few records of female fisher being trapped, and there are no recent reports of fisher presence. This area may represent the northern limit of fisher distribution in British Columbia and it is unknown whether fisher in the Taku River represents a viable breeding population. Trumpeter swans (blue-listed) use a number of lakes and wetland areas distributed throughout the Territory as migratory stopovers and as spring and fall rendezvous sites. Additionally, swans breed in notable numbers along the Taku River in suitable wetland habitats (RRCS and TRTFN, unpubl report). Other notable species at risk that are found in the region (Table 1) include wolverine (blue-listed), Dall's sheep (blue-listed) and gyrefalcon (blue-listed).

Grizzly bears are provincially blue-listed, and are found in variable abundances across the TRTFN Territory, due to widely varying habitats. The Taku River is internationally recognized for its salmon-grizzly bear system that has historically supported high numbers of grizzly bears. There is recognition by TRTFN members and long-term local residents familiar with the Taku system that the grizzly bear population in the watershed has undergone dramatic declines over the last few

Table 1: Mammals and birds at risk that are reported within the TRTFN Territory. [1]

SPECIES	BC RANKING
Grizzly Bear *(Ursus arctos)*	Blue
Fisher *(Martes pennanti)*	Blue
Wolverine, luscus subspecies *(Gulo gulo luscus)*	Blue
Dall's Sheep *(Ovis dalli dalli)*	Blue
Tundra shrew *(Sorex tundrensis)*	Red
Glacier bear *(Ursus americanus emmonisii)*	Blue
Meadow jumping mouse, alascensis subspecies *(Zapus hudsonius alascensis)*	Blue
Short-eared owl *(Asio flammeus)*	Blue
Upland sandpiper *(Bartramia longicauda)*	Red
Smith's longspur *(Calcarius pictus)*	Blue
Oldsquaw *(Clangula hyemalis)*	Blue
Trumpeter swan *(Cygnus buccinator)*	Blue
American Peregrine Falcon, anatum subspecies *(Falco peregrinus anatum)*	Red
Peregrine flacon, pealei subspecies *(Falco peregrinus pealei)*	Blue
Gyrfalcon *(Falco rusticolus)*	Blue
Wandering Tattler *(Heteroscelus incanus)*	Blue
Short-Billed Dowitcher *(Limondromus griseus)*	Blue
Hudsonian godwit *(Limosa haemastica)*	Red
Red-necked phalarope *(Phalaropus lobatus)*	Blue
American golden-plover *(Pluvialis dominica)*	Blue

1 The Red list includes any indigenous species or subspecies (taxa) considered to be extirpated, endangered, or threatened in British Columbia. Extirpated taxa no longer exist in the wild in British Columbia, but do occur elsewhere. Endangered taxa are facing imminent extirpation or extinction. Threatened taxa are likely to become endangered if limiting factors are not reversed. Red-listed taxa include those that have been, or are being, evaluated for these designations. The Blue list includes any indigenous species or subspecies considered to be vulnerable in British Columbia. Vulnerable taxa are of special concern because of characteristics that make them particularly sensitive to human activities or natural events. Blue-listed taxa are at risk, but are not extirpated, endangered or threatened.

decades. The underlying causes for these declines are unknown, but they are expected to include excessive trophy hunting, increased life and property defense killings, and declines in salmon returns, particularly chum salmon. Grizzly bears occur in naturally lower population densities in the northern portions of the Territory, where access to salmon is limited or non-existent. It is believed that some grizzly bears travel from regions such as the northern Territory to the Taku River watershed to take advantage of the seasonal abundance of salmon protein. The wide-ranging habits of grizzly bears, their diverse seasonal habitat requirements, and their social importance at local, provincial and international levels require that they receive special management attention.

2.3.2 Wildlife Species of Cultural or Regional Significance

The northern woodland caribou is a regionally significant species in the Territory and a historically important food source of the Taku River Tlingit. The ranges of three caribou herds overlap the Territory – the Level-Kawdy, the Atlin, and the Carcross/Squanga. The Atlin and Carcross/Squanga herds, along with the Ibex herd in the Yukon, are known as the Southern Lakes caribou population. Widespread declines in the Southern Lakes population prompted a recovery program in 1992 by First Nations and the Yukon and BC governments to increase the herds to historic levels (www.yfwmb.yk.ca/comanagement/mgmtplans/slcrp/intro.html). Historical levels of this herd would be in the order of thousands of animals. The Taku River Tlingit have voluntarily stopped hunting caribou

Stone's Sheep

in support of this initiative. British Columbia continues to issue limited-entry hunting permits for the caribou in the Territory.

Moose are a principal source of meat for many T RTFN members and other Atlin residents, and there is local concern about moose populations in the vicinity of Atlin, due to excessive hunting pressure resulting from increased vehicle access. Similar to the woodland caribou, widespread declines of moose throughout the Southern Lakes region of the Yukon and British Columbia has resulted in the recent establishment of the Southern Lakes Moose Recovery Effort, a First Nation and Yukon Territory Government partnership.

The TRTFN Territory supports two subspecies of thinhorn sheep: Stone's sheep (Ovis dalli stonei) and Dall's sheep (Ovis dalli dalli), as well as Fannin sheep, a type of Stone's sheep showing a wide diversity of color variations. Fannin sheep are considered an intergrade between Dall's and Stone's sheep, showing color characteristics of both subspecies; Fannin sheep are found only in this region of BC and extending north into the Yukon Territory. TRTFN and other local community members have expressed concern for thinhorn sheep populations in the region, due to dramatic population declines. Stone's sheep are patchily distributed in suitable habitats from the southeastern portion of the Territory, integrating into the Fannin sheep varieties through the Atlin area and to the north. Dall's sheep (blue-listed) are found in the northwestern portion of the Territory, representing the southeastern extent of Dall's sheep distribution, which is primarily within the Yukon and Alaska.

Mountain goats (Oreamnos americanus) are found distributed throughout the Territory in suitable habitats, with the most abundant habitat found in the more western portions of the

Mountain Goat

Territory. There appears little present concern about mountain goat populations in the Territory, though some populations may be experiencing declines due to guide-outfitting or local hunting pressure. Mountain goats have been shown to be highly susceptible to population declines with increasing human access, hunting, disturbance and habitat impacts, and thus need to be monitored in any regions where these activities occur.

Other species of management interest include bald eagle, osprey, and amphibian species, all which are found in close association with wetland and aquatic habitats of the Territory. These species, and the habitats upon which they depend, require management and protection if they are to be maintained in areas receiving development pressure.

2.4 Fisheries Values

For countless generations, the Taku River Tlingit have relied on salmon as a food source and as a focal point in their relationship with their Territory. Given the historical importance of salmon to the TRTFN people, involvement in fisheries management and protection is a cultural and social necessity. The protection of healthy ecosystems for future generations continues to be of the utmost importance.

The Territory boasts a rich diversity of fish and aquatic habitats. The Taku River watershed contains approximately 28 known fish species of both Pacific and Yukon/Arctic origin. In addition to coastal species (such as the five species of salmon), interior species are surprisingly present in the same drainage (i.e. lake trout, grayling, pike, as well as others). Distribution of species is influenced not only by the coastal-interior geography of the Territory, but also by complex ecosystem processes such as glacial activity, tectonic uplift and lake buffering. This creates a dynamic system with a wide variety of fish habitat types including main-stem, off channel, tributaries and lakes/wetlands.

Since 1992, the TRTFN has operated a successful fisheries program, and their capacity to effectively undertake a wide variety of initiatives has been thoroughly demonstrated. Projects are undertaken annually as part of transboundary salmon management operations. Such ongoing projects include: live weirs for sockeye enumeration (Kuthai Lake, King Salmon Lake); a carcass weir for Chinook (Nakina River); a test fishery for Coho (Lower Taku); tag recovery for Chinook (upper Nahlin River); and participation in a fish wheel marking project (Canyon Island).

While much of the TRTFN management and conservation focus has been on salmon, they recognize the importance of all fisheries and aquatic components. Consequently, in recent years the TRTFN Fisheries Program has expanded to include habitat surveys, lake assessments, GIS (Geographic Information System) mapping and strategic conservation planning.

The need for substantial First Nation involvement in fisheries co-management has long been evident, and the TRTFN is now represented in all forums of transboundary salmon management. These include the Taku Salmon Management Committee; the Transboundary Technical Committee and the Transboundary Panel of the Pacific Salmon Commission. Representation at these levels provides the TRTFN with a unique opportunity to influence change in the Taku fisheries management regime.

Additionally, the TRTFN initiated a process for Watershed-based Fish Sustainability Planning for the Taku River watershed. The ultimate goal of this undertaking is to ensure conservation of fish and fish habitat by involving all agencies and interests in a strategic planning exercise. The basis of this strategic planning exercise was to develop a broader focus within the management regime, one that would recognize ecosystem processes and help to reduce the risk of future decline of fish populations or loss of fish habitat. This dovetails with the TRTFN CAD, to provide specific fisheries management direction.

2.5 Existing and Potential Environmental Impacts and Threats

Biodiversity loss occurs due to a wide variety of impacts, with habitat loss and fragmentation representing the greatest threats, globally. Other impacts have also historically been important, and many more are emerging as critical. For example, over-harvest has led the extinction, extirpation, or reduction in numbers and distribution in many species, such as the bison, trumpeter swan, wolf, grizzly bear and most salmon stocks in North America. Protection of populations and management of harvest are successfully recovering some of these historically over-harvested species. Still, over-harvest, as well as harvest practices insensitive to the ecology of some species, continues to be of concern for a variety of fish and wildlife species.

Increasingly, new threats continue to emerge as agents of biodiversity and ecosystem decline. These include increasing or accumulating levels of pollutants and toxins, new introduced diseases and invasive introduced species of plants and animals that out compete native biodiversity. The diversity of potential agents of environmental degradation a re too numerous and complex to discuss.

Fortunately, the Territory of the Taku River Tlingit has remained relatively untouched by many of these agents, due to its undeveloped and remote nature. However, portions of the Territory are impacted by gold mining, its associated roads, developments and environmental degradation. Additionally, a number of fish and wildlife populations have experienced over-harvest and habitat. Current pressures for resource development challenge the present land management structure to adequately control and prevent further environmental degradation. Across the Territory, many of the potential agents of environmental degradation need to be monitored for land planning and management. Below, the two most wide-spread and current threats to the ecosystem integrity of the TRTFN Territory are discussed in greater detail: habitat fragmentation and, particularly, the fragmentation and degradation caused by roads.

2.5.1Habitat Fragmentation

Although some ecological effects of habitat fragmentation are subtle and vary by species, the overall consensus among biologists is that anthropogenic habitat fragmentation and habitat loss represent the greatest threats to biodiversity worldwide (Collinge 1996; Harris 1984; Heywood 1995; Laurance & Bierregaard 1997; Wilcove et al. 1986). Still, habitat fragmentation is not entirely an anthropogenic phenomenon, as natural disturbances and geological events can act to separate ecosystems and landscapes into isolated parts. Some habitats are naturally isolated, such as oceanic islands, mountaintops, and desert springs. However, humans are currently the primary agent of habitat fragmentation world-wide and anthropogenic habitat disturbances far exceeds naturally occurring phenomena in both scale and frequency.

History has shown that the end result of human impacts, beginning with natural resource extraction and infrastructure development, is a landscape of isolated habitat remnants accompanied by a severe reduction in biodiversity. While species with modest area requirements might maintain viable populations entirely within fragments, the presence of these and more resilient species does not negate the dire consequences that arise as a result of habitat fragmentation for more vulnerable species. It is typically the large carnivores and habitat specialists that are most susceptible to the effects of habitat fragmentation (Crooks 2002; Gittleman & Gompper 2001; Harris & Gallagher 1989; Holt et al. 1999; Newmark 1986; Newmark 1995; Newmark 1996). Additionally, naturally rare species are particularly susceptible to habitat degradation, and to displacement by species invading these newly accessible systems. Application of the precautionary principle suggests that conservation plans should consider the ecological needs of the species that are most sensitive to the effects of habitat loss, fragmentation and degradation.

Shustahini Mountain

2.5.2 Roads

Roads are defined as linear human disturbances that can accommodate a motorized vehicle, including rights-of-way such as power-lines, fence-lines, pipelines, etc. A number of studies have described patterns of landscape fragmentation caused by roads and the direct and indirect impacts of roads on a wide diversity of species (Carr & Fahrig 2001; Dyer et al. 2002; Fahrig et al. 1995; Forman & Alexander 1998; James & Stuart-Smith 2000; Mace et al. 1999; Papouchis et al. 2001; Reed et al. 1996; Rich et al. 1994). Due to the systemic nature of these impacts, the density of roads is often used as an indicator of the ecological value of an area.

Roads are often referred to as a "keystone disturbance", as the construction of a new road has a proliferation effect that facilitates further human impacts on an ecosystem and initiates the spread of degradation across the landscape. Road access provides opportunities for accelerated resource extraction and development, as well as increased human presence for a variety of purposes, from development to recreational use to settlement. Roads also serve as an avenue for increased hunting and poaching because they allow greater access to target species (McLellan 1990). For large carnivores, roads translate into an increase in fatal human encounters (e.g., bears killed in life or property defense). Roads also directly impact biodiversity through traffic-caused mortality which can often exceed mortality rates in hunted populations.

Some species, such as grizzly bears and woodland caribou, show a marked avoidance of roads and other human activity areas thereby causing further fragmentation of home ranges and reduction in potential habitat (Archibald et al. 1987; Dyer et al. 2001; Dyer et al. 2002; Gibeau et al. 2002; James & Stuart-Smith 2000; Kazworm & Manley 1990; Mac et al. 1996; Mace et al. 1999; Mattson 1990; Wolfe et al. 2000). It has been found that adult female grizzly bears may avoid using high quality habitat if it is near a road, indicating that roads can potentially cause the indirect loss of high quality habitat to key reproductive animals in the population (Gibeau et al. 2002; Mace et al. 1999). Additionally, roads can potentially increase the susceptibility of prey species to predation, as these linear features may increase the mobility of the predators, particularly in the winter. For example, it was found that woodland caribou experienced higher wolf predation near roads (James & Stuart-Smith 2000).

Roads serve as an active avenue for the spread of exotic and invasive species. The edge habitats created by roads facilitates and supports species that thrive in disturbed or ecotone habitats; these species can often displace native species through competition and predation (James & Stuart-Smith 2000; Stohlgren et al. 1999; Winter et al. 2000), and reduce the habitat quality for a diversity of other species (Reinhart et al. 2001). Additionally, vehicles and people facilitate the spread of diseases through transport on spores and individuals; these diseases can have dramatic effects on the host species, as well as species that utilize the host (Gelbard & Belnap 2002; Hunt 2000; Tomback 2001). Finally, the soil erosion and sedimentation caused by roads and their construction causes widespread and chronic degradation of streams and rivers, destroying or degrading important aquatic habitats (Findlay & Bourdages 2000).

Many similar potential impacts and concerns apply to motorized boat access. Jet boats and motorized boat transportation can represent affordable and accessible access to otherwise remote regions, potentially causing increased wildlife mortality due to legal and illegal harvest, as well as life and property defense killings of predators. Boat access and use of the near-shore habitats can displace wildlife, impact sensitive riparian vegetation, cause soil erosion and transport exotic species. In remote areas with navigable rivers, streams and lakes, jet-boat access may represent the current largest access impact. This is true in the remote waterways of the Territory; the extent of the Taku River, the lower portions of its primary tributaries (the Nakina and Inklin Rivers) and several of its headwater lakes are accessed primarily by float plane or helicopter, but then extensively traveled by jet boats.

3. Conservation Area Design Planning Methodology

Although the goals and objectives of CADs are increasingly accepted and embraced, the data, analyses and approaches to developing such designs are often limiting, incomplete or coarse-scaled. Still, the need to act presently forces conscientious use of the existing data and methods by conservation scientists to develop designs based on the best available data and science. In an ideal world, research would be completed across BC's natural landscapes, as well as on the diversity of fish and wildlife species sensitive to landscape management. In today's real world, with scarce funding and political interest, the expensive and intensive research required to obtain the recommended information is, in all likelihood, not going to be completed, or even attempted. Thus, as we have attempted to do in this project, conservation biologists and managers must make the best use of the limited data available, utilize and develop techniques that optimize the use of these data, and understand and rely upon scientific foundations and ecological or conservation biology theories.

3.1 Uncertainty, Stochasticity and the Precautionary Principle

Conservation biologists and natural resources managers must allow for uncertainty inherent in limited data. Additionally, since natural systems are inherently stochastic and unpredictable, considering and incorporating natural stochasticity must be an integral part of developing a conservation area design. The "precautionary principle" forwards that the uncertainty in managing natural systems should be explicitly acknowledged and managers should make every effort to err on the side of caution (deFur & Kaszuba 2002; Raffensperger & deFur 1999; Van Den Belt & Gremmen 2002). Given the finality of extinction, conservation planning should incorporate wide margins of safety against the potential loss of organisms, populations or ecological processes. In particular, biodiversity conservation plans must carefully consider the consequences of further human impact and loss of natural habitat, even when no obvious role or effect on the ecosystem has been empirically described. In other words, the absence of ecological data does not equate with the absence of ecological importance. Under the precautionary principle, the burden of proof should be placed on development or resource extraction advocates. It is these advocates who must prove that additional human impact, including cumulative impacts, would not have any significant negative effects on the environment. Our CAD analyses and results incorporate precautionary levels of goal-setting, but we also highly recommend that all the landscapes of the Territory be managed for conservation of biodiversity, regardless of CAD designations.

3.2 Elements of Conservation Area Design

A number of increasingly sophisticated techniques are being applied to regional conservation area designs. Many represent technological or theoretical advancements in our attempts to model and predict the fundamental dynamics and diversity of the landscapes; most attempt to optimize the amount of information gleaned from sparse data, and rely on computer-intensive and GIS-based approaches. Regardless of the techniques, many recent landscape conservation planning efforts rely upon three types of information to provide the foundation of the design: focal species analyses, coarse-filter ecosystem representation analyses and fine-filter targets (special elements), as described by Noss et al. (1999). The combination of these analyses provides complementary information sources that should increase the robustness of the design as compared to the use of a single information source. A critical addition to this suite is the explicit consideration of connectivity across landscapes, for the maintenance of demographic and genetic exchange between populations, as well as the maintenance of ecosystem and landscape processes (Dobson 1999; Hoctor et al. 2000; Taylor et al. 1993). Other analyses may further our ability to capture important dynamic processes, including spatial population viability analyses (advancing focal species analyses), and ecological process modeling (e.g., fire modeling).

Our approach to the development of the TRTFN CAD involved integration of principles from conservation science and TRTFN ecological knowledge. We used a combination of methods, including conducting interviews with TRTFN hunters and elders to gathering TIEK, development of habitat models for multiple focal species based on this ecological knowledge, coarse-filter ecological community classification and representation analyses, regional connectivity analyses, and spatial optimization procedures. This combination of complementary methods was used to address the limitations and shortcomings of each individual technique, and to meet the widely-adopted goals set by Noss (1993; 1996), as discussed in Chapter 1.

3.3 Information Sources

As stated previously, one of the main motivations for the development of the CAD presented in this report is the lack of any similar analyses for this region. Additionally, there is little available scientific monitoring or data on the status of the region's wildlife and wildlife habitats. The lack of base-line ecological information for the Territory provided a challenge for the development of the CAD. We collected and utilized the best available information; this includes information from a diverse suite of sources.

3.3.1 Taku River Tlingit Ecological Knowledge Interviews

In 2000, TRTFN and RRCS conducted interviews to record and document the traditional and indigenous knowledge (TIEK) of the TRTFN, with a particular focus on key wildlife species of the region. An interview question set was developed, based upon a question set used by the Gwich'in Renewable Resource Board in the mid-1990s to document traditional knowledge about wildlife species that were used by the Gwich'in. The question set included 60 questions, ranging in topics from Tlingit names, traditional uses and management, current status, basic ecology and seasonal habitat requirements for each of five CAD wildlife focal species, the Pacific salmon of the Taku River and additional species of importance to the Tlingit.

Semi-structured interviews were conducted with nine TRTFN elders and hunters. The interviews were recorded on audiocassettes and the interviewees were encouraged to mark areas on maps in response to questions. We collected over 1200 pages of transcribed interviewee responses, as well as a spatial database of their digitized mapped responses. Confidentially concerns of the TRTFN and the members who agreed to be interviewed limits the specific interview responses provided here. The interviews provided information for the development of the focal species habitat models, and summaries of some of the TIEK related to these models is provided in Appendix A: Focal species models.

3.3.2 BC Government Information

In 2001, the BC provincial government released a document summarizing existing ecological, cultural, socio-economic, and resource use information for the region (Horn & Tamblyn 2001). We have used the information contained in this document to supplement our own information collection efforts.

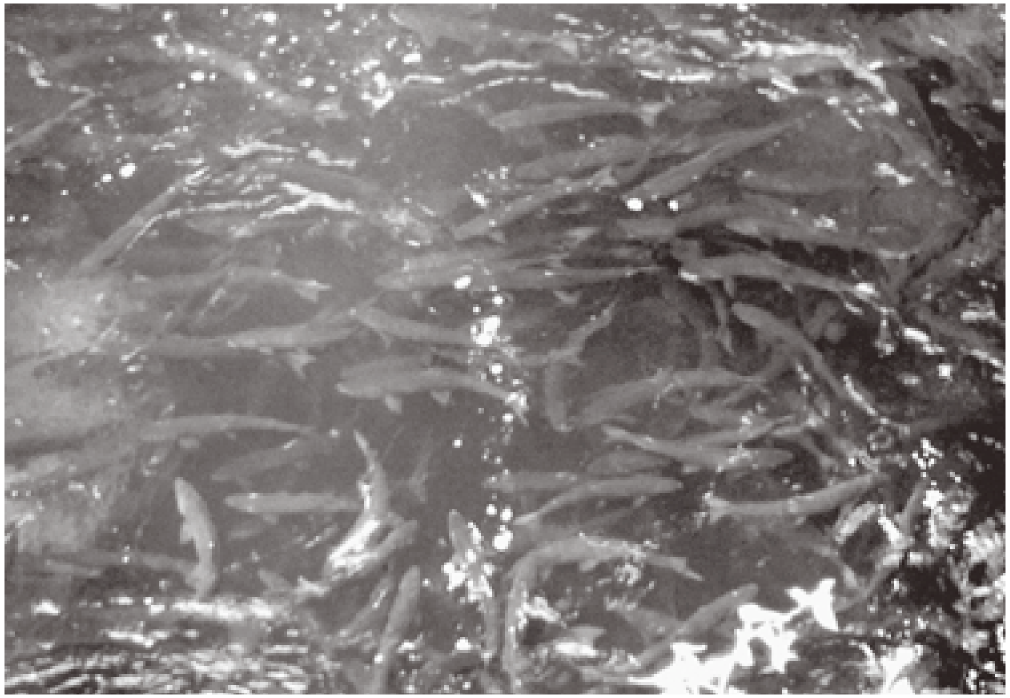
The BC government also initiated several radio-telemetry wildlife projects in late 1999, in conjunction with the proposed Tulsequah Chief mine and road project. These wildlife studies were established along the proposed road route and surrounding areas to assist in documenting the potential effects of the proposed project on key wildlife species, including woodland caribou, moose, mountain goat, stone sheep and grizzly bear. Few of these data or associated analyses have been released or made available to the TRTFN. A limited number of relocations were released, encompassing the first five – nine months of the wildlife studies. We used these limited data to assist in habitat model validation.

3.3.3 Local Atlin Resident Ecological Knowledge Interviews

In addition to interviews with TRTFN citizens, interviews of other wildlife knowledgeable Atlin residents were initiated during the winter of 2001/02. These standardized interviews are similar to the TIEK interviews, though narrower in scope. TRTFN staff suggested interviewees, and assisted in the interview process. There were 37 questions in the questions set. Semi-structured interviews were conducted and recorded on audiocassettes. Interviewees were encouraged to mark areas on maps in response to set questions. The local ecological knowledge has been used to corroborate and complement the TIEK, and has been incorporated into the habitat mapping efforts. Again, confidentially concerns limit the presentation of these data.

3.3.4 Fisheries Information

Of all the ecological systems within the Territory, the most extensive set of data exists for some of the key aquatic ecosystems. As described earlier, the Taku River supports ecologically and economically important Pacific salmon, and this



Salmon in the Silver Salmon River

resource has received substantial scientific and management attention from TRTFN, Canada Dept of Fisheries and Ocean (DFO), and Alaska Dept of Fish and Game (ADFG). We have utilized information from these sources to identify important fisheries values across the Territory. These values include the distribution of each of the five species of Pacific salmon, as well as steelhead and lake trout, and the location of known spawning areas for these species. Much of the available information on salmon and the Taku River watershed is thoroughly summarized and documented through the Take watershed fish-sustainability project.

3.3.5 Spatial Data

The development of the CAD is limited and defined partially by the available spatial (GIS) data that are available for the identification of the various conservation elements. We researched and obtained the best available spatial environmental data available across the Territory. The BC Forest Inventory Project (FIP, 1:20,000) was used to identify vegetation distribution, along with the BC Biogeoclimatic Ecosystem Classification (BEC, 1:250,000) for biogeoclimatic information. The BC Terrain Resource Information Mapping database (TRIM, 1:20,000) was used to identify roads and topography. The BC Watershed Atlas (1:50,000) was the source for data related to rivers and streams, and the Fisheries Information Summary System (FISS) was used to complement TIEK in determining salmonid species distributions and spawning areas.

3.4 Focal Species Analyses

Although conservation planning for all biodiversity is desirable, it would be impossible (and possibly counterproductive) to determine and manage for the ecological needs of every species in a region (Franklin 1993; Poiani et al. 2000). As an alternative, researchers have suggested the identification of a suite of focal species to guide conservation planning (Lambeck 1997; Miller et al. 1998). Focal species are selected such that their protection, as a group, would concurrently protect all or at least most remaining native species. Planning for the maintenance or restoration of healthy populations of multiple focal species can provide a manageable set of objectives for identifying and prioritizing areas, and for determining the necessary size, location and configuration of conservation areas. Focal species monitoring can also be a useful tool in judging the effectiveness of the conservation plan once implemented.

Using a diverse suite of focal species should provide umbrella protection for a broader array of biodiversity than the selection of a single focal species or guild. For example, Kerr (1997) points out that using only carnivores for conservation area selection fails to protect a number of invertebrates. Similarly, an analysis of the umbrella function of grizzly bears in Idaho found that protection of grizzly bears in Idaho would protect 71% of other mammalian species, 67 % percent of birds, and 61 % of amphibians, but only 27 % of native reptiles (Noss 1996). It is now generally accepted that a suite of focal species should be selected, and these species-specific analyses combined with other approaches, such as coarse-filter representation analyses and special elements filters (Margules et al. 2002; Noss et al. 1999; Poiani et al. 2000; Reyers et al. 2002).

3.4.1 Focal Species Selection

Given the central role of focal species planning to current landscape planning efforts, much thought has gone into providing guidance to focal species selection. Below, some key characteristics that are broadly used in focal species selection are discussed.

- Keystone Species are those that play a disproportionately large role (relative to numerical abundance or biomass) in ecosystem function (Collen & Gibson 2001; Miller et al. 1999; Mills et al. 1993; Power et al. 1996). The influences of keystone species can occur through a variety of interactions and processes including competition, mutualism, dispersal, pollination, disease and by modifying habitats and abiotic factors. The loss of keystone species can trigger changes in relative abundance and distribution (including local extinction) of many other species present in an ecosystem (Berger et al. 2001; Rosell & Parker 1996; Soulé et al. 2003; Terborgh et al. 1999). In the TRTFN Territory, Pacific salmon are considered a keystone species guild, as the loss of salmon would dramatically affect multiple trophic levels and the overall productivity, viability, and biodiversity of the region.

- Umbrella species are those that require significant conservation protection, such that successful maintenance of umbrella species requirements will ensure the conservation of many other native species. Umbrella species typically have large area requirements and cover large areas in their daily or seasonal movements, and/or require a diversity of habitats to meet their life requisites (Caro 2003; Carroll et al. 2001; Lambeck 1997; Noss et al. 1996). In general, an umbrella species approach is suited to answering the questions of how much land is necessary in a conservation area network and how that land should be configured. For the TRTFN Territory, we have selected grizzly bear, moose and woodland caribou as umbrella species due to their wide space requirements and diverse habitat requirements.

Species of special management concern are categorized as such due to their current population status (e.g., rare or declining), or social or cultural importance (harvested species, sacred species). Species that are naturally rare may be inherently sensitive to landscape changes that may alter their productivity, at levels of landscape change that would not cause notable changes in other, more abundant or resilient species. Species that are declining or have declined to low densities will also be highly susceptible to any additional stresses placed on their populations and productivity, and will generally have low resiliency to landscape changes. Similarly, harvested species are already likely under population pressure due to potential increased mortality above natural background levels, and potentially from shifts in age and class structure that often occur when humans target certain types of animals for harvest (e.g., prime adult males). These species, similar to rare or declining species, will likely have reduced resiliency to habitat and landscape changes, particularly those changes that may increase their susceptibility to harvest or reduce their productivity. All of our 13 (five wildlife and six salmonid) focal species are considered species of special management concern, due to historic or present harvests and special cultural and social importance to the TRTFN people.

The development of the TRTFN CAD relies upon a foundation of fish and wildlife focal species that best represent umbrella, keystone, sensitive and culturally important species of the Territory. We used five terrestrial wildlife species: grizzly bear, moose, woodland caribou, mountain sheep and mountain goat. Additionally, six species of freshwater salmonids were utilized, the five anadromous species (sockeye, Chinook, chum, coho, pink) and steelhead.

3.4.2 Aquatic Focal Species

All six of the salmonid species occur in the Taku River watershed, while Chinook, coho and sockeye are found in the Whiting River. Chinook salmon are also found in the Teslin, Jennings, Gladys, and Swift River watersheds of the upper Yukon River.

We used a compilation of data sources to define the known distribution of these focal aquatic species across the Territory, including the Fisheries Information Summary System (FISS), TRTFN field surveys and TRTFN traditional and indigenous knowledge collected during formal interviews (see Section 3.3.1), as well TIEK compiled within existing TRTFN fisheries databases. The FISS database did not specifically identify spawning areas, whereas the other available data sources did. To complement the existing spawning areas data, we modeled areas of potential spawning habitat. These areas were classified as the upper 2 kilometers of mapped salmon distribution from the FISS database, as well as any tributary stream that intersects this zone, up to approximately 2 kilometers of stream reach on each of these intersecting streams.

3.4.3 Terrestrial Focal Species

We developed coarse-scale habitat suitability models allows an evaluation of the relative importance of different habitats for each focal species across the Territory. Model development methods are described in Appendix A, and are only briefly summarized here. Based on seasonal habitat use of the species, the habitat suitability models prioritize certain ecological community types on a seasonal and annual basis. The models predict current habitat suitability, and do not predict actual or potential habitat capacity or occupancy. Additionally, the models indicate habitat potential, and do not indicate species presence or relative population densities; in fact, many of the predicted potential habitats may not currently support populations. Where historic and/or current species distribution information was available, we modeled habitat suitability only within these distribution extents.

To determine habitat relations of each species, we first collected existing data and habitat models for each species. As discussed elsewhere, limited standardized data exist for species in the region, and existing radio-telemetry data from Provincial studies in the Territory were generally unavailable. Semi-standardized interviews with TRTFN elders and hunters provided information on the seasonal habitat relations of each of these species (see Section 3.1.1), and this was used as the primary information for the development of the models. This information was supplemented with general seasonal habitat relations from the scientific literature, and to a limited extent, coarse-scale Provincial habitat models, which helped to define general distributional limits and geographic patterns in habitat quality of some species.

We translated habitat relations, as described primarily by the TIEK, into predicted preferred habitats based on vegetative cover, slope, aspect, elevation, and hydrology using GIS algorithms. Given the coarse-scale nature of the available spatial data, resulting models provide only general predictive measures of habitat suitability. Seasonal models were developed for each focal species; season definitions were based on the ecology of the species and our ability to model changes in seasonal habitat use. Relative habitat suitability was identified through a rank scoring, with lower ranks indicating lower predicted habitat suitability. Annual habitat suitability was predicted based on the sum of seasonal habitat scores.

We conducted preliminary validation of the seasonal and annual models using the limited radio-telemetry data obtained from the BC government. Each draft habitat model was peer-reviewed by between two and four species specialists with knowledge and experience in northern BC and the Yukon. Additionally, TRTFN citizens were provided drafts of the modeling effort for comments, and an Atlin non-native resident with extensive wildlife experience provided review and comments on each of the draft models. Reviewer comments and suggestions have been incorporated into the models, as feasible.

The annual predicted habitat values were used in the CAD site selection analyses, and representation of both predicted seasonal and annual habitats were calculated for proposed the proposed CAD.

3.5 Ecosystem Representation Analysis

The objective of the coarse filter or ecosystem representation analysis is to identify and protect intact examples of each vegetation or habitat type in a region. This generally equates to the protection of ecosystems rather than focusing on any individual species (Kintsch & Urban 2002; Margules et al. 2002; Noss et al. 1999; Sarkar & Margules 2002; Sierra et al. 2002). The assumption with this approach is that if ecological communities or ecosystems remain intact and well-distributed, so, presumably, will populations of species that depend on these communities. A further assumption, often implicit, is that gradients in species composition parallel gradients in physical variables or vegetation types, which reflect environmental gradients and are surrogates for biodiversity (Noss et al. 1999). Coarse-filter approaches have wide appeal because they tend to protect a large fraction of biodiversity and are relatively easy to carry out. Many hundreds of species of yet unknown bacteria, fungi, invertebrates, and plants reside in northwestern BC, particularly in the soil or forest canopy; there is little hope for a comprehensive examination of all these species. Large-scale approaches at the level of the ecological communities, ecosystems and landscapes are probably the only way to conserve these essential elements of biodiversity (Franklin 1993). A major advantage of using a coarse-filter approach is that vegetation and habitat data are widely available and are relatively easy to obtain and map, as compared with demographic and autecological information on a particular focal species or suite of focal species.

Table 2. The Forest Inventory Project 'Growth Group' types were used to provide a classification of forest species groups. There were 10 growth type groups in the Territory. These were then further divided based on biogeoclimatic variables, topographic features and age classes.

FOREST GROUPING	LEADING SPECIES	SECONDARY SPECIES	AREA (HA)
Aspen-Deciduous	Aspen	Any deciduous species	32,994
Aspen-Coniferous	Aspen	Any conifer species	59,686
Hemlock	Hemlock	Any species	15,710
True Fir	True Fir	Any species	582,457
Spruce/Mixed spruce	Spruce	Any spruce species	555,211
Spruce/Lodgepole	Spruce	Lodgepole, deciduous	100,646
Spruce/Mixed Conifer	Spruce	True fir, hemlock	117,560
Pure lodgepole pine	Lodgepole	None	166,791
Lodgepole/Mixed conifer	Lodgepole	Any other conifer species	697,066

We predicted the occurrence and distribution of ecological communities through the development of an ecological landscape unit (ELU) model. This model uses biogeoclimatic classification (BEC), vegetative cover, forest age class, and topographic variables to predict unique ecological communities. Forested and non-forested vegetation types were classified were based on the BC Forest Inventory Project (FIP, 1:20,000). We used the FIP 'growth type group' classification to identify forest communities, and expanded this classification to include the additional forest types included in the existing classification. The growth type group classification uses the first two leading forest species to identify forest types; 10 forest cover type groups are classified in the Territory (Table 2). Non-forested vegetation was identified using FIP to class open alpine communities, as well early seral stages of grass or shrub communities. Non-vegetated classes included a glacier/ice class and open water (lakes). The forest groupings were further divided based on the projected forest age class into three age classes: young (projected forest age <80 years), mature (projected age 81-140 years old), and old (projected age >140 years). Ecological communities were classified as either on warm southerly aspects (120°-240°) or cool, northerly aspects (240°-120°). Finally, elevation, climatic and coastal influences were captured through divisions based on BEC zones, of which there are seven zones in the study area (Map 2).

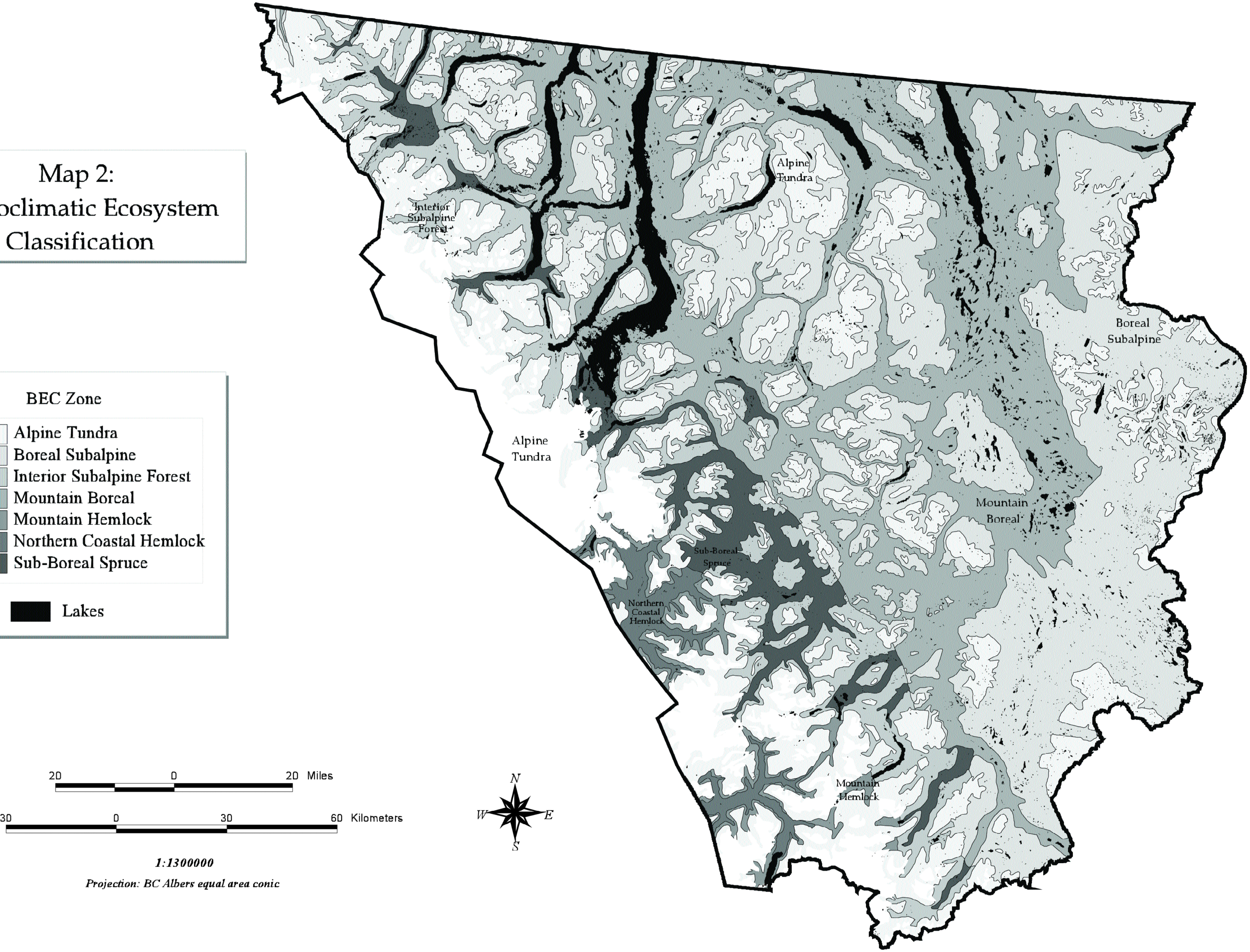
The use of data of different resolutions creates potential errors in the ecological community definitions. For example, the BEC zone data is at a scale of 1:250,000, while the forest cover has a resolution of 1:20,000. Therefore, caution must be inherent when evaluating the predicted communities, particularly those that may be predicted to be rare, as these could be the result of regions of misaligned polygon boundaries. We have conducted preliminary checking of predicted rare communities to ensure that we have minimized these potential errors as is feasible.

3.6 Special Elements

Special elements are sites that are deemed important for conservation, and typically include such elements as rare species occurrences or critical habitats, and endangered or critical ecosystems. The special element approach to conservation involves locating, mapping, and protecting individual occurrences of imperiled species or other areas of concentrated conservation value (Noss et al. 2002; Noss et al. 1999)

Special elements included occurrences were compiled by the Conservation Data Centre, by TRTFN Natural Resources Dept. and RRCS from a variety of data sources, including field surveys. Even compiling multiple sources of special elements, there are few data points for the ecological phenomena in the study area. Due to the scarcity of data, we used special element analyses only in a limited extent to check the representation of these elements in the potential conservation area design scenarios. The special elements compiled for representation analyses included

Map 2: Biogeoclimatic Ecosystem Classification



occurrences of rare plants and animals, the documented nesting locations of sensitive species such as bald eagles, trumpeter swans, and osprey; the lakes supporting lake trout; and wetlands.

3.7 Site Selection Procedures

One goal in the development of a conservation areas design is to effectively minimize the "costs" of conservation through minimizing the area needed to meet conservation goals. Software packages such as SITES and MARXAM have been developed for organizations such as The Nature Conservancy; these software packages use spatially-explicit optimization procedures to potentially increase the "efficiency" of the conservation site selection process. Presently, the most commonly used optimization procedure (provided in SITES and MARXAM) is a simulated annealing process which iteratively selects and discards sites to identify the set of sites that achieves the prescribed goals with a high level of efficiently (Csuti et al. 1997; Pressey et al. 1996). SITES, related software and the simulated annealing procedure have received criticism for the lack of identifying the true optimal solution, and for sensitivity to potentially arbitrary selection of parameters by the user that can strongly influence the resulting site selections. Still, the use of optimization processes has proved valuable to increase the efficient selection of sites that represent high conservation value across a diversity of targets and goals. These procedures are recommended by Noss (2003), and are widely used in conservation area design efforts, including by The Nature Conservancy, the Nature Conservancy Canada, The Wildlands Project and the Coast Information Team.

We used the SITES software package, which was developed for The Nature Conservancy in 1999, to assist us in designing and analyzing alternative site selection scenarios. The SITES program works as a utility of the ArcView software. Goals for the representation of various conservation elements (e.g., focal species habitats or ecological communities) are user-defined. Through simulated annealing iterations, SITES attempts to meet the established goals while minimizing the cost required. The total cost of the site selection is calculated according to the following simple formula:

Cost = Area + Species Penalty + Boundary Length

Where Cost is the objective (to be minimized), Area is the number of hectares in all planning units selected for the portfolio, Species Penalty is a cost imposed for failing to meet target goals, and Boundary Length is a cost determined by the total boundary length of the portfolio. Attempting to minimize the boundary length (or edge) of the selected areas forces the solutions to clump selected areas; higher boundary length values tend to select a few larger areas rather than many smaller areas.

Alternative scenarios can be evaluated by varying the inputs. For example, the goals for various elements (e.g., focal species or ecological communities) can be varied; and the boundary length cost factor can be increased or decreased depending on the assumed importance of a spatially compact portfolio of sites. Possible SITES scenario building exercises might include varying the target goals to assess different levels of risk to the conservation strategies, from one that embraces high certainty by way of high targets to portfolios that may represent high ecological risk by setting lower targets. More information about the SITES tool can be found by visiting the following website: http://www.biogeog.ucsb.edu/projects/tnc/toolbox.html.

3.7.1 SITES Parameters

Several factors besides the number and type of targets used influence SITES outcomes. These include the spatial extent of the analyses units or planning areas, type of planning units, planning unit cost measure, penalty applied for failure to meet target goals ('species penalty factor'), penalty applied for dispersed rather than clustered planning units in results ('boundary length modifier'), and the number of repeat runs of the algorithm (and number of iterations within each run)

3.7.1.1 Spatial stratification

To ensure that the selected sites, and thus the habitats for each species, were well distributed across the region, we divided the Territory into three ecologically distinctive planning areas (Figure 1), based on the three major watersheds of the region. These regions are defined by the Teslin watershed along the northeast portion of the study (998,287 ha), the Atlin Lake/Tagish Lake watersheds (1,133,634 ha), and the Taku River/Whiting River watersheds (1,818,552 ha). This stratification, while approximately equal in size, also represents broad ecological values across the study region. The Taku and Whiting Rivers support the primary salmon supporting watersheds. The Atlin Lake/Tagish Lake watersheds drain into the Yukon River watershed, and are

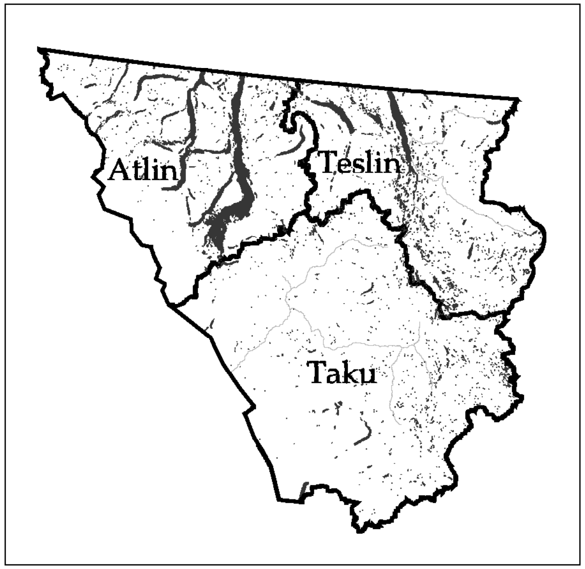


Figure 1. To assure that conservation elements were well represented across the Territory, site selection goals were set for each of three stratified areas, based on the three major watersheds.

strongly influenced by the coastal mountain ranges, while the Teslin headwaters to the Yukon represent an interior boreal system with strong artic influences. Stratification of goals across these primary watersheds assures that the diverse ecological values represented within each region are independently represented, without being potentially over-shadowed by prominent values elsewhere in the Territory.

3.7.1.2 Planning Units

We used 200 ha hexagons to create uniform sized planning units that avoid area-related bias, and to minimize the edge-area ratio by approximating a circle (minimal edge:area ratio).

3.7.1.3 Impacts Layer

In addition to the goal of minimizing the total cost of conservation through efficient area selection and reduction of the edge to area ratio, some scenarios also imposed a cost based on existing impacts to habitats. These impacts are identified as existing human developments including urban areas, residential areas, camps, mining areas, roads, and trails (Map 1). While these existing impacted areas are limited, they represent not only potential present impacts, but also indicate regions where continued development, use and resource extraction are likely to occur. Thus, these areas may have experienced or may experience reduced habitat effectiveness for many wildlife species.

We used TRIM cultural features and roads to identify impacts and placed a 200m buffer around these features, thus accounting for both the direct habitat loss, as well as a level of displacement and indirect impacts. Overlapping areas were not penalized differently (i.e. overlaps were only counted once).

To account for planning units with relatively little vegetated area (and consequently little developable area and little productive habitat) we used the following suitability index:

Cost Index = Planning Unit Area + (Planning Unit Area * Human Impacted Area / Potential Vegetated Area)

with all areas measured in hectares. Potential Vegetated Area was calculated as the sum of vegetated habitat plus the sum of urban areas. This assumes that existing development took place on formerly vegetated habitat areas. Note that this calculation omits bare rock, glacier and lake areas.

With this index applied, planning units with no human impacted area were given a cost of 200ha, while those having all potential vegetated area impacted had a cost of 400ha and partially impacted planning units had cost between 200 and 400ha. Because the SITES algorithm seeks to minimize total portfolio cost, it selects planning units with low cost unless higher cost planning units contain targets that cannot be found elsewhere.

3.7.1.4 Number of intermediate solutions and iterations

The final site selection scenario provided by the SITES simulated annealing process is based upon replicating the selection process multiple times and calculating from these solutions the “best run” that most efficiently meets goals. Within each selection process, individual planning units are iteratively selected or rejected a set number of times (or iterations). Each of our site selection scenarios is based upon 100 intermediate solutions, and each of these is produced using one million iterations of planning unit selection.

3.7.1.5 Species Penalty Factor

We used the same penalty factor (one) for all targets.

3.7.1.6 Boundary Length Modifiers

We used boundary length modifier of 0.0001. In trial runs, this value appeared to balance the requirements for large, contiguous with the select planning units with high conservation value.

Sheslay River

3.7.2 Targets and Goals

The site selection procedures are driven by the goals set for representation of the ecological values of the Territory, as described by the focal species and ecological community models. We created several potential conservation area designs by varying the level of representation between 20 and 80% of either the habitat values for the focal species or the area of the ecological community. Representation targets were set for each of the three stratified regions in the study area. Thus, a target of 30% would attempt to represent 30% of the area of each ecological community, or 30% of the total habitat value for each focal species within each of the three regions.

The predicted habitat value for a focal species was based on the habitat scores in the annual habitat models (see Appendix A). The habitat modeling was conducted using a grid representation of the Territory, with 50 sq. m. cells; cells were attributed with the annual habitat score for each species, and the sum total of all of the scores (e.g. across all the cells) for a species in a stratified region represented the total value of a focal species habitat (in the region). The sum of the habitat values for a focal species within a 200 ha planning unit represented the habitat value for that focal species within the planning unit. In the site selection process, goals were based on capturing a set percent of the total habitat value within each of the three stratified regions. This technique favors the selection of planning units with high habitat values, as the analyses attempts to minimize the total amount of area needed to meet the target goals. While favoring the selection of highest value habitats, lower quality habitats also contributed towards meeting the habitat goals for each species. Thus, this enabled optimization of areas to meet multiple species targets, even if some areas represented high quality for one species and only low or moderate quality for other focal species. Aquatic focal species were included in the analyses by "locking in" the known or predicted spawning areas for each of the six river salmonids (steelhead, sockeye salmon, Chinook salmon, coho salmon, chum salmon, pink salmon).

The simulated annealing algorithm provided in the SITES program was used to identify scenarios that efficiently achieved a diversity of representation goals. The spatial configuration of a scenario is influenced by the target goals, as well as the incorporation of additional costs associated with anthropogenic impacts. As described above, we varied the target goals across potential scenarios, with goals varying between 20 and 80% of the habitat values for the focal species and the area of the ecological community. We approached the simulations in two different ways. One series of simulations varied only focal species targets between 20% and 80%, in 10% increments, but kept ecological community representation goals at 30% across the 7 scenarios.

We also ran a set of simulations with goals varying between 20% and 80% (in 10% increments) for focal species and ecological communities simultaneously. While this produced another seven potential designs, the design with 30% representation was practically identical to the 30% focal species run described in the above paragraph, so we removed this replicate output.

One set of each type of goal scenario was created without consideration of potential anthropogenic impacts in the study area. This is justified given the relatively unimpacted condition of the study area, and that most roads within the study area (with obvious exceptions) are old, un-maintained mine roads that have limited use during most of the year. Another set of scenarios was produced using the impact layer as an additional cost factor in the site selection simulations. Therefore, a total of four different simulations types were completed, each producing six or seven site selection scenarios:

1. Variable focal species goals (20-80%), with ecological community 30% (total of seven designs); referred to a VFS No Impact scenarios

2. Variable focal species targets (20-80%), with ecological community 30% and impact costs included (total of seven designs); referred to a VFS Impact scenarios

3. Focal species and ecological community representation combined (20-80%, six designs); referred to as VFS-ELU No Impact scenarios

4. Focal species and ecological community representation with impact costs included (20-80%, six designs); referred to as VFS-ELU Impact scenarios.

While each scenario includes the actual selection of areas or sites to meet the defined representation goals, additional information is provided by the SITES output. As described in Section 3.7.1, each SITES simulated annealing site selection is actually the combined result of 100 independent solutions (each of which is optimized based upon 1 million iterations of the simulated annealing process). Thus, in addition to the actual selection of sites, the final output also includes a "summed solution score" for each planning unit that ranges between 0 – 100, indicating how many times that planning unit was selected in the 100 intermediate solutions. Compared to the "in or out" site selection output, this score provides a more detail about the potential importance of any planning unit in meeting conservation goals.

3.8 Core Area Analyses

We used the summed solution score from each of the 26 scenarios (see above) to provide a measure of ecological or conservation irreplaceability (Noss et al. 2002) for each planning unit. The scores across the 26 site selection scenarios were summed for all the planning units in the Territory, creating a total summed solution score. These values ranged from 0 – 2600, with a score of 2600 representing a planning unit that was selected in every solution (i.e., 2600 interim solutions). We normalized the value range to 0-100, with 100 representing 100% selection. These became our index of relative conservation value.

We transformed the conservation values index into a spatially-explicit density of conservation values across the Territory, with the conservation value density of each planning unit represented by its conservation value index (0 -100). Defining the conservation value index as conservation densities allows us to utilize spatial density estimators to identify areas representing high levels of conservation value. We used the kernel density estimator available in the Animal Movement extension (Hooge et al. 1999) for ArcView. To take advantage of the kernel estimator, we transformed the planning unit conservation index values to points, with the number of points equal to the conservation index in each planning unit. We used kernel density analyses to calculate the conservation density (as represented by this point density) of each planning unit, and to create a suite of isopleths representing identified percentages of total conservation value. We reduced the default smoothing factor in the kernel density estimator to increase the sensitivity of the isopleth configuration to the value density; this created less "smoothed" isopleths that were more accurately defined by the spatial distribution of high conservation value areas.

We used the boundaries identified by the isopleths to evaluate potential core areas. We calculated the representation of focal species habitat values and ecological communities, as well as the amount of area within each conservation density isopleth. The proposed core areas were selected based on the conservation density level that provided both adequate representation and relative area efficiency. We removed polygons smaller than 0.1% of the total core area, these small patches represented less than 2% of the original area of the potential portfolio and were too small to represent functional cores.

3.9 Regional Connectivity Analyses

Explicit consideration of connectivity is required when considering large study areas that will likely support multiple core conservation areas. Maintenance of ecological linkages is critical the long term viability of all species, as well as key ecological processes. The value of connectivity is reviewed in several publications (e.g., Andreassen et al. 1995; Beier & Noss 1998; Collinge 1996). We represented regional connectivity through predictions of potential movement paths or movement corridors for grizzly bear across the Territory. Grizzly bears and other wide-ranging species make ideal umbrella species for analyses of connectivity, as their daily and seasonal movements can be long and cover diverse landscapes.

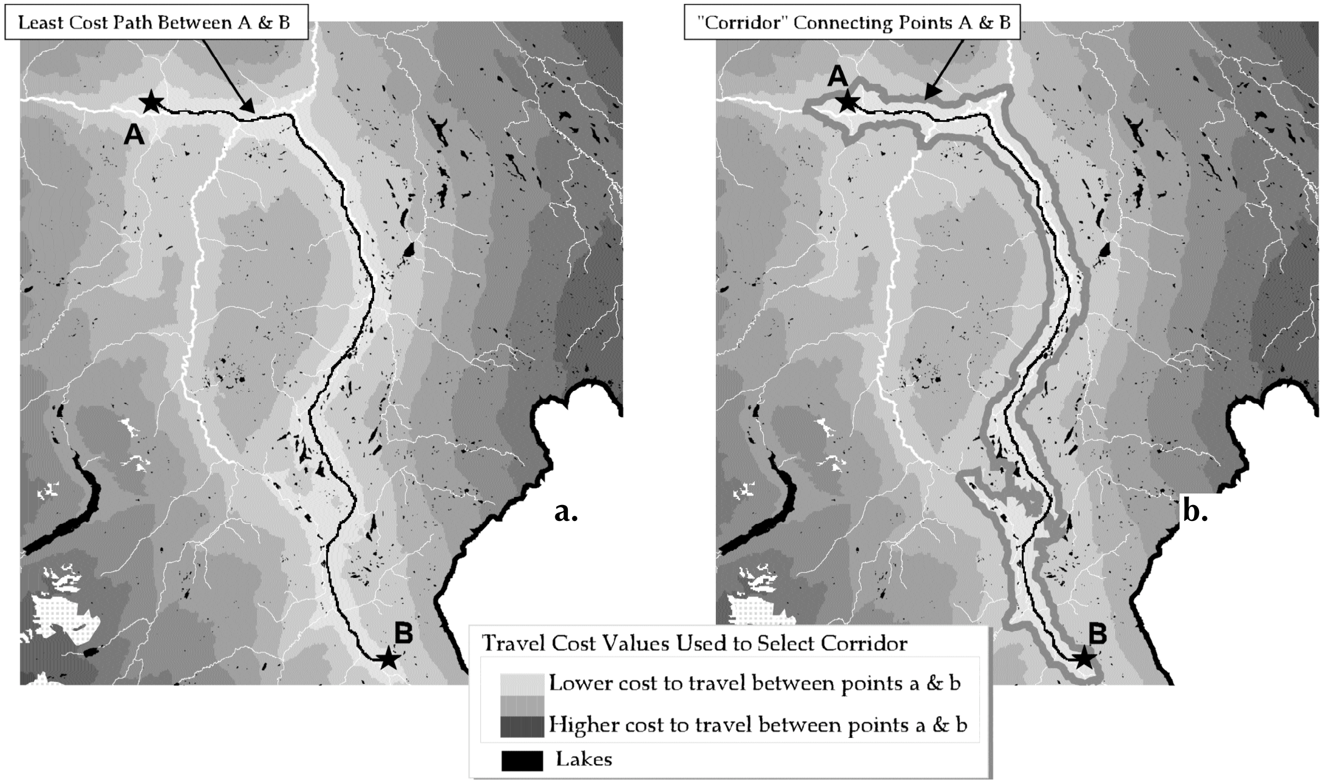


Figure 2. Least-cost paths were used to identify thresholds in corridor costs. The highest cost accepted by a path was initially identified (a), and the corridor cost values that were less than or equal to this value were identified and defined as the potential linkage habitats (b).

3.9.1 Least-Cost Path Modeling

We used a least-cost path modeling approach, using a combination of ArcInfo Grid commands, including 'path distance', 'cost-path', and 'corridor'. Potential movement paths or corridors were modeled as most cost-effective route connecting two points. The cost of movement was modeled as a combination of total distance (horizontal movement distance), habitat values and topography. Obviously, shorter distances were preferred, but this was moderated by a preference for higher quality habitats (as predicted by the grizzly bear habitat suitability model) and the cost of traversing across steep topography.

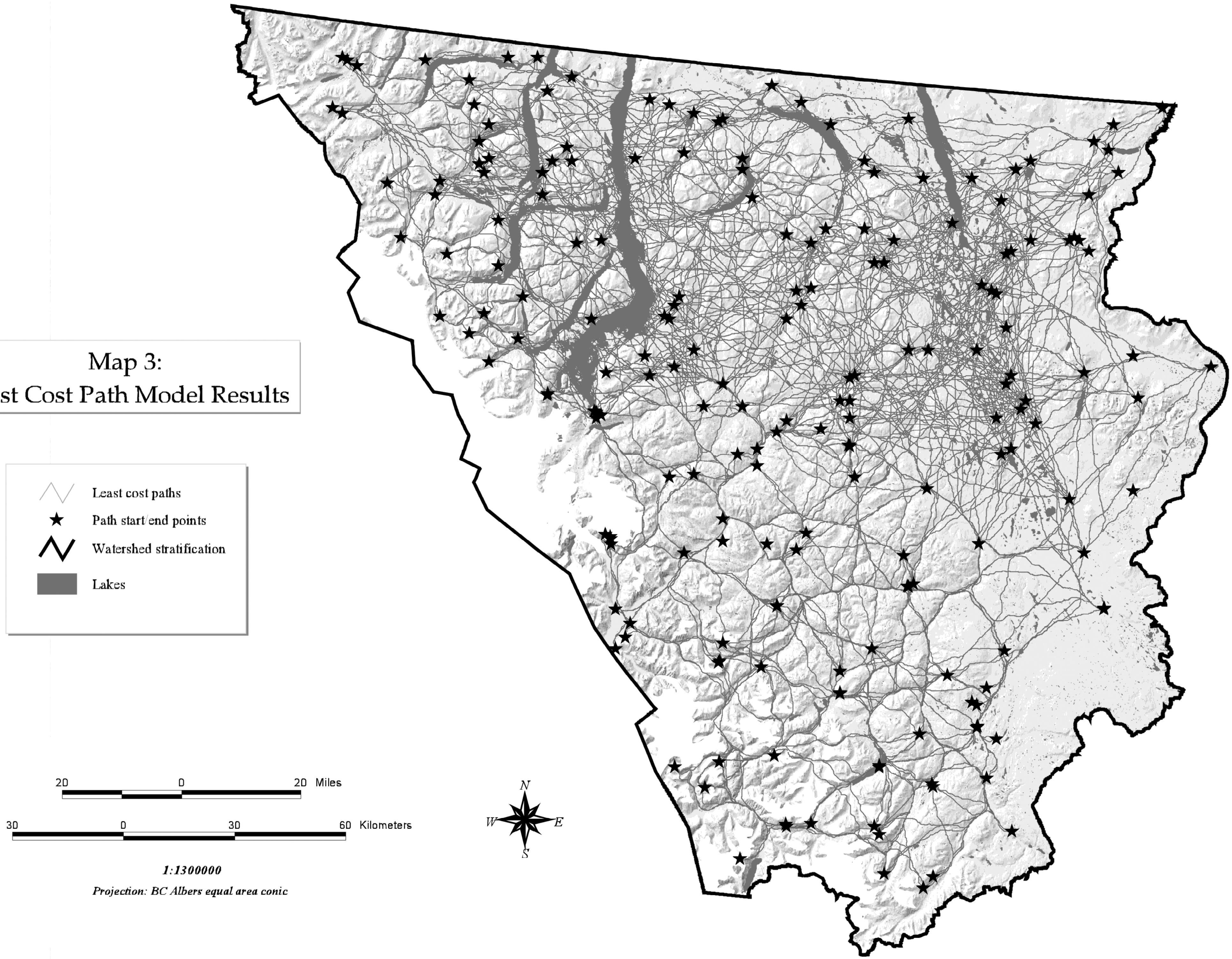
Movements uphill were more costly, and this increase in cost was defined through a cosine-secant function, with a weighting factor of three. The weighting acknowledges that topographic considerations are important in movement decisions; animals will likely minimize using steep slopes if there exists an efficient alternative. The topographic costs and the cost associated with habitat quality are combined with Euclidean distance and horizontal distance to create the final path cost surface or grid, specific to a location on the landscape. This path distance cost grid determines the movement decisions of paths originating from this location.

A total of 203 points within potential core areas were randomly selected from each of the three watershed strata, and path cost grids were created for each. Least-cost paths between subsets of these random points were calculated through a series of modeling iterations using 9 to 15 randomly selected points. We did not create paths between all random points (which would create 41,006 paths). Our iterations created a total of 2,320 least-cost path predictions across the study area. Subsequently, we filled in regional "gaps" in these data by selecting an additional 30 points, and running two modeling iterations of 15 points each, for an additional 240 paths. Our total number of paths generated across the study area is 2,564 (Map 3). Each path is identified as single string of cells in the path cost grid connecting two points in the landscape.

3.9.2 Connectivity Area Analyses

To identify the landscape connectivity associated with these least-cost paths, we combined path cost surfaces between pairs of points connected by the least-cost path modeling. From these corridor cost surfaces, we defined a threshold cost value using the highest cost accepted by the least-cost paths connecting two points (Figure 2a). The potential corridors between the two points was defined by selecting grid cells with cost values that were less than or equal to this threshold value; these areas identified linkage habitats of relatively low movement costs (Figure 2b)

Map 3: Least Cost Path Model Results

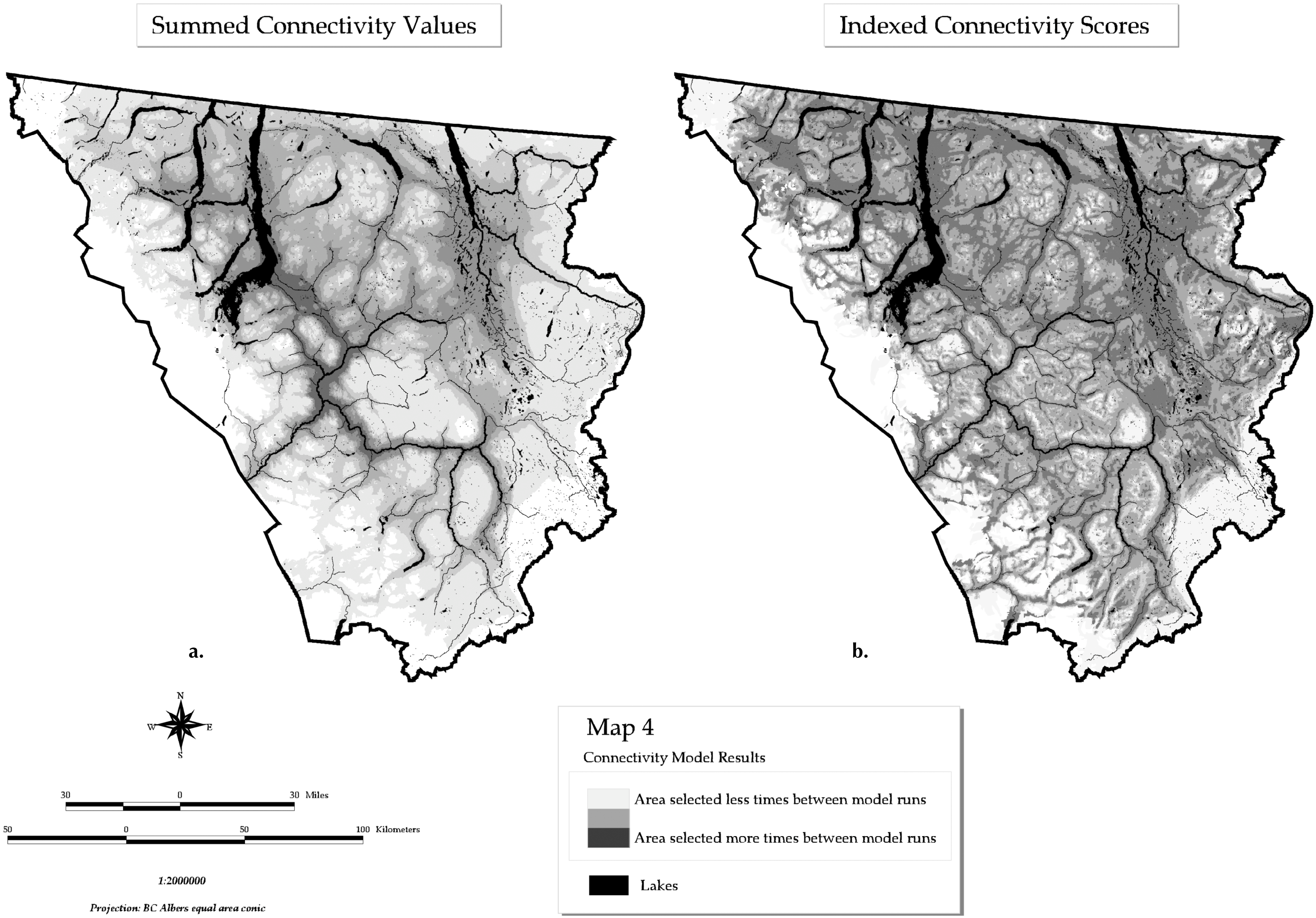


Repeating this for all connected points, we created 2,564 predicted landscape corridors, each identified in a binary (1=corridor) grid. We combined all grids to create a summed connectivity value surface for the study area, with cell values representing the number of overlapping corridors (Map 4a). Because sampling intensity varied across the study area, we used a four km2 moving window to standardize values to range between zero and one by dividing the score of each cell by the maximum cell value in the four sq km window. This provided a connectivity index score standardized to the local region for evaluating connectivity values across the Territory (Map 4b).

Because index values representing effective connectivity varied across the study area and was influenced by topography, we stratified the selection of connectivity values by major watershed (Atlin, Teslin, Taku). Within each watershed, we queried the connectivity values to select three value thresholds that represented increasing levels of connectivity across the watershed. We then selected connectivity values at or above the identified threshold value that were either adjacent to identified core areas, or connected to a core area by connectivity values greater or equal to the established threshold value.

For each threshold value, we evaluated the effectiveness of the selected connectivity scenarios in creating a connected network of core areas. This assessment included calculating the number of isolated core areas in the study area at each of the three connectivity threshold levels. Ideally, the connectivity scenario would link all core areas to create a single, connected set. Obviously, we could maintain a completely connected set of cores if we selected all the matrix habitats in between the cores. To evaluate the relative "cost" of each set of potential connectivity scenario, we calculated the total area encompassed by the potential scenario (core and connectivity area). Increasing total area indicates increasing "cost" of the conservation solution, if cost is measured in amount of land managed for biodiversity maintenance.

Woodland Caribou


Summed Connectivity Values
Indexed Connectivity Scores
a.
b.
N
W
E
S
30
0
30 Miles
50
0
50
100 Kilometers
1:2000000
Projection: BC Albers equal area conic
Map 4
Connectivity Model Results
Area selected less times between model runs
Area selected more times between model runs
Lakes

4. Results

This chapter presents results of the analyses and modeling efforts that informed the development of the recommended conservation area design, as well as presenting the CAD, itself. Full presentation of some of these analyses is provided in additional Appendixes, as indicated.

4.1 Focal Species Habitat Suitability Models

We developed habitat models for each of the five terrestrial focal species, and conducted preliminary validation of these models using an independent set of radio-telemetry data. All models received peer-review, and feasible changes to the models based on review comments were incorporated into the models. The full model descriptions are provided in Appendix A; limited presentation of the modeling effort is presented below.

4.1.1 Grizzly Bear Habitat Model

The TRTFN TIEK provided consistent descriptions of seasonal grizzly bear habitat. This knowledge coincides well with other information sources on bear habitats and foraging tactics. We developed seasonal submodels for spring, summer and late summer/fall. We have not attempted to incorporate a denning habitat component into the model, as the data on denning characteristics for this region are lacking and incidental information provided through TIEK and local knowledge indicates that a wide diversity of habitats across the Territory are used by grizzly bears for denning.

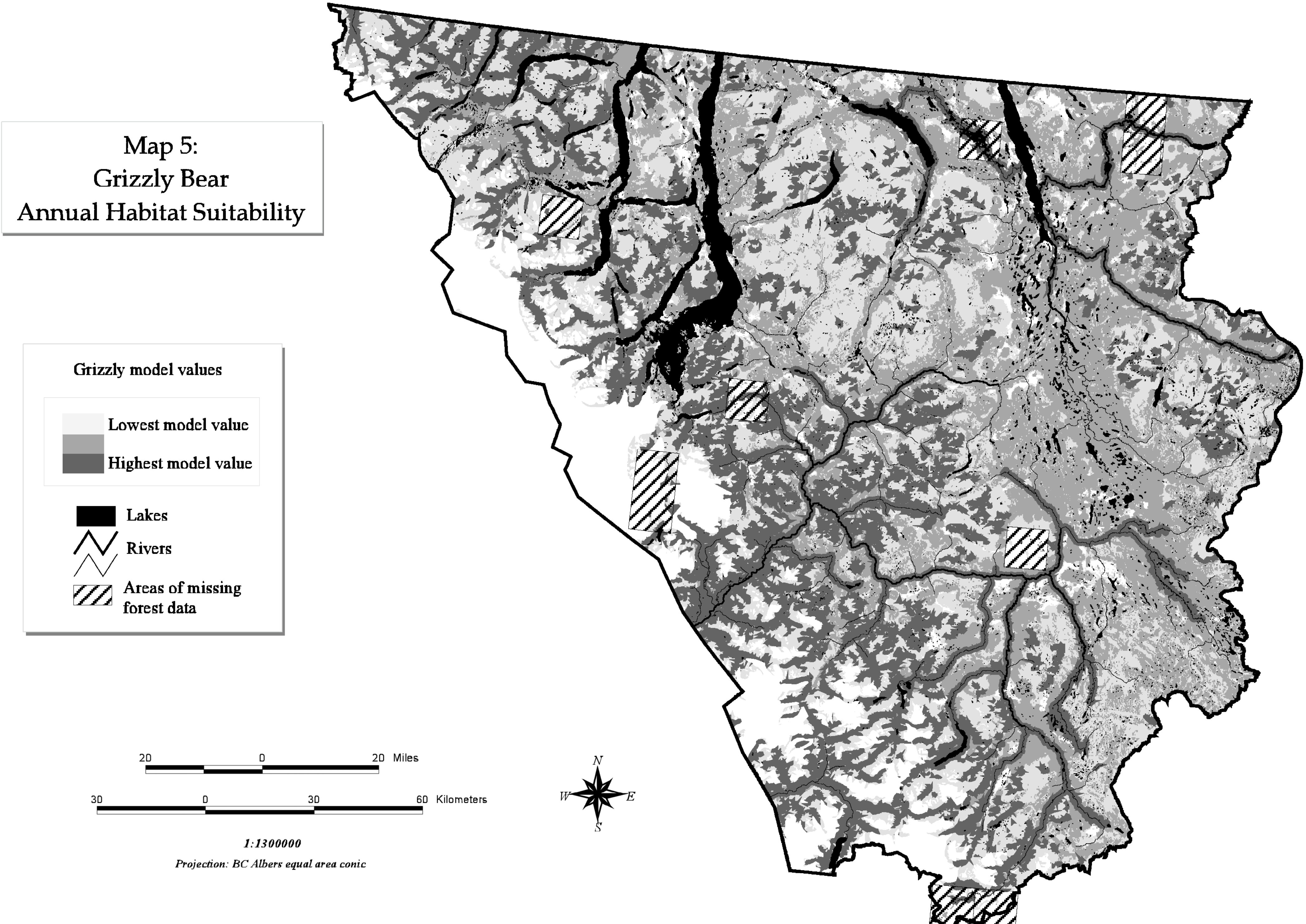
Nakina River Grizzly Bear

The predicted annual habitat suitability is the additive score of the seasonal submodels. The final annual habitat suitability ranks ranged from 0 – 27 (Map 5), and these values were used in the CAD site selection analyses. For validation purposes, we generalized the results of the model outputs by reclassifying the ranked habitats into four categories: nil or low, fair quality, good quality and high quality classifications. The nil or low quality habitats did not meet any of the selected habitat criteria, and so remained unclassified (score = 0). The remaining scores (i.e., scores >0) were divided into three approximately equal-area classes, based on the total amount of classified habitat. The equal-area reclassification resulted in the merging of sequential ranks to divide the predicted habitat into three classes.

Approximately 83% of the Territory is predicted to support grizzly bear habitat. The highest annual habitat suitability values are generally associated with those habitats that have high use across multiple seasons. This includes salmon habitats that support both summer and fall run species, and also includes habitats such as floodplain or riparian habitats that offer a diversity of foods throughout the year. A diversity of warm aspect habitats also are ranked relatively high, as these habitats generally support food plants beginning early in the spring with green up, through late fall berry production.

4.1.2 Woodland Caribou Habitat Model

All information sources indicated that the woodland caribou in the Territory rely primarily upon low-elevation mature pine forests in the winter, and use a range of high elevation alpine and subalpine habitats in the summer. Lichens are the critical winter food source for caribou; because lichen are very slow growing, the highest densities of lichen are associated with older pine forests. In years when snow conditions make cratering or snow removal by caribou difficult or unproductive, the caribou may move to high elevation, open habitats that have been wind-cleared of snow.


Map 5:
Grizzly Bear
Annual Habitat Suitability
Grizzly model values
Lowest model value
Highest model value
Lakes
Rivers
Areas of missing forest data
20 0 20 Miles
30 0 30 60 Kilometers
1:1300000
Projection: BC Albers equal area conic
N
W
E
S

Bull Moose

Our ability to model the seasonal habitats of woodland caribou is limited by our knowledge of seasonal habitat use patterns, the likely variability in those patterns across the Territory and between years, and the availability of applicable environmental GIS data for the region. Caribou distribution is limited in their winter range by snow conditions as well as habitat quality. We used mapping conducted by the Ministry of Environment Lands and Parks (2000) to define the extent of the caribou distribution within the study area. Because of the importance and potential limiting influence of low elevation mature pine forests in the winter, this habitat received additional weight in the habitat suitability model.

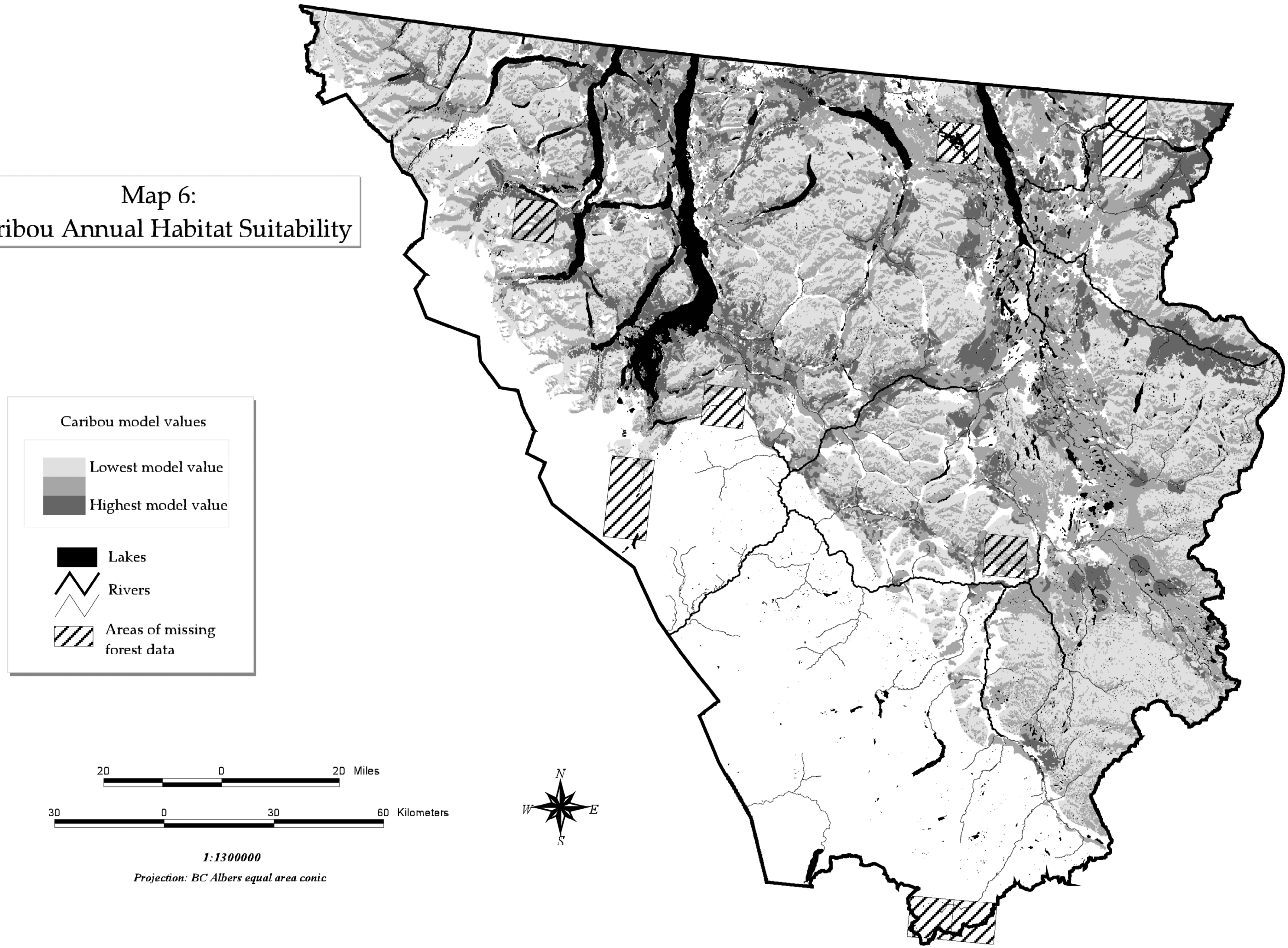
The annual habitat suitability model is the additive score of the two seasonal submodels that were developed for summer and winter. Scores for the annual habitat suitability model ranged from 0 – 12 (Map 6), and these values were used in the CAD site selection analyses. For validation purposes, we generalized the results of the model outputs by reclassifying the ranked habitats into four categories: nil or low, fair quality, good quality and high quality classifications. The nil or low quality habitats did not meet any of the selected habitat criteria, and so remained unclassified (score = 0). The remaining scores (i.e., scores >0) were divided into three approximately equal-area classes, based on the total amount of classified habitat. The equal-area reclassification resulted in the merging of sequential ranks to approximately divide the predicted habitat into three classes.

Approximately 58.6% of the Territory is predicted to support woodland caribou habitat. Approximately 12% of this area is predicted to support high value habitat. The highest value habitats predicted for woodland caribou included low elevation mature pine habitats and adjacent mature forests. Warm aspect alpine and subalpine areas were rated either as of high or good quality for woodland caribou. Approximately 35% of the predicted habitats were rated as fair quality habitat for caribou; these were primarily cooler aspect alpine and subalpine habitats, used primarily in seasons outside of the winter season. While these habitats are important during these seasons, they are extensive across the caribou distribution and likely do not limit the caribou populations, as we have assumed that the winter habitats may.

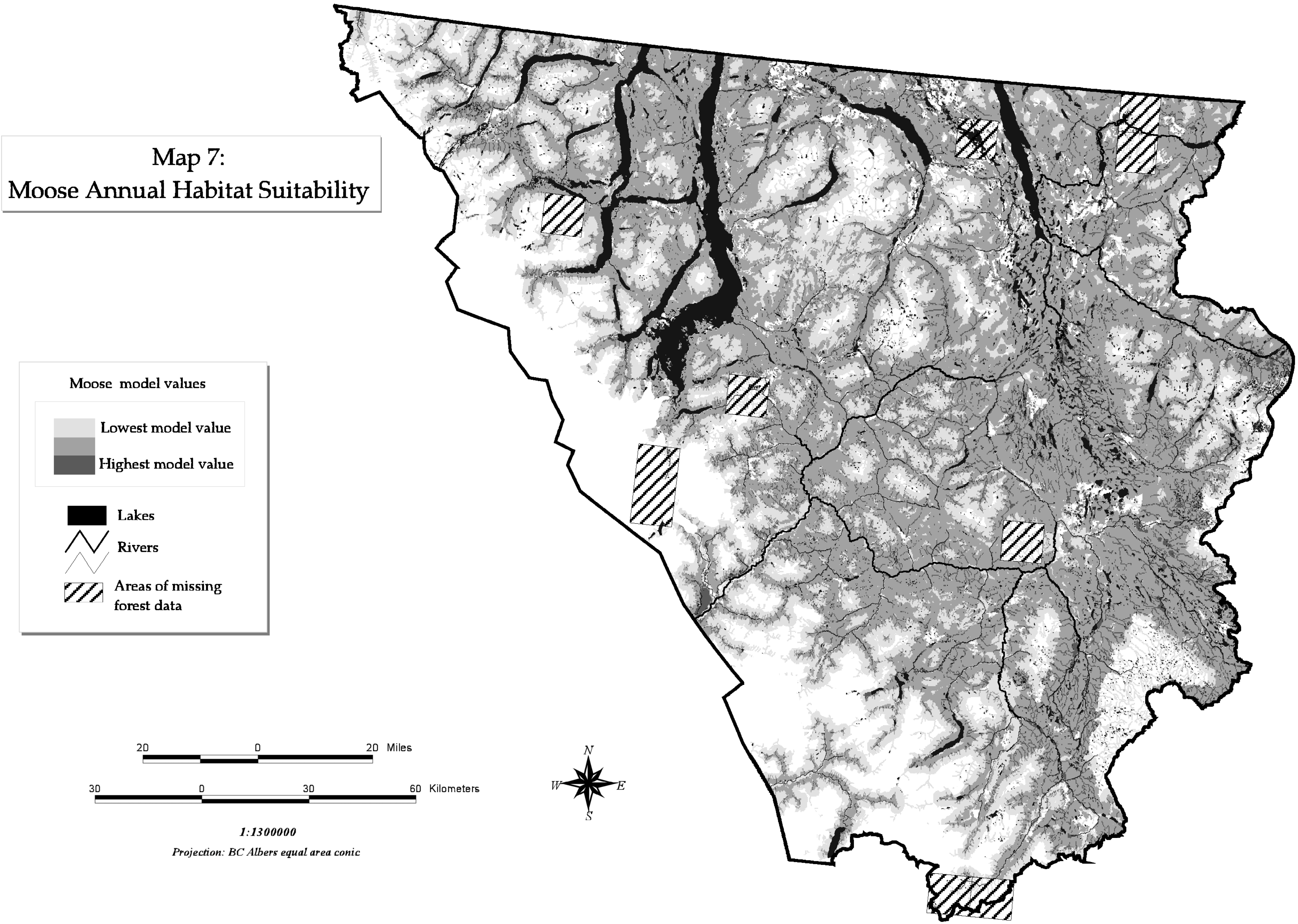
4.1.3 Moose Habitat Model

The TIEK, other local knowledge and existing literature identify moose as closely associated with habitats that support lush willow growth, as well as other shrubby and herbaceous plants that they forage upon. Wetland habitats, including marshes, river sloughs and "weedy" lakes are used heavily, as are higher elevation (subalpine and alpine) willow patches. Burns and other open, shrubby habitats were identified as important for moose. Moose use forest cover throughout the year, but particularly during fall rutting for protection, and during the winter to escape deep snows. Seasonal habitat descriptions are consistent across the interviews, and identify a diversity of habitats used by moose throughout the year (see Appendix A). During winter, moose will use high elevation shrubby habitats until the snow drives them out. Through mid-winter and spring, low elevation habitats are important, including wetland associations and other open, shrubby habitats at lower elevations. Additionally, low

Map 6: Caribou Annual Habitat Suitability



Map 7: Moose Annual Habitat Suitability




Stone's Sheep

elevation forests provide snow interception in the winter. Over the summer and through the fall, moose expand their habitat use to a wider diversity of habitats, including high elevation, shrubby habitats in alpine and subalpine areas, open slopes and burns. During this time, some moose continue to use low elevation, aquatic habitats. Security and thermal habitats are important throughout the year, but particularly during fall and winter, when moose can be found close to forest cover or within forests at tree-line or low elevation valley bottoms.

Based on the existing information, we developed GIS-based algorithms to identify potential habitats and rank their relative importance in each of two seasonal habitat submodels. The two seasons were selected based on our ability to differentiate habitat preferences, and combined summer and fall into a single season (summer/fall; June – November) and winter and spring into another season (winter/spring; December – May). The annual habitat suitability model is the additive score of the two seasonal submodels that were developed for summer and winter. Scores for the annual habitat suitability model ranged from zero to eight (Map 7), and these values were used in the CAD site selection analyses.

Approximately 75% of the Territory is predicted to support moose habitat. A large proportion of this area (44%) has high habitat values. These high value habitats are those used across multiple seasons, and include a wide diversity of habitat types that support willow and other forage species for moose. As expected, wetland and other aquatic associated habitats are predicted to be of high quality, as are open, shrubby habitats, particularly those found on warm aspects.

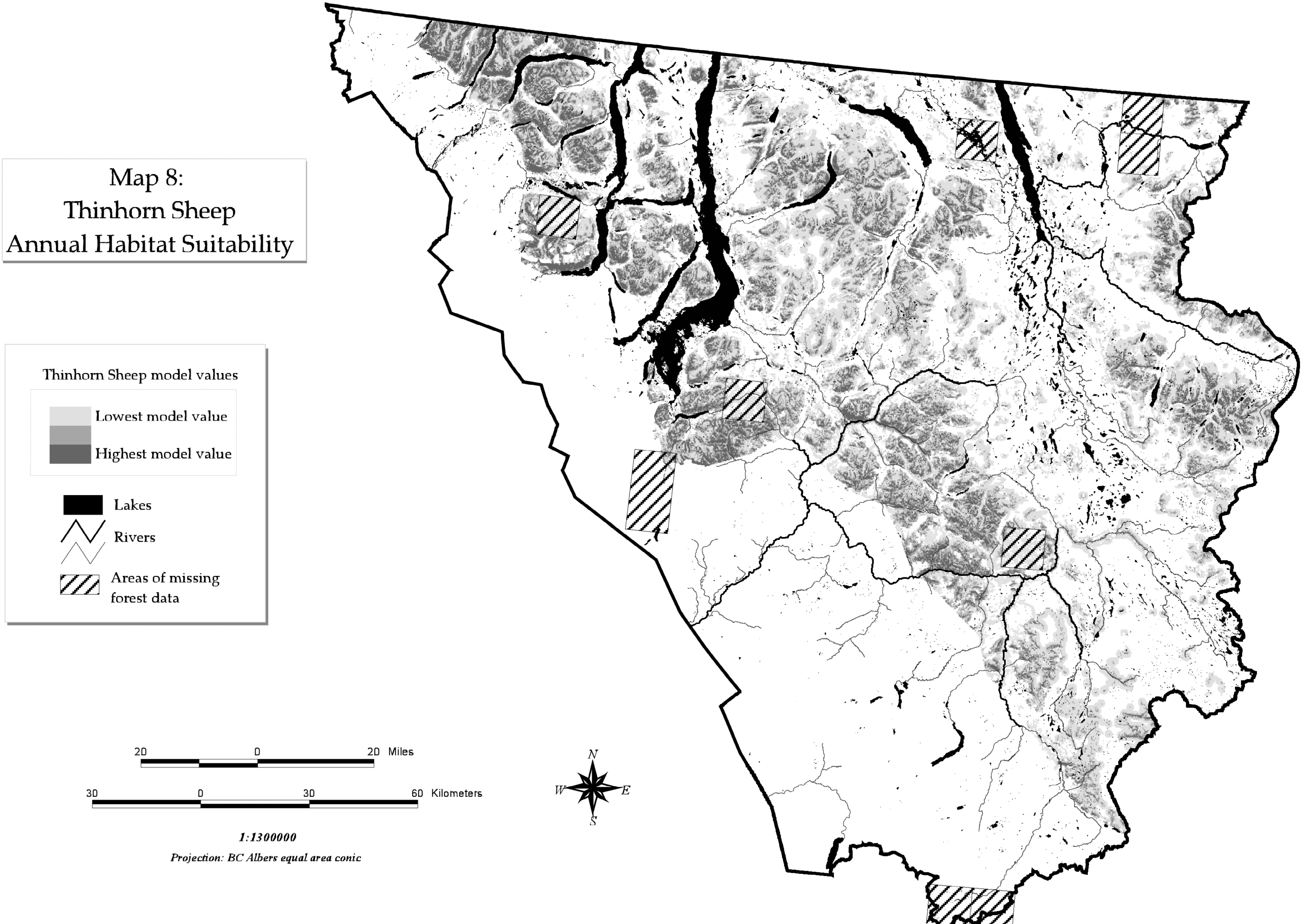
4.1.4 Thinhorn Sheep Habitat Model

The TRTFN TIEK and other local knowledge document that thinhorn sheep (Dall's sheep and Stone's sheep, including Fannin sheep) are patchily distributed in the Territory in suitable habitats. Sheep are found in steep, rocky and rugged mountainous areas with adjacent open, rolling hillsides, and are described as primarily eating grasses, with some use of shrubby plants (See Appendix A). While foraging, sheep remain close to cliffs and rocks for security, and move into these habitats if alarmed. During winter, sheep are described as selecting habitats with low snow, while requiring the close proximity of steep, rocky areas for security. These winter habitat include high elevation, wind-blown areas; south-facing or warm aspect, steep areas or lower elevation areas below snow or at tree-line. During summer, sheep are described as feeding in areas that are greening up as the snow melts. Summer habitats are high elevation areas, typically with open, rolling topography near escape terrain.

Sheep are found distributed across the Territory in patches of suitable habitat that are partially defined by characteristics we did not model, including snow depth. This appears to be particularly true for the western portions of the study area, where sheep populations are not found. To limit the model to regions known to historically or presently support thinhorn sheep populations, we limited the model extent to the western boundaries of those areas identified as supporting sheep through interviews with TRTFN members as well as other Atlin residents (local ecological knowledge interviews). We selected all areas identified by at least two people as historically or presently supporting sheep (Map 8).

We used the TRTFN TIEK and other existing information to develop GIS-based algorithms to identify potential habitats and rank their relative importance in each of two seasonal habitat submodels. The two seasons were selected based

Map 8: Thinhorn Sheep Annual Habitat Suitability



on our ability to differentiate habitat preferences, and combined summer and fall into a single season (summer/fall; June – November) and winter and spring into another season (winter/spring; December – May). Both seasonal submodels included rules that limited potential habitat based on the relative proximity of security habitat features and foraging habitat.

The predicted annual habitat suitability is the additive score of the seasonal submodel ranks, with final scores ranging between 0 and 18. Within the distribution of potential sheep occupancy, the model predicted 32% of the habitats supported potential sheep habitat. Of this, 7% supported high quality sheep habitat, which provided both high quality winter and summer habitats. The quality of the habitat was determined primarily by the quality of the escape habitat and the proximity of the escape habitat and foraging habitat to each other.

4.1.5 Mountain Goat Habitat Model

TRTFN TIEK and other local interviews document that mountain goats are distributed across the Territory in suitable habitats. The TRTFN TIEK provided consistent descriptions of mountain goat habitat (see Appendix A). Generally, goats are found in steep, rocky and rugged mountainous areas. Food includes grasses and forbs, as well as brush such as willows; general foraging habitat was described as open habitats at high elevations and brushy habitats at lower elevations. While foraging, goats remain close to cliffs and rocks for security, and move into these habitats if alarmed. Several TRTFN interviewees described goat habitat use during winter. Goats move to lower elevations during periods of snow, including selecting areas just

Mountain Goat

below snowline in the early winter and the use of forests, particularly at tree-line when the snow is deep. Additionally, goats are described as using areas of low snow pack, such as on warm aspects, in wind-blown areas or steep terrain. Lambing occurs in the more rugged areas, which provide the kids with security. During summer, goats remained tied to security habitat, but generally use a wider diversity of habitats than are available during the winter months.

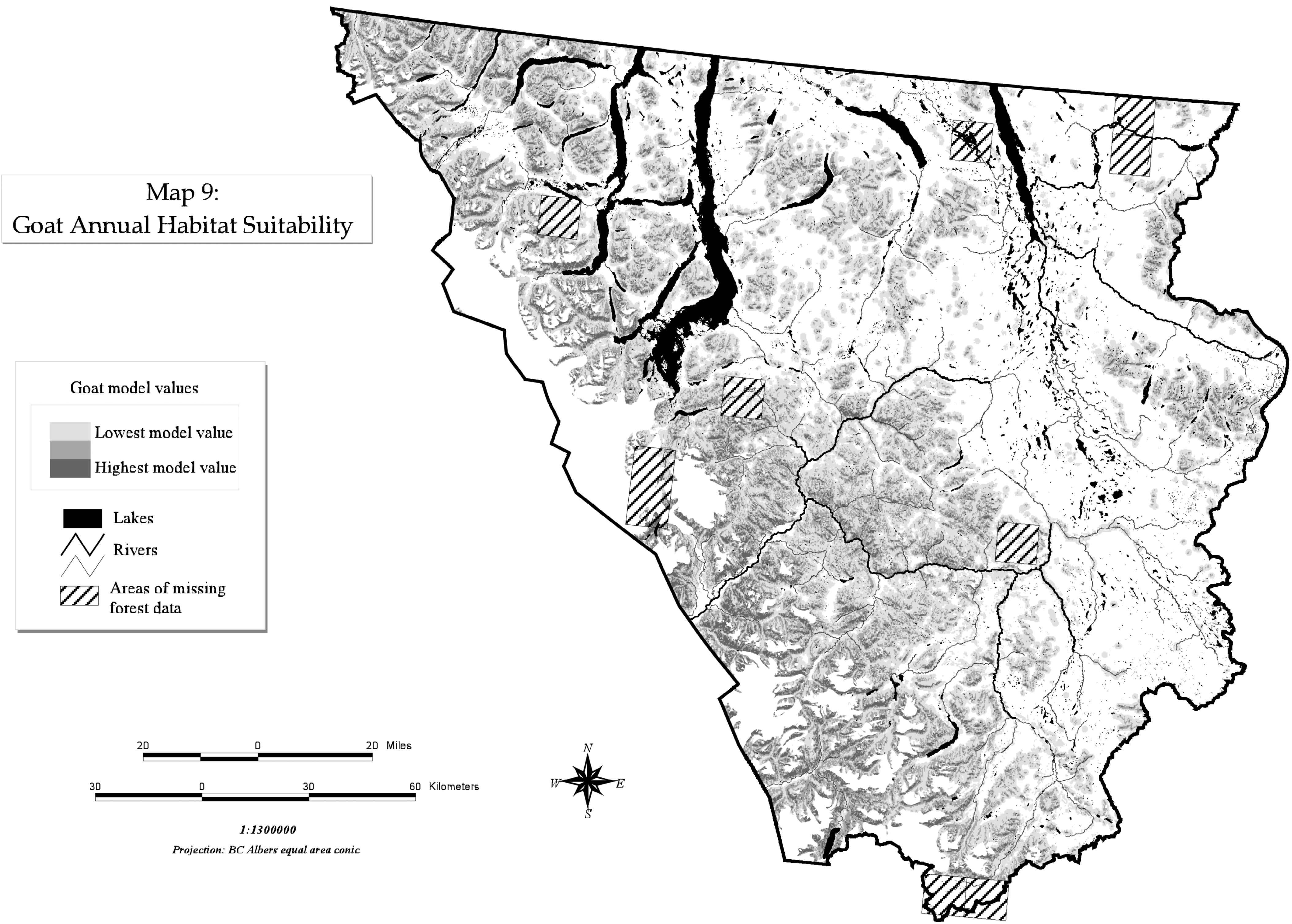
We developed the habitat model based on TRTFN TIEK, supplemented with information from other sources, where needed. In particular, specific parameters, such as degrees slope to define the "steepness" of security habitats, have been extracted from existing literature. Based on this information, we developed GIS-based algorithms to identify potential habitats and rank their relative importance in each of two seasonal habitat submodels. The two seasons were selected based on our ability to differentiate habitat preferences, and combined summer and fall into a single season (summer/fall; June – November) and winter and spring into another season (winter/spring; December – May). Both seasonal submodels included rules that limited potential habitat based on the relative proximity of security habitat features and foraging habitat.

The predicted annual habitat suitability is the additive score of the seasonal submodel ranks, with final scores ranging between 0 and 15 (Map 9). The habitat model predicted 44% of the habitats supported potential goat habitat. Of this, 5% supported high quality goat habitat, which provided both high quality winter and summer habitats. The quality of the habitat was determined primarily by the quality of the escape habitat and the proximity of the escape habitat and foraging habitat to each other.

4.2 Salmonid Focal Species

We gathered information on the distribution of 6 salmon species: sockeye, chum, Chinook, coho and pink salmon and steelhead, and on the known or estimated salmon spawning habitats.

Map 9: Goat Annual Habitat Suitability



There are over 4600 km of salmon supporting rivers and streams in the Territory, and an estimated 2800 km of river and stream reaches supporting spawning habitat for one or more species of salmon (Map 10). The vast majority of the habitat is within the Taku River, with nearly 3700 km of salmon rivers and streams, of which 2700 km are identified as supporting spawning habitat. The small Whiting River watershed supports almost 800 km of salmon rivers and streams, but no identified natural spawning habitat. For representation purposes, we have combined the Taku and Whiting Rivers, representing our southern watershed stratification (Taku strata), as described in Chapter Three. There is also more than 800 km of salmon reaches within the Teslin watershed, including over a 100 km of rivers and streams supporting spawning habitat.

Sockeye Salmon in the Nakina River

4.3 Ecosystem Representation

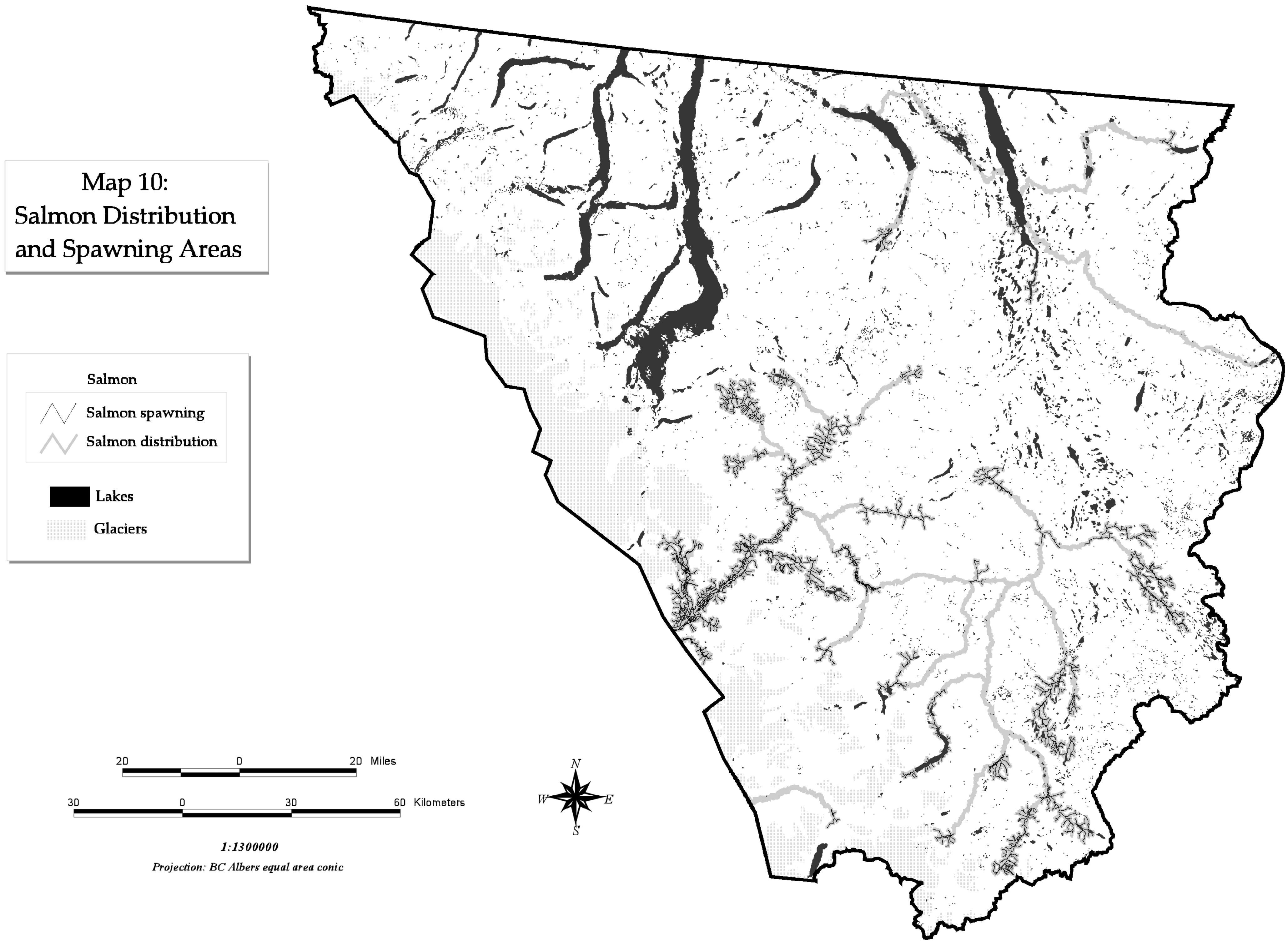
The ecological landscape unit model predicted 201 ecological communities across the Territory (see www.roundriver.org for map). These potential ecological communities are not easy to label or name, but are identified by the combination of ecological variables that identify them. Appendix B provides a complete listing of the predicted ecological communities. The rarest identified habitat includes some of the hemlock communities, with the rarest predicted to cover less than six ha. The most common identified communities include some of the high elevation non-forested classes, including the most common community of cool, non-forested Alpine Tundra (20.5% of the Territory) and cool, non-forested Boreal Subalpine (10.6% of the study area). The most common forested communities are also cool, high elevation communities, and include cool, old true fir communities in the Boreal Subalpine (4.8% of Territory) and cool, old spruce communities in the Mountain Boreal (2.4% of Territory).

4.4 Special Elements

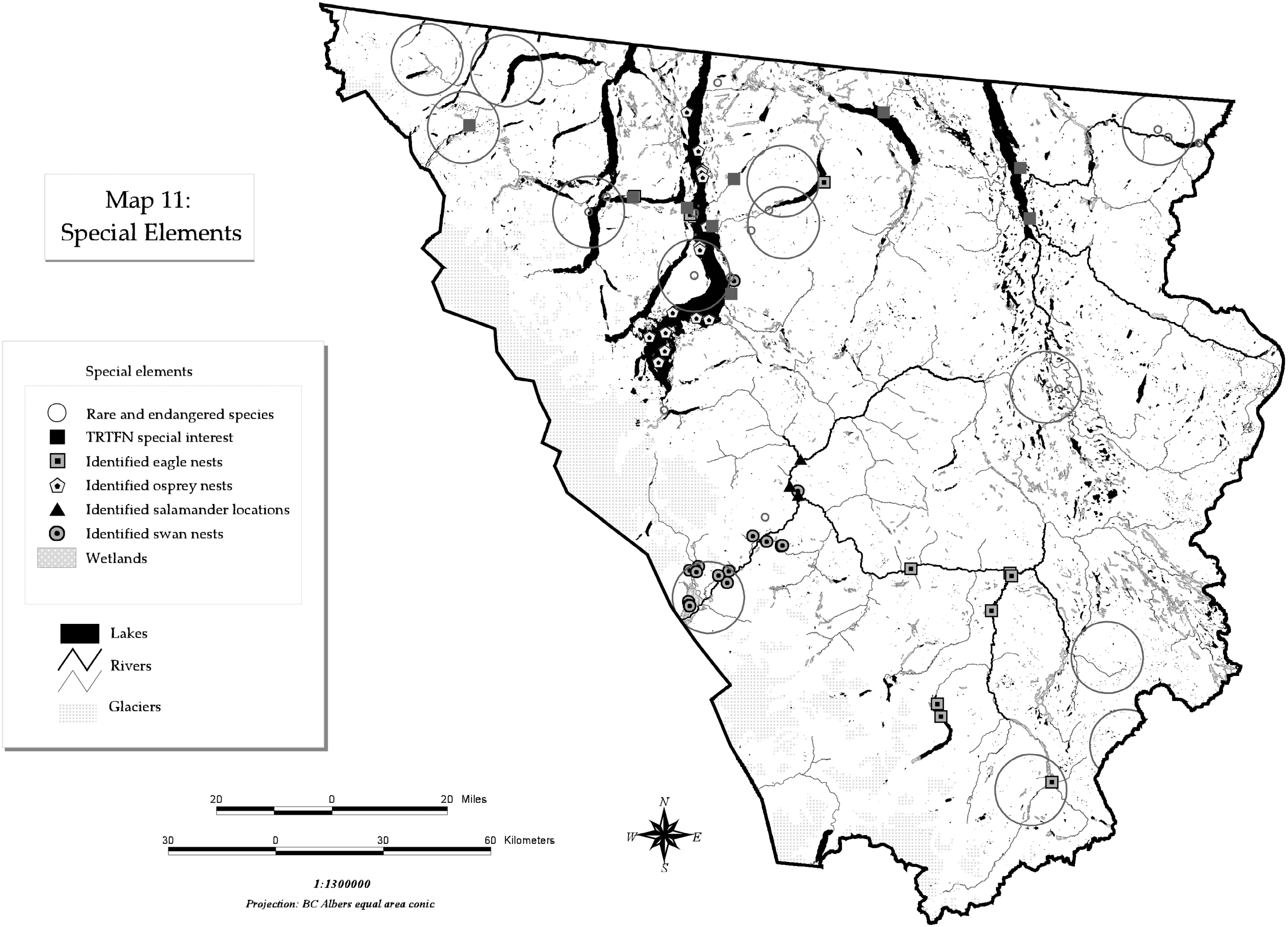
There are 120 special fish and wildlife occurrences identified across the TRTFN Territory (Table 3). These range from rare plant locations identified by the BC Conservation Data Centre to locations of rare amphibians, osprey nests and bald eagle nests identified by RRCS and TRTFN during surveys. In addition, wetland habitats are identified as a special element in the CAD, due to the high value and sensitivity of this habitat type. Using the BC FIP database, there are over 1700 wetland habitat areas identified across the Territory, encompassing over 51,000 Ha. Most of the species occurrence data is limited to areas more easily accessed by people: adjacent to road systems, or along the shores of larger lakes or sections of navigable river sections within the Taku River watershed (Map 11). The CDC data does not provide point locations of rare or listed plants or animals, but large regions within which the special element occurs. For representation analyses, we estimated the location of these elements as the center of the identified region.

4.5 Site Selection Scenarios

We developed 26 different potential site selection scenarios that incorporated differing levels of representation for focal species habitats and ecological communities. Additionally, the inclusion of human impacts represents another suite of site selection portfolios. In all runs, salmon spawning areas were “locked” into the solution to assure that these important habitats were always within the selected sites. Below, we present general results across the 26 potential site


Map 10:
Salmon Distribution
and Spawning Areas
Salmon
Salmon spawning
Salmon distribution
Lakes
Glaciers
20 0 20 Miles
30 0 30 60 Kilometers
1:1300000
Projection: BC Albers equal area conic
N
S
E
W

Map 11: Special Elements



selections. Maps showing each site selection scenario can be found on the RRCS web page (www.roundriver.org).

4.5.1 Influence of Varying Targets

Our suites of analyses included site selections with increasing focal species habitat goals (20%-80%) and a set ELU goal at 30%, and site selections in which both the focal species habitat goals and the ELU area goal simultaneously increased from 20% to 80%. As would be expected, any increase in the goals results in an increase in the amount of area selected. The addition of increasing ELU goals simultaneously with focal species habitats goals resulted in site selections with the largest areas (Figure 3). This increase in area does not increase the level of focal species habitat representation, but includes a larger number of planning units that provide moderate values (when summed over the planning unit) of focal species habitat. For example, we can compare the distribution of woodland caribou habitat values in planning units selected with focal species habitat goals at 40% and the set ELU goals at 30%, with the distribution of woodland caribou habitat values in planning units selected with both focal species habitat and ELU goals set at 40%. The distribution of woodland caribou habitat values of selected planning units is shifted towards those supporting a moderate value of caribou habitat in the site selections with higher ELU goals. Still, there is little difference in the number of planning units selected with high quality habitat (Figure 4). Impressively, few of the planning units with high quality habitat that selected with lower ELU goals were removed when ELU goals were increased.

Table 3. Documented special elements occurrences with the Territory are rare. Existing information has been compiled from multiple sources, see the text for further information.

SPECIAL ELEMENT	TYPE OF ATTRIBUTE	# OF LOCATIONS (OR AREA)	SOURCE
Wetland Habitat	Area	51 m ha	BC FIP
Rare and Endangered Species	Buffered Point	42	Conservation Data Centre
Bald Eagle Nest	Point	10	TRTFN/RRCS
Lake Trout	Point	14	BC Fish Wizard/ TRTFN
Osprey Nest	Point	18	TRTFN
Trumpeter Swan Nests/Locations	Point	24	RRCS/TRTFN
Special interest fish and wildlife	Point	9	TRTFN
Long-toed Salamander	Point	3	RRCS/TRTFN

4.5.2 Changes with Inclusion of Impacts

The inclusion of impacts in the site selection analyses dramatically altered the selection of sites in regions with identified impacts, across all site selection scenarios. With increasing goals, impacted areas were increasingly included in the site selections, indicating that these areas become increasingly necessary to meet higher representation goals. The anthropogenic impacts included in the analyses are primarily limited to the Atlin region and surrounding lands to the east that support a network of dirt roads (Map 1). While causing some spatial shifting in selected sites, the inclusion of the impacts in the analyses did not notably shift the quality of habitats selected for any species, reduce the representation of ecological communities or increase the amount area needed to meet the goals of the site selections. The minimal influence of existing impacts to the ability to meet conservation goals is likely due to the extremely limited nature of the present impacts.

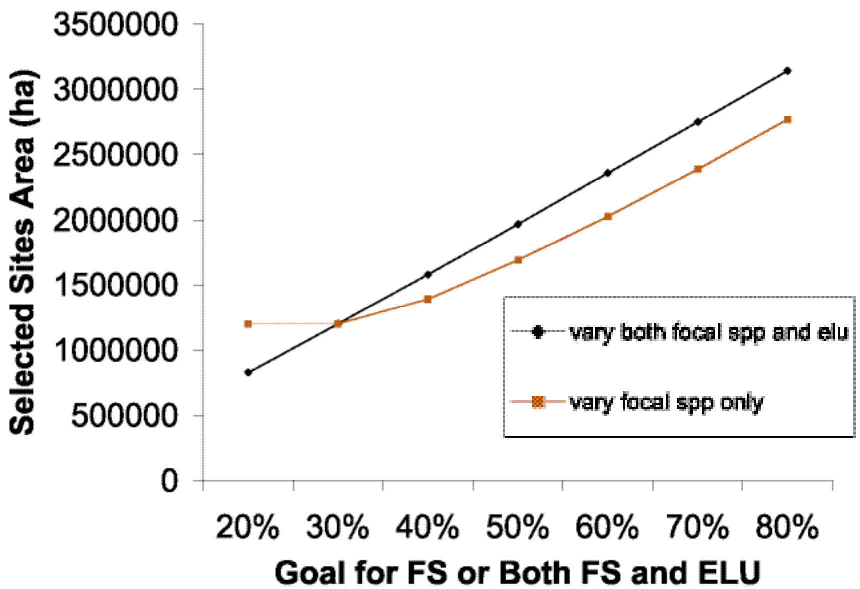


Figure 3. Amount of area increases as goals increase, regardless of target set. The largest amount of area is needed for scenarios including increases in both focal species and ecological community goals

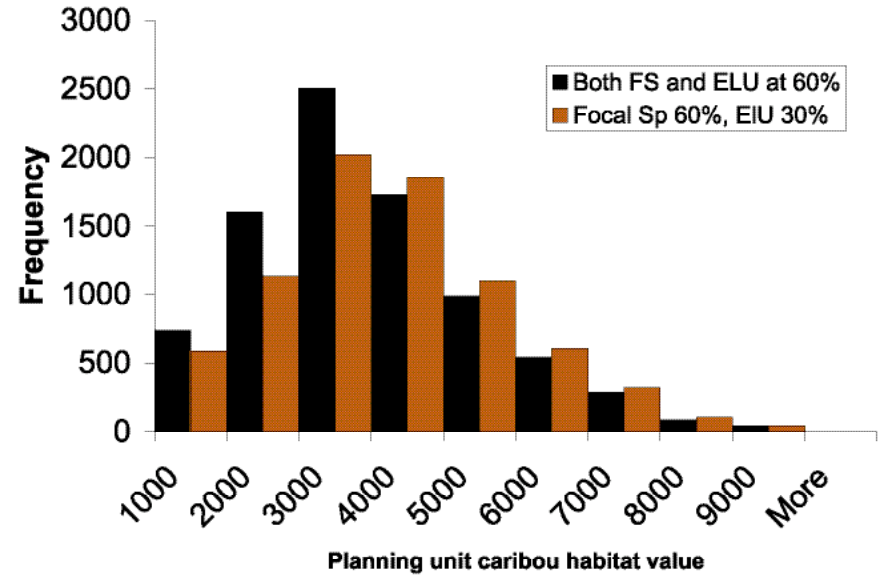


Figure 4. When the ELU goal increases with the focal species targets, additional planning units with moderate quality focal species tend to be selected, and slightly fewer of the planning units with higher quality focal species habitat.

4.6 Conservation Areas Design

The suggested conservation area design was developed through a combination of analyses to define recommended core areas and analyses to identify connectivity areas that both provide connectivity between core areas, and also, importantly, increase the focal species habitat and ecological community representation in the conservation areas design.

4.6.1 Core Area Selection

The summed solutions across the 26 different site selection scenarios provided our spatial index of conservation value, or our "conservation density surface", across the Territory (Map 12). There are significant conservation values indicated across the entirety of the Territory. Still, several "hot spots" can be visually identified; these areas represent areas selected consistently across site selection scenarios and, therefore, are of high irreplaceability (Noss et al. 2002).

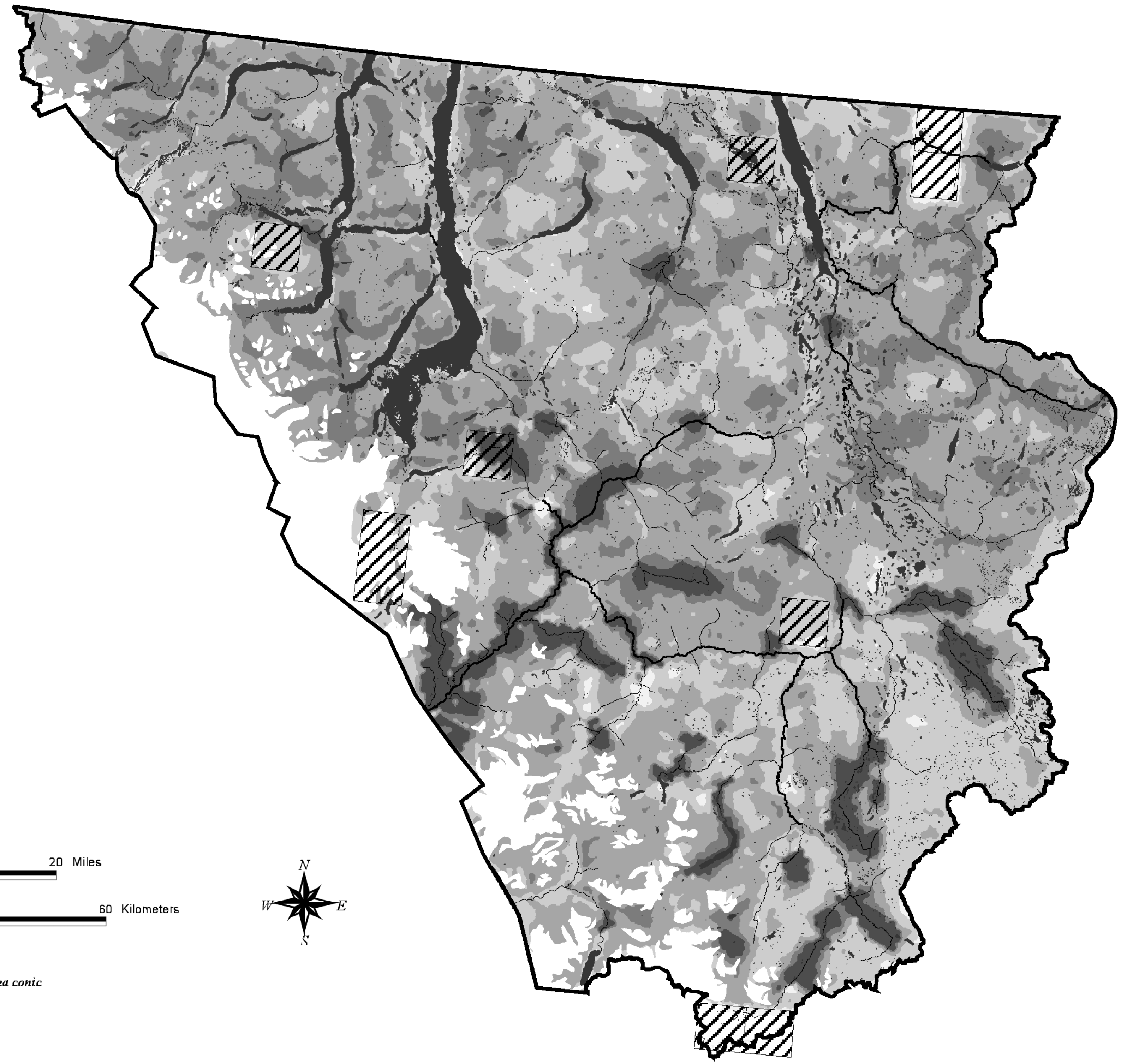
4.6.1.1 Identification of Proposed Core Areas

We translated the conservation values of planning units into a conservation density surface, enabling us to identify those areas with highest conservation densities. We used a kernel density estimator to create density isopleths that effectively identified high value areas, and provided information about the relative amount of conservation values within an identified isopleth boundary. Isopleths were constructed at 5% density increments, creating potential core areas capturing between 30% - 60% of the Territory-wide conservation values (Map 13).

We examined the amount of area required to capture increasing levels of conservation value, as identified within 5% density isopleth increments (Figure 5). The isopleths with lower goals identified relatively small areas, and the incremental increase in the area needed to capture higher density goals is relatively small. As the density goals increase past 45-50%, the area needed to meet these goals rapidly increases.

We calculated the percent of the focal species habitat values represented within each isopleth boundary (Figure 6). The amount of habitat value for all species increases rapidly with

Map 12: Summed Sites Solutions



Summed solutions

Selected least

Selected most

Lakes

Rivers

Areas of missing forest data

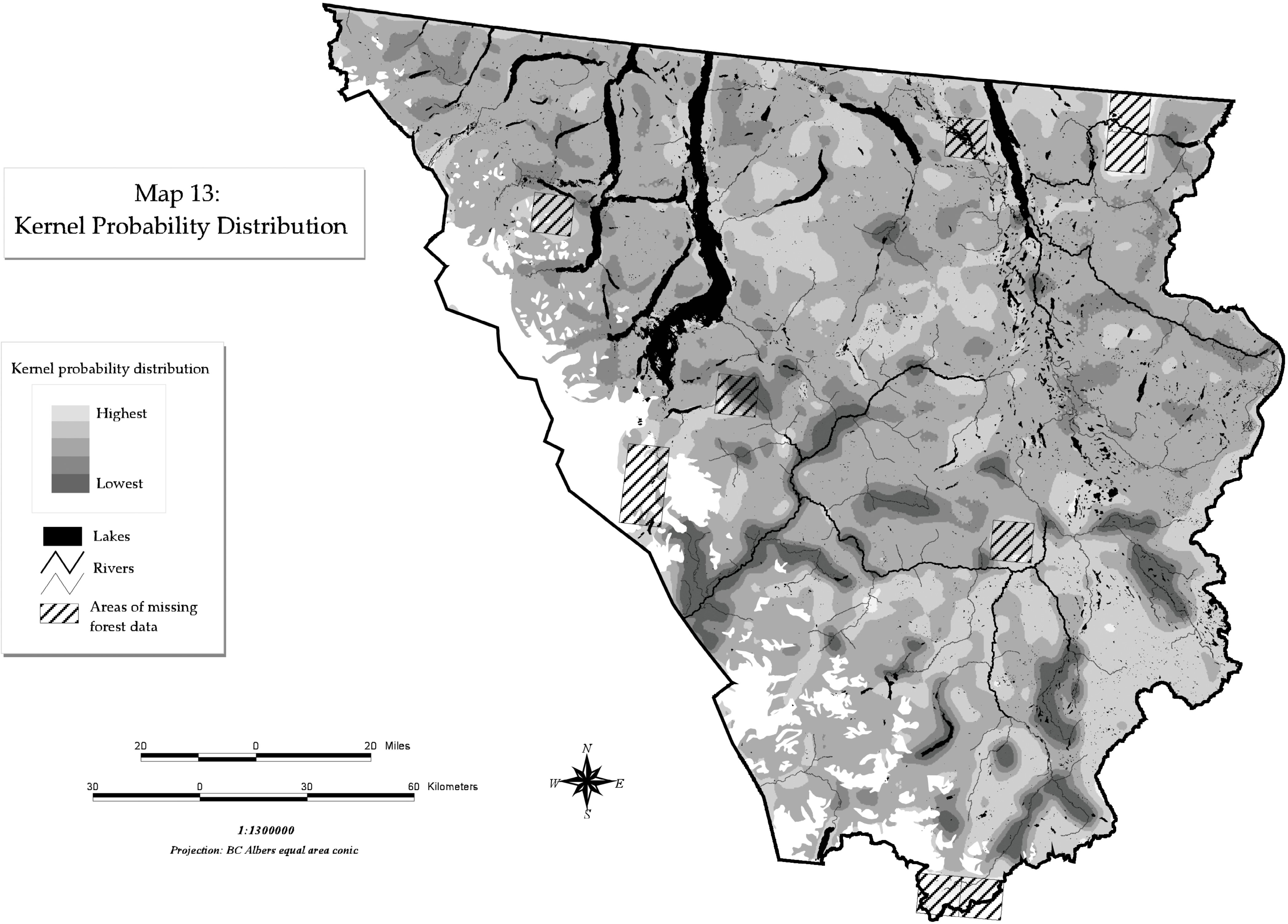
20 0 20 Miles

30 0 30 60 Kilometers

N W E S

1:1300000

Projection: BC Albers equal area conic



Map 13:
Kernel Probability Distribution

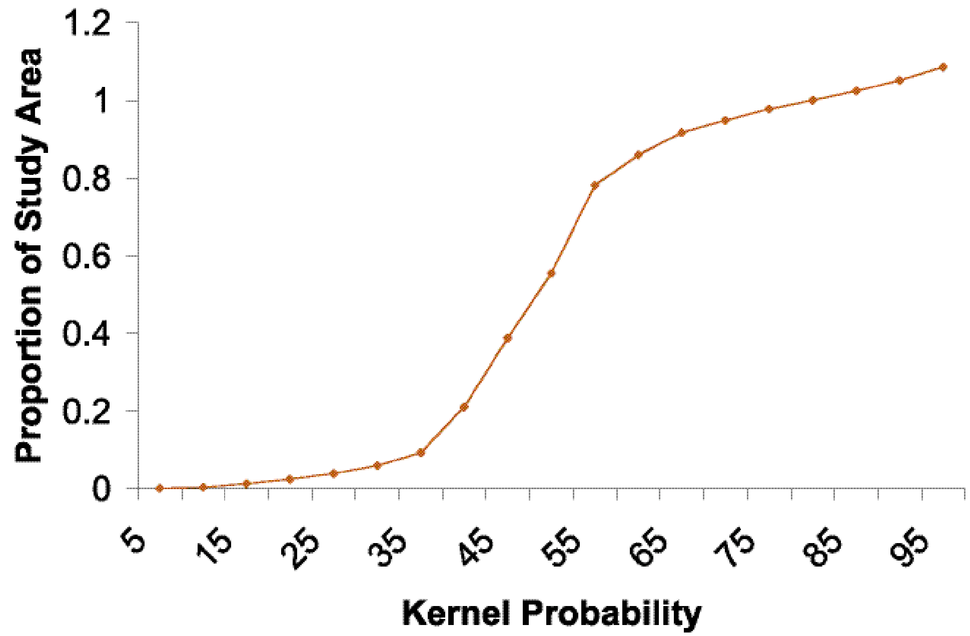


Figure 5. Proportion of the Territory identified as within potential core areas as the amount of conservation value included increases (equivalent to increasing kernel probability

increasing density goals. At low density goals, we see a slow increase in focal species habitat representation; at these low conservation goals, goals set for ecological communities may be driving the site selections, as half the site selections also had 30% targets for ecological community representation. The representation in ecological communities increases more linearly, and representation values are higher over all, but particularly at low density goals. Yet, average ecological community representation may be misleading, as several ELU classes will be well represented; a better evaluation may be the number of ecological communities that are under-represented (i.e., <30%). Up to 80% of the ecological communities are under-represented at low-density isopleths, but the representation rapidly increases with increasing density goals (Figure 7).

Representation of the majority of ELU classes is achieved as the conservation density goal approaches 50%.

Based on the assessments of representation and of area efficiency, we selected the 45% isopleth to define our core areas. The areas identified by the 45% conservation density boundary captures well over 30% of all focal species habitat values and 80% of the ecological communities in the Territory. It achieves these representation levels through the identification of only 29% of the available area.

4.4.1.2 Representation within Proposed Core Areas

We calculated the representation values for focal species annual habitat values, focal species seasonal habitat values, ecological communities and special elements within the proposed core areas (Table 4). These areas represent 36%-42% of the focal species annual habitat values, as described above. When we examine the focal species seasonal habitat values captured in these core areas, we find that most seasonal habitats for most species are also well represented, ranging from 33% to 44%.

Additionally, these core areas provide >30% representation for 162 of the 201 predicted ecological communities of the Territory. The actual distribution of ELU representation shows that the majority of the ecological communities have a very high level of representation within the core areas (Figure 8), as a total of 39 ecological communities fall below the >30% goal for representation. Still the majority of these (35 of 39) have notable representation (>10%).

Approximately 73.4% of the rivers and streams supporting salmon are within the proposed core areas, as are 99.6% of the stream reaches identified to support spawning by one or more of the six salmonid species (Table 4). Seventy-eight percent of the salmonid distribution within the Taku and Whiting River watersheds falls within core areas, as does 50% of the salmonid distribution in the Teslin watershed.

Special element representation analyses showed that special elements associated primarily with riverine habitat are well represented within the core areas. These include swan nests, eagle nests, amphibian sites and wetland habitats. Yet, other special elements are poorly represented or not represented at all within the proposed core areas (Table 4). These include known occurrences of osprey nests (all on Atlin Lake) and some special interest lake spawning areas.

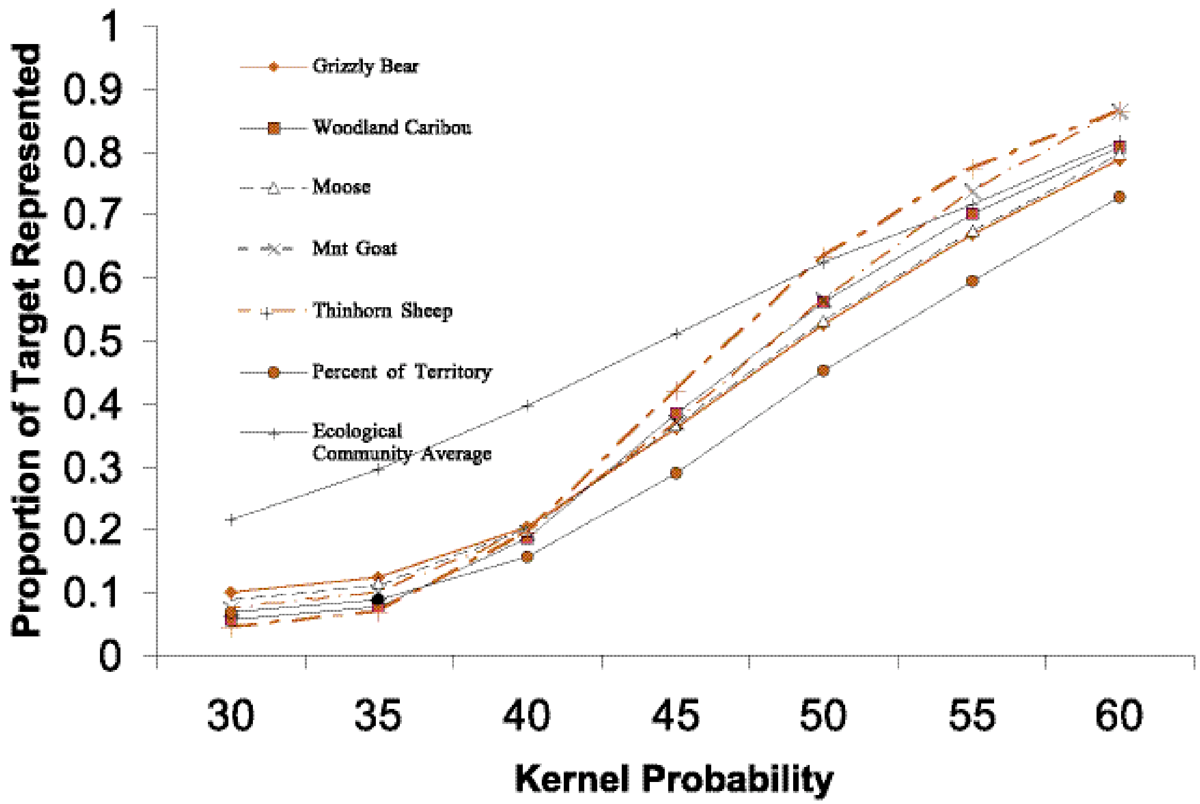


Figure 6. Proportion of the focal species annual habitat values and average area representation of ecological communities identified as within potential core areas as the amount of conservation value included increases (equivalent to increasing kernel probability).

4.6.2 Connectivity Areas

We evaluated three potential connectivity scenarios, each selected based upon a decreasing threshold value. As the acceptable threshold value declines, more area may be identified within the potential connectivity areas. We compared the number of connected core areas and the total area required in each potential scenario to guide our selection of recommended connectivity areas.

Decreasing the threshold value used to define the connectivity scenario increases both the level of connectedness in the landscape and the amount of area within the scenario (Table 5). Only the most liberal threshold (scenario one) fully connects all the core areas, but scenario two connects all cores except one small core in the north (2100 ha core in the Teslin watershed). This mid-threshold level, thus, connects over 99% of the proposed core area. The most conservative of the threshold scenarios does a very poor job of connecting the core areas, creating 27 assemblages of core areas that are not connected. The change in area identified between scenario one and scenario two is notable, decreasing from 2.7 m ha to 2.2 m ha (core area included). The smallest area is required in the most fragmented scenario (scenario three), which identified 1.4 m ha. We chose scenario two to define our proposed connectivity areas, as this scenario provided a highly connected landscape, while identifying less area needed than the more liberal scenario that fully connected all core areas. It also far exceeded the more stringent scenario 3 in achieving connectivity across the Territory. Additionally, across scenario two, most core areas have multiple connectivity areas linking them to multiple adjacent core areas and, thus, providing many alternative movement alternatives across the landscape (Map 14).

4.6.3 Recommended Conservation Area Design

The combination of selected core and connectivity areas provides the basis for our recommended Conservation Area Design (Map 15-inside back cover). Additionally, the recommended CAD includes suggestions for special management consideration of additional areas. These include areas or habitats important for the long-term maintenance or recovery of sensitive species or habitats. Preliminary identification of some of these areas is included on Map 15; some cannot be shown due to mapping limitations. A higher resolution is available on the RRCS web page (www.roundriver.org). The core, connectivity and special management areas are described below.

CONSERVATION ELEMENT	REPRESENTATION WITHIN CORE AREAS (%)
Focal Species Annual Habitat Values	
Grizzly Bear	36.1
Woodland Caribou	38.5
Moose	36.6
Mountain Goat	36.9
Thinhorn Sheep	42.1
Focal Species Seasonal Habitat Values	
Grizzly Bear Spring Habitat	34.9
Grizzly Bear Summer Habitat	36.7
Grizzly Bear Fall Habitat	35.3
Woodland Caribou Summer Habitat	33.2
Woodland Caribou Winter Habitat	40.6
Moose Summer Habitat	36.0
Moose Winter Habitat	36.5
Mountain Goat Summer Habitat	34.8
Mountain Goat Winter Habitat	37.9
Thinhorn Sheep Summer Habitat	39.7
Thinhorn Sheep Winter Habitat	43.1
Salmon Habitat	
Salmon Spawning Habitat	99.6
Salmon Distribution	73.4
Ecological Communities (Average)	51.2
Ecological Communities (St. Deviation)	26.1
Ecological Communites (Range)	39
Special Elements	
Wetlands	40.6
Swan Nests	87.5
Osprey Nests	0
Special Interest Fish and Wildlife	1.2
Eagle Nests	40.0
Long-toed Salamander Locations	100.0
Rare and endangered species (CDC)	19.0

Table 4. Representation of conservation elements within the proposed set of core areas. Representation is presented as the percent of the habitat values that are within core areas for focal species habitats, the percent of the areas or the point occurrences that are within core areas for the ecological communities and the special elements.

Table 5. Summary statistics calculated for each of three connectivity area scenarios. Scenario one represents the most liberal scenario, while scenario three represents the most restrictive scenario. The number of isolated cores is zero when all cores are linked through connectivity areas. The area calculations combine the area of the proposed cores and the scenario connectivity area.

SCENARIO	NUMBER OF ISOLATED CORE AREAS	TOTAL AREA (million ha)
Scenario one (lowest threshold value)	0	2.66
Scenario two (mid threshold value)	1	2.18
Scenario three (highest threshold value)	23	1.42

CONSERVATION ELEMENT	REPRESENTATION WITHIN RECOMMENDED CAD
Focal Species Annual Habitat Values	
Grizzly Bear	63.4
Woodland Caribou	64.3
Moose	66.6
Mountain Goat	46.1
Thinhorn Sheep	51.4
Focal Species Seasonal Habitat Values	
Grizzly Bear Spring Habitat	64.7
Grizzly Bear Summer Habitat	66/1
Grizzly Bear Fall Habitat	62.4
Woodland Caribou Summer Habitat	47.6
Woodland Caribou Winter Habitat	76.1
Moose Summer Habitat	67.4
Moose Winter Habitat	68.1
Mountain Goat Summer Habitat	44.4
Mountain Goat Winter Habitat	50.2
Thinhorn Sheep Summer Habitat	50.9
Thinhorn Sheep Winter Habitat	54.1
Salmon Habitat	
Salmon Spawning Habitat	100.0
Salmon Distribution	99.2
Ecological Communities (Average Representation)	79.4
Ecological Communities (St. Deviation in Representation)	17.3
Ecological Communities (>30% Representation)	3
Special Elements	
Wetlands	82.3
Swan Nests or Locations	93.8
Osprey Nests	94.4
Special Interest Fish and Wildlife	100.0
Eagle Nests	100.0
Long-toed Salamander Locations	100.0
Rare and endangered species (CDC)	71.4

Table 6. Representation of conservation elements within the proposed set of core areas. Representation is presented as the percent of the habitat values that are within core areas for focal species habitats, the percent of the areas or the point occurrences that are within core areas for the ecological communities and the special elements.

4.6.3.1 Core and Connectivity Areas

The core and connectivity areas create a matrix of habitats providing for the conservation of biodiversity and ecological processes across the Territory. The combination of the core and connectivity areas represents approximately 55% of the Territory. As can be seen in Table 6, the connectivity areas include important additional habitats that result in a high level of representation across all of our conservation elements. Focal species seasonal and annual predicted habitat values are well represented, with representation levels ranging from 44% to 76%. Importantly, many of the predicted winter habitats, which are often critical and limiting to many species, are represented in high numbers in the CAD. For example, 76% of caribou winter habitat values are within the CAD areas, as are 68% of the moose winter habitat values, 50% of the predicted goat winter habitat values and 54% of the sheep winter habitat values. Nearly all (99.2%) of salmon river and streams are within the recommended CAD, as are 100% of the stream reaches identified to support spawning by one or more of the six salmonid species. In addition, the connectivity areas provide increased conservation of the diversity of ecological communities in the Territory, and provide >30% representation of all but 3 ecological communities. Most of the ecological communities are

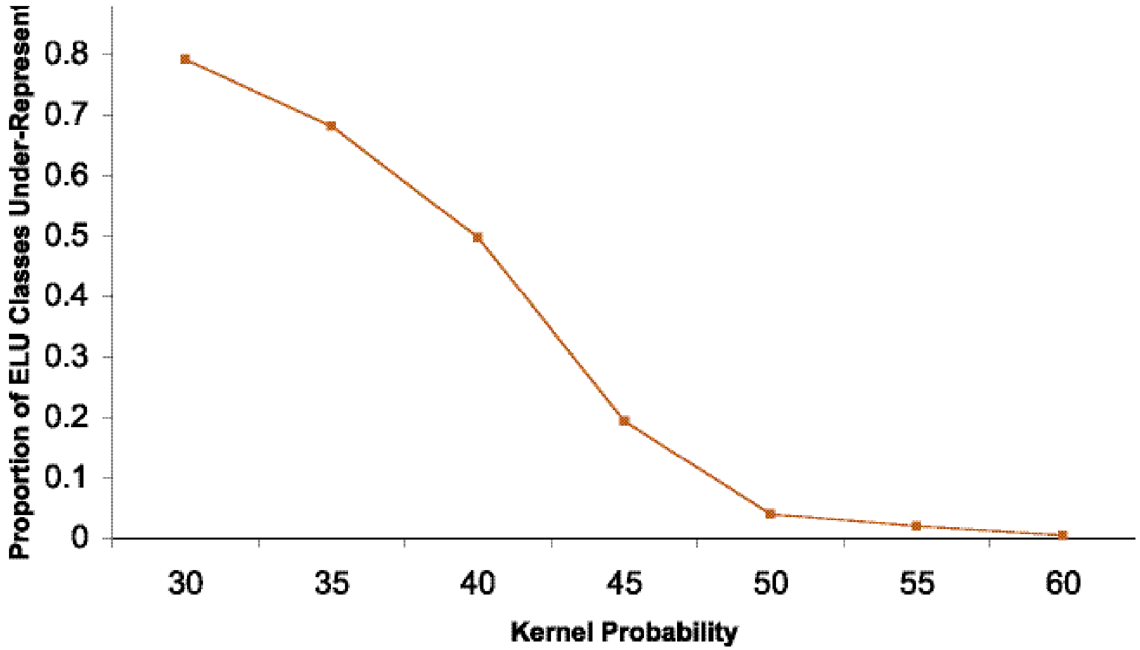


Figure 7. Proportion of the ecological communities that are under-represented (<30% representation) within potential core areas as the amount of conservation value included increases (equivalent to increasing kernel probability).

represented well above the minimal 30% goal (Figure 9). Two of the three "under-represented" communities achieve 27 and 28% representation, nearly meeting our goal of 30% representation. The final under-represented ecological community is glacier habitat, which is not considered a priority for conservation in the present analyses. Glaciers in this region face few threats that can be managed through regional conservation and management, relative to more productive, lower elevation habitats. Finally, the connectivity areas dramatically increase the representation of known special elements in the Territory. The corridor areas are critical not only for providing connectivity across the Territory for wildlife, plants and ecological processes, but also to complement the core areas in conserving biodiversity elements and populations.

4.6.3.2 Special Management Areas

In addition to the core and connectivity areas, we recommend the establishment of special management areas (SMAs) that have known critical values for sensitive species or habitats. We have identified where these special management areas may be established, based upon the available information. Refinement of the location and extent of these area designations is recommended, based upon more fine-scale analyses of the species and habitats. Development of management guidelines within these areas should consider the sensitivity of the species or habitats identified.

Salmon Watershed SMA. Maintenance of healthy and intact watersheds is essential to the long-term maintenance of salmonid populations. There are several watersheds within the Territory that are fortunate in supporting wild run salmon populations. These include the Taku and Whiting River watersheds, as well as Teslin, Jennings, Gladys, and Swift River watersheds.

Wetland Habitat SMA. Wetlands provide critical resources to many wildlife and plant species, as well as providing critical ecosystem services. Wetlands, and many of the species and processes dependent upon them, are sensitive to disturbance; loss of even small wetlands can have a profound impact upon the local ecology.

Thinhorn Sheep SMA. Thinhorn sheep within the Territory are a species of special concern, due to reported declines in populations and population productivity (based on TIEK and local interviews). Because of the isolated nature of the current distribution of sheep population, each of these populations is highly vulnerable to additional impacts. Additionally, until population numbers and productivity are recovered, it is unlikely that these isolated populations are connected through immigration and emigration; thus recolonization of historic habitats or natural immigration into small populations is unlikely. We have identified Thinhorn Sheep SMA areas based upon TIEK and local knowledge of the current extent of the sheep populations within the Territory. The identified areas are those

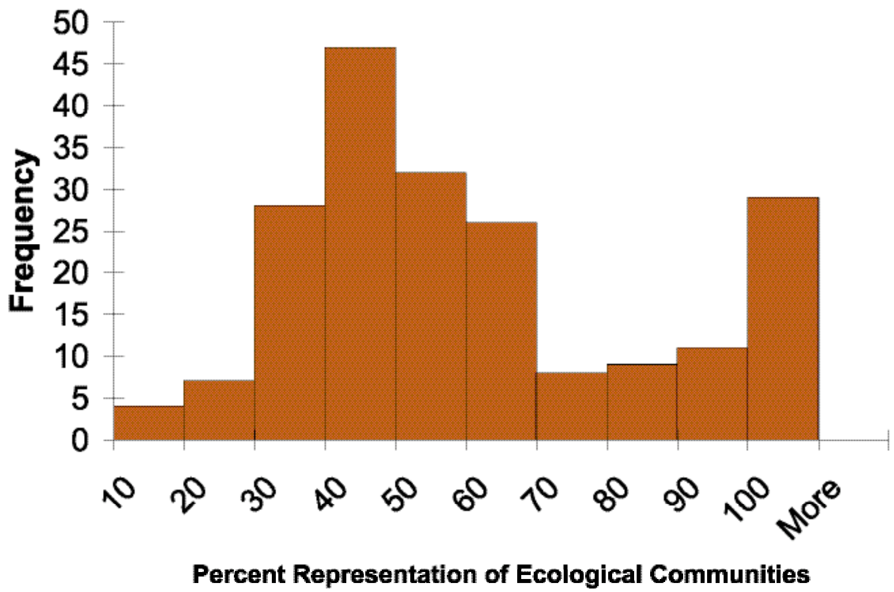


Figure 8. Histogram of the representation of ecological communities achieved with proposed core areas. Line indicates >30% representation goal

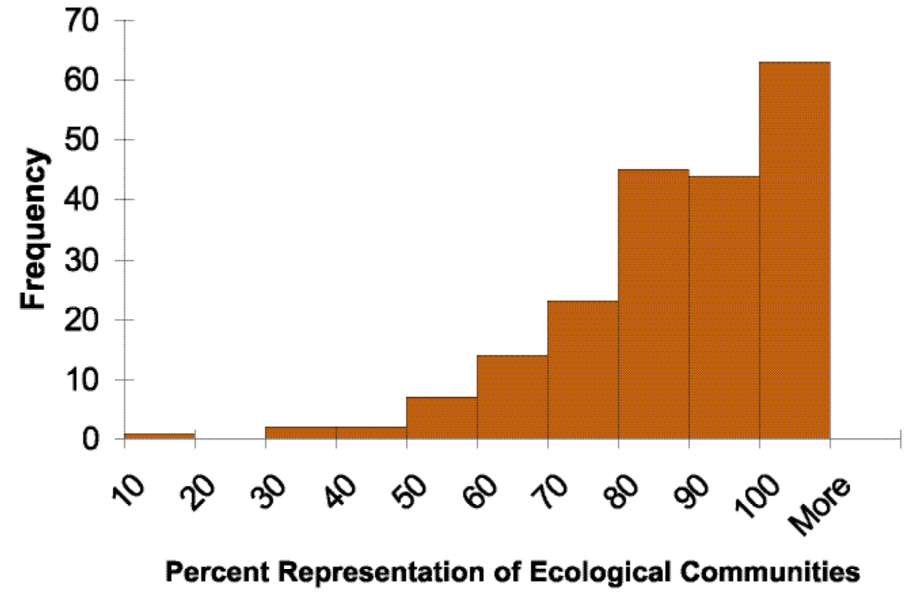


Figure 9. Histogram of the representation of ecological communities achieved with recommended CAD core and connectivity areas. Line indicates >30% representation goal.

which at least two interviewees identified as supporting sheep presently or in the recent past.

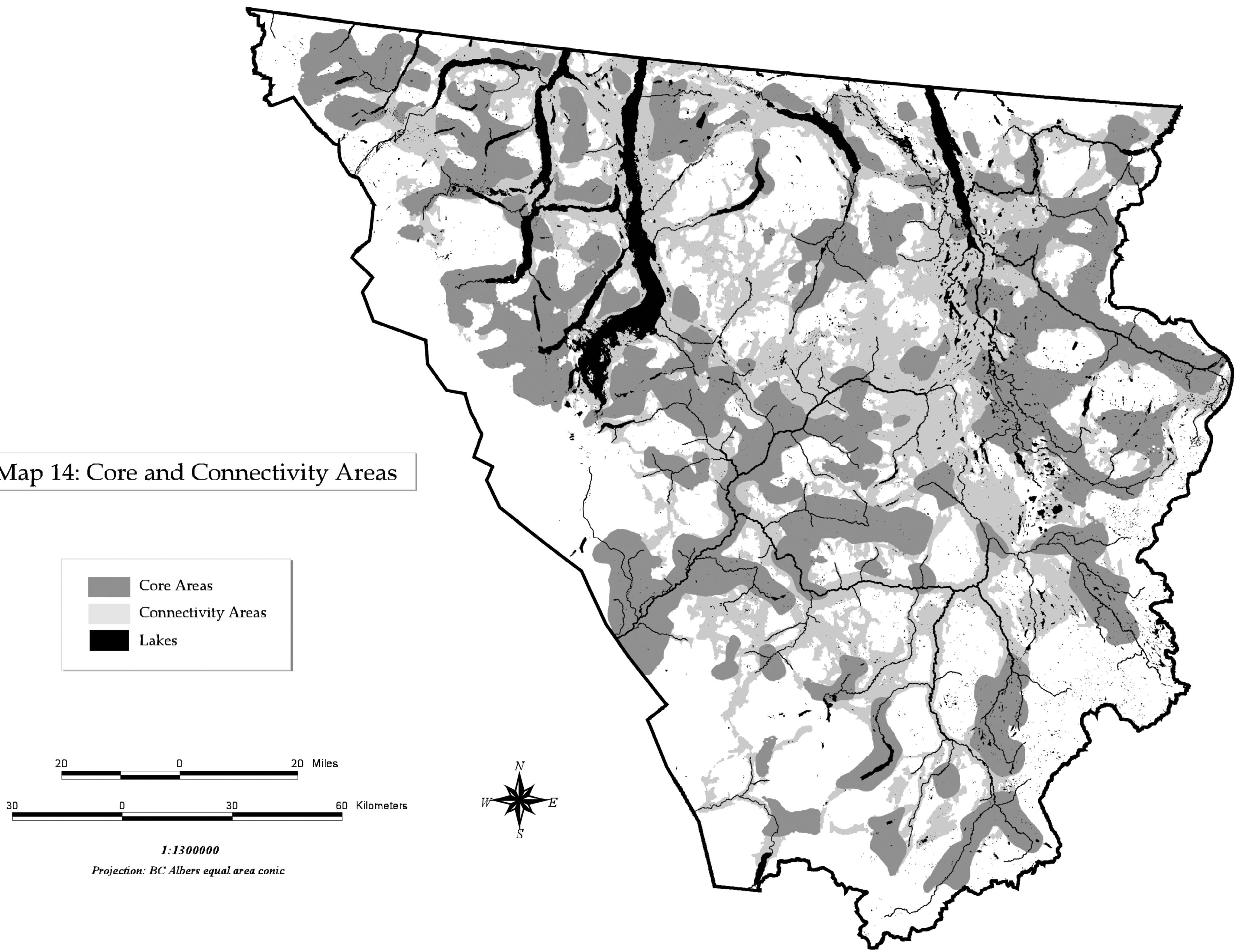
Woodland Caribou Winter Habitat SMA. Based upon existing literature, TIEK and local knowledge, northern woodland caribou rely upon mature lodgepole habitats and associated forests that support abundant terrestrial lichen. These critical winter habitats are potentially limiting to the caribou of the Territory and recovery of these habitats after severe disturbance literally could take hundreds of years. Additionally, caribou within these habitats during the winter are particularly vulnerable to disturbance and displacement, as well as increased mortality due to either direct (hunting) or indirect (other predation) anthropogenic access. It has been shown in other areas that woodland caribou mortality is significantly higher within 200 m of an existing access route (e.g., road, snowmobile route (James & Stuart-Smith 2000). This mortality is due to the increased use of these easy travel routes by wolves and other predators (potentially including humans).

Restoration SMA. Roads and human impacts associated with access decrease the integrity and resiliency of core and corridor areas. Where roads and other human development features occur within these CAD designations, special management guidelines should be developed to ensure the conservation of these areas, and options for the restoration of the impacted areas to natural habitats should be considered.

4.6.3.3 Matrix Areas

The landscapes and habitats falling outside of the recommended CAD and special management areas remain critical to the overall integrity and resiliency of the ecological processes and biodiversity of the Territory. As identified in the conservation values analyses (Map 15), nearly all areas of the Territory have substantial conservation value. All the lands within the Territory should be carefully managed to ensure the maintenance of ecological values.

Map 14: Core and Connectivity Areas



5. Discussion and Research Recommendations

The recommended Conservation Areas Design provides an ecological basis to prioritize landscapes for the conservation of biodiversity. The decisions of where and how much habitat to conserve represents some trade-off (if it is below 100%) of increasing risk versus precautionary management. However, using the best available science to determine where and how much land should be afforded protection can minimize biological risks and optimize the spatial configuration of conservation areas. Still, it must be recognized that, while the TRTFN CAD was developed using the best available information and analytical techniques, information gaps limited other useful analyses. Over the next two years the TRTFN and RRCS will undertake additional ecological research to better identify ecological values and priorities for conservation across the Territory.

Grey Wolf

Because a system of conservation areas is unlikely to be large enough to meet long-term conservation goals, the entire landscape should be managed to maintain ecological integrity, which includes the maintenance of disturbance regimes, focal species populations and connectivity. Soulé and associates (2003) recommend that key species, called highly interactive species such as large predators, should be maintained across all landscapes to ensure that ecological processes and structure are maintained. It has been shown in several recent studies on protected areas in North America, Canada, and East Africa, that single protected areas or parks become island-like within a landscape inhospitable to biodiversity and natural processes (Newmark 1995; Newmark 1996). These landscapes inevitably lose key species, particularly wide-ranging mammalian species. The parks or park complexes that escaped the loss of mammal species over time were exceptionally large, over 1000 km2 and usually around 10,000 km2.

It is important to point out that the above-mentioned studies do not include measurements of human activities in the landscapes surrounding the protected areas. Parks & Hartcourt (2002) found that although size of protected areas is critical, loss of species is also tightly linked to human pressures in the surrounding matrix lands (e.g., agricultural conversion, urbanization). Additionally, human pressures (i.e., hunting) inside protected areas is important in determining the fate of native biodiversity (Brashares et al. 2001). Depending on long-term land uses, formal protected status may not be required

Table 7. Percentage of land recommended for protection in a number of regions.

SOURCE	REGION	RECOMMENDED AREA
Odum (1970)	Georgia	40%
Odum and Odum (1972)	General	50%
Noss (1993)	Oregon Coast	50%
Cox et al. (1994)	Florida	33.3%
Mosquin et al. (1995)	Canada	35%
Ryti (1992)	San Diego Canyons	65%
Ryti (1992)	Islands in Gulf of California	99.7%
Margules et al. (1988)	Australian river valleys	44.9% - 75.3%
Noss (1996)	General	25% – 75%
Noss et al. (1999)	Klamath-Siskiyou	60% – 65%
Hoctor et al. (2000)	Florida	50%
Rodrigues & Gaston (2001)	Tropical region	93%
Rodrigues & Gaston (2001)	Globally	74%
Noss et al. (2002)	Greater Yellowstone Ecosystem	43%
(Solomon et al. 2003)	South Africa	>50%
Carrol et al. (In press)	US-Canada Rocky Mnts	37%

across the entire region, if environmentally sensitive management is implemented across the wider landscapes. Within these mosaic landscapes, protected or conservation areas become our insurance that biodiversity and ecological processes remain viable across the region and activities outside of protected areas largely determine whether or not long-term conservation goals are met.

A diversity of scientists and research efforts has proposed minimum targets for biodiversity conservation, either generally or for specific regions (Table 7). The implicit objective of these recommendations is to reduce extinction rates to near-background levels, maintaining the integrity of all ecosystems, and to sustain natural ecological flows and processes on a regional scale. Generally, most experts have reported that some degree of protection for at least 40-60% of the terrestrial lands and fresh waters would be required to sufficiently protect biodiversity. Using spatially-explicit population models linked to site selection procedures, Carroll and colleagues (In press) determined that at least 37% of their US-Canadian Rocky Mountain study area would need to be protected to meet population viability criteria for large carnivores (grizzly bear and wolf). Their modeling procedures preferentially selected the most productive (e.g., source – need to define in footnote?) habitats, based on estimated fecundity, mortality and connectivity parameters. In planning efforts without reliable parameter estimates coupled with spatially explicit population viability modeling, it may be impossible to select, a priori, similar critical (i.e., irreplaceable) sites in optimal configuration, and the precautionary principle dictates that higher levels of targets should be set. Solomon (2003) found that at least 50% of the habitats would need to be protected to p rovide some assurrences of maintaining viable populations of ungulates associated with Kruger National Park, South Africa.

Although it is difficult (and perhaps dangerous) to directly transform these diverse efforts into specific management prescriptions, these various research efforts do provide some general insights into the question of "how much is enough". There appears to be a general consensus that at least 40-60% of a region should receive biodiversity protection, with some scientists suggesting substantially higher levels and a few suggesting lower levels (Table 7). The actual amount of a landscape provided such protection, and the form and function of that protection will vary across regions, depending upon social, political and economic constraints. Based on the range of recommendations available, it appears that 40% would be the lower responsible limit, if data are sufficient to design optimal configurations and estimate population viability for several focal species. Higher levels would be more responsible, particularly if data are sparse or lacking on the ecological dynamics and requirements to maintain focal species, biodiversity and natural processes. In such cases, the precautionary principle dictates higher levels of protection to buffer against these uncertainties.

In many areas of western Canada and northwestern US, large predators, such as the grizzly bear, wolf or wolverine, are selected as umbrella and keystone focal species, as they require large contiguous or linked areas of high quality habitats to ensure viable populations and their removal from the system can lead to a cascade of detrimental ecological changes (Ripple & Larsen 2000; Soulé et al. 2003). For such species, population viability ideally should be assessed to determine how many individuals and populations are necessary to insure a high probability of long-term persistence across the region of interest. Although estimating population viability has been forwarded as a major objective of conservation science, the data required to accurately determine the viability of populations are usually limited or absent (Boyce 1992; Morris & Doak 2002; Shaffer 1981). Nevertheless, conservation concern has pushed scientists to provide insights into the amount of area or the population numbers needed to ensure population persistence of targeted wildlife species.

Carroll et. al. (In press) used spatially-explicit population viability analyses with limited data to assess the area requirements for wolf and grizzly bear in the BC Southern Rockies. More typically, researchers have used knowledge of genetic and demographic responses to provide minimum population estimates, and translations of those estimates into preliminary area requirements for viability. For example, in the United States, the goal of the official recovery plan for grizzly bears is an effective population of 500 individuals (i.e. adult-breeding individuals, contributing to the gene pool). Biologists assume that this number is sufficient to buffer the population against most factors contributing to regional extinction (Harris & Allendorf 1989). Even this number, though, represents an actual population size of about 2000 individuals, and some theoretical studies

Young male Grizzly on the Nakina River

(Lande et al. 1994) suggest the actual number may be considerably higher. With adequate connectivity, these animals may be distributed across multiple subpopulations, with individual movements connecting them demographically and genetically. Harris and Allendorf (1989) estimate that approximately 13 million (m) ha would be required to support a population of 2000 grizzly bears.

Grizzly bears are particularly suitable for insights into the spatial requirements for biodiversity maintenance, because their area requirements are large. If landscapes are managed for the spatial requirements needed to maintain viable and well-distributed grizzly bear populations, this management is likely sufficient for a large proportion of other biodiversity elements (see Section 3.4 for discussion). Recent research on the minimum

Wolverine

requirements to maintain grizzly bear populations across British Columbia provides potential relevant insights into the area requirements for short-term population viability within British Columbia (Wielgus 2002). Wieglus estimates that the maintenance of a single population of grizzly bears with relatively low risk of extinction over the short term (20 years) would require a starting population of at least 250 bears. Based on a range of population densities, maintenance of a population of this size would probably require somewhere between 300,000 ha and one m ha of contiguous, secure area. In order to minimize edge effects, Wieglus recommends buffers around these secure areas, increasing area requirements to between one m ha and four m ha. Additionally, a population of this size can not be expected to be viable in isolation, and should be protected within a matrix of landscapes that supports a larger, contiguous population. It would be consistent with a precautionary approach to provide protection for several (e.g. >3) of these populations, distributed across the region and connected through linkage zones (Wieglus 2002).

Comparing these suggested conservation area sizes to the proposed CAD can provide a context for our recommendations. First, we have recommended a CAD that explicitly attempts to maintain a connected landscape through a series of core and connectivity areas. This system of core and connectivity areas is identified across approximately 55% of the Territory; this level of protection falls well within the recommendation made by ecologists and conservation biologists internationally (Table 7). Second, any single recommended core area will be insufficient to maintain grizzly bears or other wide-ranging species, and thus the biodiversity values for which they function as an umbrella. The average size of a single core area within our proposed CAD is less than 25,000 ha, and the largest single core is less than 300,000 ha. The total recommended core area is 1.13 m ha, distributed across the Territory. Obviously, these core areas need to be maintained as a connected network to provide the desired level of biodiversity conservation. Our connectivity areas provide a minimum recommended set of ecological linkages connecting these core areas. Together, the core and connectivity areas identify approximately 2.14 m ha for biodiversity management. Third, as mentioned repeatedly, the CAD assumes that the matrix landscapes outside of the core and connectivity areas are managed in ways consistent with biodiversity conservation. This is also emphasized by Wieglus (2002) in examining minimum viable population sizes and areas for grizzly bears. This is particularly important in regions such as the TRTFN Territory, where ecosystem integrity and processes remain largely intact due to the wilderness nature of the region.

Finally, it must be recognized that the Territory is positioned within a matrix of pre-defined political boundaries and associated land management regimes: the US/Alaska border on the west, the Yukon border on the north, and several First Nation Territories surrounding all sides. Despite the size and largely intact nature of the Territory, it will inevitably be influenced by natural resource management practices across these diverse jurisdictions. In recognition of this, management within the Territory should be pro-active, and TRTFN should take all opportunities to advise and influence the management of natural resources both inside and outside their Territorial boundaries. For example, the woodland caribou herd of the Territory use habitats that span the BC and Yukon border and harvest and habitat management is currently delegated to these provincial or territorial governments. Obviously the decisions by these governments influence the health and viability of this important species in the Territory.

Another particularly important example of mixed jurisdiction management of a key natural resource is the harvest and management of salmon populations. The vast majority of the harvest of Taku River salmon occurs outside of the Territory – in US waters and the open ocean. Obviously, these harvest practices have an enormous influence upon the ecological health of the entire Taku watershed and beyond. Similar transboundary fisheries management interests are held for Chinook populations in the Teslin, Jennings, Gladys, and Swift River watersheds in the northern portion of the Territory, as well as the management of the large, transboundary lake systems.

The TRTFN is investing in pro-active and informed development of land and natural resource planning for their Territory. This planning is informed by the analyses and development of the TRTFN CAD, and the information sources included in it. Importantly, the traditional and indigenous ecological knowledge of the TRTFN provided a key information source for the development of the focal species habitat models, and also provided confirmation that the areas selected in the CAD are in accordance with their knowledge of where critical habitats and regions are in their Territory. The CAD recommendations will be combined with cultural, social and economic information in developing TRTFN land planning and management guidelines.

Bald Eagles

5.1 Research Recommendations

Continued advancement of the TRTFN CAD will help ensure proper management for the long-term viability and robustness of the ecological systems of the Territory by providing increasingly insightful synthesis of existing and new information. This continued refinement and advancement of the CAD as a dynamic conservation tool is critical to maintaining its usefulness as a guide for managers, particularly as new information, data, analyses and modeling approaches become available. Compared to other sciences, the science of applied conservation biology is relatively new, and technology in the collection, interpretation and analyses of ecological data for conservation of biodiversity is rapidly advancing. We make several recommendations for the advancement and improvement of the TRTFN CAD, increasing the baseline data and information sources and, importantly, for establishing a long-term ecological and environmental monitoring regime that can assist in detecting whether conservation goals and standards are being met and maintained.

5.1.1 Incorporation of Additional Ecological Data and Analysis.

Given the sparse data available, it is critical to test the robustness of the data and analyses underlying the CAD with independent data sources and/or analyses. As information and data become available, we recommend that the CAD be upgraded to include additional analyses and modeling, including:

Validation and refinement of ecological models. Presently, there has been limited opportunity to validate and refine the focal species models and the ecological landscape unit model. As more data become available through the field collections, collaboration with other scientists and agencies, and peer-review and input, these models will be validated and refined based on this information.

Expand study area boundaries. Presently, the study area is defined by the extent of the Taku River Tlingit Statement of Intent for their Territory, and, thus represents a political boundary, not an ecologically meaningful region. Fortunately, it does include the entirety of the Taku River and Whiting River watersheds, but cuts across other major watershed boundaries in an ecologically arbitrary fashion. Many ecological dynamics are bounded naturally by watersheds. We recommend that the study area be expanded to encompass the whole of Teslin watershed, thus more fully incorporating the rich aquatic processes (extensive wetlands, lake trout, salmon values) of this watershed and regional large mammal dynamics (e.g., population connectivity, regional predator-prey dynamics). This will also enable a comparison of the configuration of core and corridor areas, as influenced by the different study area boundaries.

Future landscape predictions. The recommended CAD does not consider predicted changes in human populations, future anticipated economic development activities or landscape changes due to natural succession or natural disturbance regimes. An important step in making the TRTFN CAD more robust and useful for conservation planning is the ability to examine the implications of potential landscape scenarios, including both anthropogenic and natural influences.

Spatially-explicit population viability analyses. A key information gap is the lack of population viability assessments for key focal species under the proposed CAD. We recommend that the CAD be tested against spatially-explicit population viability analyses for selected focal species, and that these analyses are explicitly included in the CAD.

Predator-prey modeling. The TRTFN Territory supports a complete and increasingly rare large mammal predator-prey system. The dynamic and complex interspecific interactions cannot be adequately captured through static species-specific habitat suitability/capability models. Therefore, we recommend that population models of large mammal predator and prey species be linked to habitat conditions and population harvest.

5.1.2 Baseline ecological information gathering and long- term monitoring.

The CAD analyses have highlighted the critical lack of baseline ecological data for the Territory. Various monitoring and research programs in wildlife, fisheries, and water quality have been initiated in response to these information gaps (Appendix C). We recommend that these programs be evaluated and prioritized for the collection of critical baseline ecological information. Efforts should focus on establishing field protocols and research that will provide long-term monitoring information on the success of conservation management efforts.

Establishing robust and meaningful ecological and environmental monitoring protocols are particularly important due to the sparse nature of the currently available data; for this region in particularly, conservation management decisions incorporate high levels of uncertainty. The field research projects mentioned above should provide the initial foundation for these long-term monitoring efforts, and significant effort has been invested in the on-going field work. Still, much additional effort will be required to develop a full-scale and robust long-term monitoring regime and meaningful measures of success.

Appendix A: Focal Species Habitat Suitability Models

A.1 Introduction and Scope of Effort

The spatial analyses and development of the TRT CAD is based partially upon the habitat needs and ecological requirements of a set of focal species; ensuring the conservation of these focal species should serve as an umbrella for the conservation of a majority of the biodiversity and ecological processes in the region (Carroll et al. 2001; Davis 1996; Lambeck 1997; Noss et al. 2002). In particular, the ecological requirements of these species should provide strategic-level guidance about the most important regions for wildlife and biodiversity maintenance across the Territory. The terrestrial focal species chosen for the TRT CAD include the grizzly bear, thinhorn sheep, moose, woodland caribou, and mountain goat. For each focal species, habitat suitability models were developed to provide insights into the location, extent, connectedness and overlap of quality habitats for each focal species.

The goal of these habitat models is to identify coarse-scale landscape patterns in focal species habitat suitability across the Territory. Our ability to model the seasonal habitat of focal species habitat is limited by our knowledge of seasonal habitat use patterns, the likely variability in those patterns across the Territory and between years, and the availability of applicable environmental GIS data for the region. There are currently few scientific data on the chosen focal species habitat use patterns in the study area. While the Province has conducted a limited radio-telemetry research (1999-present) on these focal species in the region, few of these data are available to TRTFN. The small amount of radio-telemetry data TRTFN have received has been used to provide preliminary model validation (see "Preliminary Model Validation" below).

A.2 Use of Traditional and Indigenous Ecological Knowledge of the TRTFN

The traditional and indigenous ecological knowledge (TIEK) of the Taku River Tlingit provided a key information source on the distribution, ecology, and habitat use patterns used to develop habitat suitability models for each focal species. This information was collected through a series of taped interviews with TRTFN elders and leaders during the winter and spring of 2000/2001. These interviews included a series of questions about past and present distribution of each focal species, as well as seasonal habitat use patterns. Work with maps helped identify key areas and distributional extents. Verbal descriptions of seasonal habitat use for each focal species were extracted from the transcriptions of the interviews, and provided the foundation for the development of habitat suitability models. The TIEK information was corroborated and supplemented using other existing information on each species in other, similar regions. In addition, the TRTFN obtained a limited set of radio-telemetry locations of the focal species spanning between five and nine months, collected by the BC government in a three-plus year radio-telemetry project. This limited data set was inadequate to assist with model development, but was used to provide some preliminary model validation analyses.

We combined TIEK with standard scientific methods, including conservation science theoretical understandings, spatial modeling techniques and analyses methods. As a result, the habitat models and the CAD represent a powerful combination of these two forms of ecological knowledge. This section presents the draft habitat suitability models developed for all of our focal species in the TRTFN Territory.

A.3 Use of Spatial Data in Habitat Predictions

The development of the CAD is limited and defined partially by the available spatial (GIS) data that are available for the identification of the various conservation elements. We researched and obtained the best available spatial environmental data available across the Territory. The BC Forest Inventory Project (FIP, 1:20,000) was used to identify vegetation distribution, along with the BC Biogeoclimatic Ecosystem Classification (BEC, 1:250,000) for biogeoclimatic information. The BC Terrain Resource Information Mapping database (TRIM, 1:20,000) was used to identify roads and topography. The BC Watershed Atlas (1:50,000) was the source for data related to rivers and streams, and the Fisheries Information Summary System

(FISS) was used to complement TIEK in determining salmonid species distributions and spawning areas.

We predicted over-story habitat characteristics based on the forest cover classifications, supplemented by biogeoclimatic zones. For example, classification of "open habitat" included subalpine and alpine tundra habitats from the BEC and early seral stage forests including grass/forb through shrub classes (age or height class = 0) from the forest cover maps. Slope and aspect characteristics were also used to modify the suitability of predicted vegetative cover in some instances (e.g., "warm aspects"); we have predicted these attributes using the DEM. Warm aspects were predicted as south/southwest through south/southeast-facing slopes (120 – 240 degrees). To map the distribution of salmon we used a combination of FISS data and TRTFN indigenous knowledge.

We modeled some habitat attributes referenced in the models. We predicted riparian and alluvial floodplain habitats using TRIM DEM, and the BC Watershed Atlas. These were modeled as contiguous flat areas (<= 7% slope) adjacent to rivers and streams. These flat areas were restricted to a maximum distance of 500 meters from rivers/streams, in order to separate out flat areas that are not influenced to the same degree by hydrologic forces. We modeled the distribution of avalanche chutes as areas of 'brush" forest types on or contiguous to slopes between 25 and 50 degrees.

A.4.1 Grizzly Bears Ecology and Habitat Relations in the Territory

Interviews with TRTFN hunters and elders, as well as other local Atlin citizens, documents that grizzly bears are found distributed throughout in the Territory. Several interviewees spoke of "mountain bears" inhabiting the northern portions of the Territory, where salmon are unavailable, and the "salmon" bears that heavily rely upon seasonal salmon resources, primarily in the Taku and Whiting Rivers. Bear abundance is much higher in the Taku watershed compared to the boreal systems of the northern Territory, due to high quality habitats, as well as the seasonal salmon resources. All of the interviewees indicated grizzly bears have declined in abundance, and many were particularly concerned about the dramatic reduction in grizzly bear numbers in the lower Taku River watershed. The underlying causes for these declines are unknown, but may include increased life and property defense killings, trophy hunting and/or declines in salmon returns, particularly chum salmon. Grizzly bears occur in naturally lower population densities in the northern portions of the Territory where access to salmon is limited or non-existent. It is believed that some grizzly bears travel from regions such as the northern Territory to the Taku River watershed to take advantage of the seasonal abundance of salmon protein. The wide-ranging habits of grizzly bears, their diverse seasonal habitat requirements, and their cultural and social importance to the TRTFN, as well as regionally, provincially and internationally, indicate that this species should receive special management attention.

The TRTFN TIEK provided consistent descriptions of seasonal grizzly bear habitat (Table A1). This knowledge coincides well with other information sources on bear habitats and foraging tactics. Below, we describe the key habitat features that were incorporated into the model. These assumptions are summarized in Table A2,

Table A1. Summary of grizzly bear seasonal habitat descriptions provided by 8 TRTFN elders and hunters during traditional and indigenous ecological knowledge interviews. Names of interviewees are withheld for privacy purposes.

Habitat Value	Description	Interviewees
Spring:	High, open habitat for grasses, new growth, gophers and ground squirrels	AW, BJ, DJ, GT, HC, TJ
Spring	Along river corridor: scavenging for salmon, moose carcasses, new plant growth	AW, BJ, DJ, TJ, JW
Spring	Calves of various ungulates	DJ, GT, RC, TJ, JW
Summer	Diversity of berries	AW, BJ, GT, HC, JW
Summer	Foraging along river for salmon and berries	AW, BJ, GT, HC, TJ, JW
Fall	Spawning salmon along river	AW, BJ, DJ, GT, TJ, JW
Fall	Diversity of berries	TJ, JW

Table A2. Seasonal habitat classification rules. Within each seasonal submodel, rankings are mutually exclusive with highest ranking value taking precedence. The exception to this rule is for salmon submodels, within which ranks are additive.

Season	Habitat Description	Rank
Spring General Foraging Submodel	Cottonwood floodplains, riparian habitats within salmon distribution	3
Spring General Foraging Submodel	Warm aspect (S/SE-S/SW), open slopes (alpine, subalpine, early forest seral stages (grass/forb through shrub stages) plus adjacent 1 km buffer of shrub or older seral stage forests	3
Spring General Foraging Submodel	Cottonwood floodplains, riparian habitats outside salmon distribution	2
Summer Salmon Submodel	Known sockeye, Chinook and pink spawning areas (each scored separately, even if they overlap) and adjacent 2 km buffer	3
Summer Salmon Submodel	Known sockeye, Chinook and pink distribution (each scored separately, even if they overlap) plus adjacent 2 km buffer	2
Summer Berry Submodel	Warm aspect open habitats plus adjacent 1 km buffer of shrub or older seral stage forests (security habitat)	3
Summer Berry Submodel	Warm aspect mixed conifer forests	2
Summer Berry Submodel	Cool aspect open habitats, plus adjacent 1 km buffer of shrub or older seral stage forests (security habitat)	1
Fall Salmon Submodel	Known coho and chum spawning areas and adjacent 2 km buffer	3
Fall Salmon Submodel	Known coho and chum distribution and adjacent 2 km buffer	2
Fall Salmon Submodel	Known sockeye, Chinook and pink spawning areas (each scored separately, even if they overlap) and adjacent 2 km buffer	2
Fall Salmon Submodel	Known sockeye, Chinook and pink distribution (each scored separately, even if they overlap) plus adjacent 2 km buffer	1
Fall Berry Submodel	Warm aspect open habitats and adjacent 1 km buffer of shrub and older seral stage forest	3
Fall Berry Submodel	Cottonwood floodplains, riparian habitat	2
Fall Berry Submodel	Cool aspect open habitats and adjacent 1 km buffer of shrub and older seral stage forest	1
Fall Berry Submodel	Warm aspect mixed conifer	2
Avalanche Submodel	Predicted avalanche habitats adds additional value to any habitat identified above	1

and were used to develop GIS-based algorithms to identify potential habitats and rank their relative importance in each of 3 seasonal habitat models (spring, summer, and fall). Importance of each predicted habitat association was identified through a numeric rank ranging from 3 (highest quality) to 1 (lower quality); unclassified habitats received a nil (0) score. The spring season was assumed to encompass the time from den emergence in early/mid-April through June, the summer season encompassed the earlier salmon spawning returns in July and August, while the fall season encompassed later running salmon spawning returns in September through to denning in mid/late November; thus we broke the seasons based on identified resources availability. We have not attempted to incorporate a denning habitat component into the model, as the data on denning characteristics for this region are lacking and incidental information provided through TIEK and local knowledge indicates that a wide diversity of habitats across the study region are used by grizzly bears for denning. Additionally, we have not included potential human impacts to habitat quality in this model; these impacts were included in a separate analysis in the CAD.

A.4.2 Spring Habitat (Den emergence in early/mid-April to mid-June)

Tradition and indigenous ecological knowledge of bear activities following emergence from winter den sites indicate that there is a limited diversity of foraging opportunities during this season. Bears utilize open slopes, primarily on warm (snow-fre e) aspects (particularly avalanche chutes) for early g rowing plants such as crocus and grass, as well as a variety of roots and bulbs (e.g., hedysarum).

They follow the phenology of growth from lower elevation and warmer microclimates to higher elevation subalpine and alpine habitats as the snow melts. This is very similar to documented habitat use in interior, as well as coastal habitats (Hamer et al. 1991; Mace et al. 1999; McLellan & Hovey 2001; Shoen & Beier 1990). We defined these high quality potential spring foraging habitats as south/southwest to south/southeast alpine, subalpine, or early seral forest types (through shrub stages). Highest rated of these habitats are predicted avalanche chutes. We also identified brush and forest habitats adjacent to these foraging areas as security habitat. Table A2 provides descriptions of the rules or assumptions for seasonal habitat predictions.

Additionally, TIEK indicates that bears are also commonly along the river corridor during spring, primarily focusing on scavenging over-wintered salmon carcasses, as well as several other potential food sources, including both meat (e.g., scavenging) and plant (e.g., sedges) sources. Again, such foraging tactics are widely documented in other regions (McLellan & Hovey 2001; McLoughlin et al. 2002; Shoen & Beier 1990). We modeled these habitats using TRIM, combined with forest cover to select cottonwood floodplains and riparian areas. The highest quality spring habitat rating was given to these habitats within the identified salmon distribution, while these same habitats outside of the salmon distribution were assumed to be of lower quality.

Taku River Tlingit ecological knowledge, as well as other local knowledge and research in other areas (Ballard 1990; Reynolds & Garner 1987; White & Berger 2001), indicate that grizzly bears will readily take the newborn calves of a variety of ungulate species, including moose, caribou, and goats. This high protein source may be critical to some bears in this spring season. We did not attempt to incorporate ungulate calving habitats into the grizzly bear habitat model, given the wide diversity of habitats used by the suite of ungulate species in the study area (moose, caribou, stone sheep, and mountain goat).

A.4.3 Summer Habitat (mid-June through August)

The TRTFN TIEK indicates that bears forage extensively on both berries and salmon during the summer season. While salmon provide a rich source of food for bears, and typically support the highest seasonal density of bears, habitats supporting berry-foraging is a critical alternative food resource in such salmon systems. Not only do these habitats provide an alternative or supplemental food source to salmon, but some interviewees indicated that female bears with cubs may prefer these habitats to avoid aggressive males in salmon-rich habitats. Indeed, there is growing evidence that females with cubs may avoid rich food sources, possibly to avoid encountering adult males (Demarchi et al. 2000; McLoughlin et al. 2002; Shoen et al. 1986; Wielgus & Bunnell 2000). Thus, for the summer habitat suitability model, we developed 2 submodels – the salmon submodel and the berry submodel.

Given the resolution of environmental data, as well as limited information on berry-supporting habitats, we developed general predictions of habitats that potentially support berry foraging resources. Interviewees identified a diversity of habitat types supporting berries. These included open, warm aspect habitats such as early seral stage forests, as well as subalpine and alpine habitats. We also included similar habitats on cooler aspect and warm aspect, mixed-conifer habitats as potentially supporting lower quality berry-production. Forest cover adjacent to the open (warm and cool aspect) habitats are also likely important as security habitats for open-feeding bears. Each of these habitats were identified and ranked (Table A2); habitats included in more than one berry classification were assigned the highest applicable rank. Habitats that contained avalanches received an additional score.

Traditional and indigenous ecological knowledge also indicates that salmon have high importance to grizzly bears through the summer and fall months. The salmon submodel rated summer salmon spawning areas, with a two km buffer, as the highest quality habitats. Summer salmon were assumed to include sockeye, Chinook and pink salmon species. Recognizing that our data on existing spawning areas are limited, and also that bears extensively use other, non-spawning habitats for fishing and scavenging, we additionally included the distributional extent of these three species, plus a two km buffer as potential summer habitat.

A.4.4 Fall Habitat (September-denning)

Bears continue to strongly utilize salmon resources through the fall. During this period, coho and chum salmon have historically been of key importance, according to TIEK and other local ecological knowledge, though low chum numbers presently limits bear use of this species. Plant foods, including berries, also continue to be a key resource, with some ripening berries in cooler localities, such as riparian areas. For the fall season, we again created a salmon and a berry submodel. The salmon submodel identified the known spawning areas and the distributional extent of coho and chum salmon (including a 2 km buffer) of high importance to bears in the fall. Other salmon (i.e., sockeye, Chinook and pink) spawning habitats and distributional extents, while of lower importance, were also included.

The berry habitat submodel again identified warm aspect, open habitats as supporting high berry potential. Additionally, cottonwood floodplains and riparian habitats have significant berry potential, as do warm aspect, mixed-conifer habitats. Again, avalanche chutes associated with any of these habitats resulted in a higher ranking or score.

A.4.5 Seasonal and Annual Habitat Suitability

Each seasonal habitat model was comprised of submodels, such as the spring general foraging submodel or the summer berry submodel. The seasonal suitability of any habitat was predicted as the additive score of the submodel ranks. Within each seasonal submodel, the final rank of a habitat polygon was the highest value of each of the submodel components (except salmon species, as described below). A component of a submodel, for example, would be the summer berry submodel algorithm selecting warm aspect open habitats; another component of this same submodel selected warm aspect mixed conifer forests. If, due to the resolution of the spatial data, a cell was selected in both of these query algorithms, then it would receive the highest rank of the 2 classes. The exception to this rule was for summer and fall salmon submodels, within which each species was assigned a rank independently, and these ranks were then summed to produce the submodel ranks. This results in scoring areas that support multiple salmon species higher than those that supported only a single salmon species.

Within each submodel component, ranks ranged from zero to three, and in all but the salmon submodels, final submodel ranks also ranged from zero to three. Salmon submodel ranks could be substantially higher, with the highest potential salmon submodel rank being 11, possible in the fall in areas supporting spawning all five salmon species. This high value is very unlikely, given the different spawning requirements of each species.

Final seasonal scores were the additive scores across seasonal submodels, and the predicted annual habitat suitability is the additive score of the seasonal scores. The range of scores varied between seasons, depending upon the overlap of submodel resource values. The spring habitats ranks ranged from 0 - 4, the summer ranks ranged from 0 -12 and the fall ranks ranged from 0 – 15.

Because the annual model ranks are the additive scores of the three seasonal ranks, the variable ranking of seasonal submodels results in an annual model that is biased towards summer and fall salmon habitats. We have accepted this seasonal bias in the predicted annual habitat suitability, as we feel it accurately reflects the critical nature of the summer and fall salmon sources in maintaining the grizzly bear population of this region. Additionally, the high overlap in seasonal habitats (e.g., floodplains and riparian areas) likely ensures that habitats predicted as important in the spring are appropriately identified as relatively important habitats in the annual habitat suitability predictions. The final annual habitat suitability ranks ranged from 0 – 31 (Map 5). Seasonal submodel maps can be obtained from the RRCS website (www.roundriver.org)

A.4.6 Preliminary Model Validation

For validation purposes, we generalized the results of the model outputs by reclassifying the ranked habitats into four categories: nil or low, fair quality, good quality and high quality classifications. The nil or low quality habitats did not meet any of the selected habitat criteria, and so remained unclassified (score = 0). The remaining scores (i.e., scores >0) were divided into three approximately equal-area classes, based on the total amount of classified habitat. The equal-area reclassification resulted in the merging of sequential ranks to divide the predicted habitat into three approximately equal area classes (Table A3). For most models, the "high quality" category spanned the widest range of original scores, as each of these higher scores tend to account for a very small area of actual habitat. For each of the seasonal submodels and for the annual habitat model, the reclassification is summarized in Table A3.

The validity of the model as a predictor of grizzly bear habitat quality can be evaluated by comparing the model predictions against the distribution of known grizzly bear habitat use patterns. Unfortunately, little scientific data are available for model validation purposes. To provide a preliminary assessment of the utility of the habitat model predictions, we used the limited radio-telemetry data that the TRTFN was able to obtained from the BC Ministry of

Table A3. Summary of annual and seasonal submodel ranks and reclassification of ranks, based on equal-area divisions of habitats ranked > 0.

Model or submodel	Original scores	Reclassified value	Percent of Study Area
Annual Model	0	Nil/Low quality	17.7
Annual Model	2 - 3	Fair quality	2.0
Annual Model	4 – 8	Good quality	40.4
Annual Model	9 – 31	High quality	39.9
Spring Submodel	0	Nil/Low quality	55.3
Spring Submodel	2	Fair quality	9.6
Spring Submodel	3	Good quality	32.6
Spring Submodel	4	High quality	2.4
Summer Submodel	0	Nil/Low quality	23.3
Summer Submodel	1 - 2	Fair quality	31.9
Summer Submodel	3	Good quality	33.5
Summer Submodel	4 - 12	High quality	11.3
Fall Submodel	0	Nil/Low quality	17.7
Fall Submodel	1	Fair quality	1.8
Fall Submodel	2 - 3	Good quality	67.0
Fall Submodel	4 - 15	High quality	13.7

Sustainable Resources Management. These radio-telemetry data were collected over approximately five months, from May – December, 2000, which represents only the first few months of a multi-year radio-telemetry project. The location of each animal was collected every four hours, through GPS collars, resulting in apparently high numbers of locations that could potentially hide the low number of individuals actually sampled or the relatively short sampling window. While a total of 6 animals were represented across the five-month time period, there were highly variable numbers of animals present in any season. In fact, there is only a single bear monitored in the spring (153 locations), resulting in a very poor ability to evaluate this season. Summer has the best radio-telemetry data, with six animals and 940 locations. For the fall, we had six animals and 629 locations for validation. Caution must be used in interpreting the results of this validation effort, as the radio-telemetry project sought to capture and collar bears in the northern portion of the study area, along a proposed road route. These bears may not well represent the habitat use patterns of bears in the Taku River watershed, particularly the high use of salmon resources.

We compared the distribution of predicted spring, summer, fall and annual habitats to the radio-telemetry spatial distribution (Table A4). For validation purposes, the model habitat distributions (representing the proportions of each classification available in the landscape) represent the expected distribution of bear locations, if the bears were exhibiting no habitat selection. For example, for the summer, 23.3% of the landscape remained unclassified (i.e., score = 0), and so the expected distribution of radio-telemetry points in unclassified habitat would be 23.3%. Similarly, we would expect 31.9%, 33.5% and 11.3% of the radio-telemetry points in the summer season to fall in the predicted fair, good and high quality summer habitats, respectively. If the model appropriately ranks habitat values, we would hope that a higher than expected number of bear locations falls within the higher value habitat classes. Indeed, we find that most radio-telemetry points (95.1%) fall within classified habitat, with 72.6% of them located within good and high quality habitats. The results for the other seasons (spring and fall), as well as the annual model are similar, with more than expected numbers of locations falling within the classified habitats, particularly the good and high quality habitats. Comparisons of the seasonal expected and observed distributions indicate that there are significant differences in all cases (chi-square evaluations, p-values <<0.0001 in all cases).

A.5.1 Thinhorn Sheep Ecology and Habitat Relations in the Territory

The TRTFN Territory supports both subspecies of thinhorn sheep: Stone's sheep (Ovis dalli stonei) and Dall's sheep (Ovis dalli dalli), as well as Fannin sheep, a type of Stone's sheep showing a wide diversity of color variations. Fannin sheep are considered an intergrade between Dall's and Stone's sheep, with color characteristics of both subspecies. Fannin sheep are found only in this region of BC and extending north into the

Table A4. Preliminary summer and fall submodel and annual model validation using grizzly bear radio-telemetry points, collected from May-November, 2000. Most locations were collected during the summer season (n=940) and fall seasons (629), so validation of the annual model is not seasonally unbiased. There were 1617 locations available for validation of the annual model. Expected distribution based on the amount of area covered by each of the habitat classifications. Observed distribution based on the distribution of modeled habitat values at bear locations.

Model/Category	Expected Distribution (% of Habitat Area)	Observed Distribution (% of Locations)
Spring Nil/Low Quality	55.3	35.3
Spring Fair Quality	9.6	22.2
Spring Good Quality	32.6	38.6
Spring High Quality	2.4	3.9
Summer Nil/Low Quality	23.3	4.9
Summer Fair Quality	31.9	22.5
Summer Good Quality	33.5	37.2
Summer High Quality	11.3	35.4
Fall Nil/Low Quality	17.7	7.5
Fall Fair Quality	1.8	1.3
Fall Good Quality	67.0	59.3
Fall High Quality	13.7	32.0
Annual Nil/Low Quality	17.7	5.3
Annual Fair Quality	2.0	4.7
Annual Good Quality	40.4	42.2
Annual High Quality	39.9	47.7

Table A5. Summary of habitat descriptions from TIEK interviews. A total of six people answered questions regarding sheep habitat use.

Habitat Class	Description	Interviewees
General habitat description	rocky, mountainous terrain with rock bluffs for escape terrain	BJ, DJ, GT, HC, RC, JW
Forage	Primarily forage on grasses	BJ, DJ, GT, RC, HC, JW
Winter habitat	Low snow: windswept, sunny or steep terrain	BJ, DJ, HC
Winter habitat	Lower elevation/below snow line/at tree-line	GT, TJ
Summer habitat	High elevation, rolling, open habitat; near top of mountains	BJ, DJ, GT, TJ, JW
Special need	Salt licks	AW, BJ, GT, HC, JW

Yukon Territory. TRTFN and local community members have expressed concern about sheep populations in region, due to dramatic population declines over the last few decades. Stone sheep are patchily distributed in suitable habitats from the southeastern portion of the Territory, integrating into the Fannin sheep varieties through the Atlin area and to the north. Dall's sheep (blue-listed) are found in the northwestern portion of the Territory, representing the south-western extent of Dall's sheep distribution, which is primarily within the Yukon and Alaska.

Traditional and indigenous ecological knowledge. TIEK and local interviews document that thinhorn sheep are patchily distributed in the Territory. The TRTFN TIEK describes sheep as found in steep, rocky and rugged mountainous areas with adjacent open, rolling hillsides (Table A5). Sheep primarily eat grasses, with some use of shrubby plants. While foraging, sheep remain close to cliffs and rocks for security, and move into these habitats if alarmed. During winter, sheep select habitats with low snow, while requiring the close proximity of steep, rocky areas for security. Winter habitats include high elevation, wind-blown areas; south-facing or warm aspect, steep areas or lower elevation areas below snow or at tree-line. During summer, sheep feed in areas that are greening up as the snow melts. Summer habitats are high elevation areas, typically with open, rolling topography near escape terrain. Several interviewees spoke of the importance of mineral licks to sheep.

Other information sources. Several researchers have described thinhorn sheep habitat as high elevation, dry, steep, rugged mountains characterized by subalpine grass and open shrub communities (Bowyer & Leslie 1992; Geist 1971; Rachlow & Bowyer 1998). Sheep eat primarily grasses and sedges, but also will forage on a variety of herbaceous forbs (reviewed in Bowyer et al. 2000). In winter, snow cover limits the availability of forage and Stone sheep select habitats that have less snow, either at lower elevations or in wind-blown areas (Bowyer et al. 2000; Geist 1971). Winter Dall's sheep range was described as lower, south-facing slopes by Banfield (1974). Wood (1994, as cited in Sims 1999) reports Stone sheep using southwest facing ridges in the Pesika drainage (WMR Ecosection) in winter. During summer, they inhabit alpine slopes and plateaus, gradually moving higher with the green-up of grasses and forbs. These foraging areas are always on or adjacent to precipitous terrain (reviewed in Bowyer et al. 2000 and in Sims 1999).

A.5.2 Model Development

We developed a thinhorn sheep habitat suitability model based primarily on TIEK (Table A5), supplemented with other local ecological knowledge, and existing research on thinhorn sheep in other, ecologically similar regions. Below, we describe the key habitat features that were incorporated into the model. These assumptions are summarized in Table A6, and were used to develop GIS-based algorithms to identify potential habitats and rank their relative importance in each of 2 seasonal habitat submodels. The 2 seasons were selected based on our ability to differentiate habitat preferences, and combined summer and fall into a single season (summer/fall; June – November) and winter and spring into another season (winter/spring; December – May).

Sheep are found distributed across the Territory in patches of suitable habitat that are partially defined by characteristics we did not model, including snow depth. We limited the model to regions known to historically or presently support thinhorn sheep populations, based on information obtained in TIEK and local ecological knowledge interviews. We selected all areas identified by at least 2 people as historically or presently supporting sheep.

Security Terrain. The TIEK describe sheep security habitat as including steep, rocky slopes. We adopted slope definitions used in other sheep modeling efforts to define these habitat characteristics in the GIS model. We defined high quality security terrain as slopes >30 degrees, moderate quality as slopes between 20 and 30 degrees, and unsuitable terrain as slopes of less than 20 degrees. This is very similar to the definitions used in sheep models developed in the Mountains and Plateaus and Northern Canadian Rocky Mountains Ecoregions of northern BC (Sims 1999, BC TEM Web Site, unpublished reports)

Foraging Habitat. A diversity of habitats within proximity of suitable security habitat may be utilized for forage, including open brush, grassland and other unforested habitats. We classified FIP alpine class as potential foraging habitat, as this zone consists primarily of open habitats interspersed with some small forest patches at lower elevations. Additionally, we used FIP to classify other potential foraging habitats, including early seral stage forests composed of grasses, forbs, low shrubs and high shrubs. While we cannot predict the local wind patterns through the study area, we did predict warm aspect exposures to have low snowpack. We defined "warm aspects" as south/southwest and south/southeastern slopes (120-240 degrees). During summer, foraging habitat is not limited by aspect.

Spatial Configuration. Sheep need both security habitat and suitable adjacent foraging habitats. Consequently, we modeled habitat suitability based on the quality of escape terrain (described above), and the spatial relationships between potential foraging habitats and escape terrain. While TRTFN TIEK acknowledged the importance of foraging habitats to be close to escape terrain, exact distances were not obtained. Therefore, we adopted parameters used in sheep habitat modeling efforts for other regions.

We calculated the value of any habitat based on the predicted quality of the security terrain, and the adjacency between predicted foraging habitat and security habitat. Three submodels were developed to quantify these values: a security habitat submodel that ranked all habitats based on their potential security value, a submodel that added foraging values to predicted security habitats, and a submodel that valued foraging habitat itself based on its adjacency to security habitat. These submodels were calculated for 2 seasons: winter and summer, and the final habitat suitability for any season was the additive score of the 3 seasonal submodels. The annual habitat suitability was the additive score across all seasons. In addition, because security habitat is a defining feature of sheep habitat, we allowed our model to identify and score security habitat that did not have identified foraging habitat adjacent to it.

Other security habitats that did have identified foraging habitats had additional value for this foraging value added to the security score, based on the distance to the foraging habitat. Foraging quality of escape terrain was based on the distance to the nearest foraging habitat, such that the foraging value of escape terrain was high (3) if foraging habitat was locate within 400 m, good (2) if foraging habitat was within 600 m, and fair (1) if foraging habitat was within 1000 m. Security habitat greater than 1000 m from foraging habitat received a value of zero for its foraging quality.

For foraging habitat, unlike security habitat, we did not add separately scores calculated based on escape terrain and foraging quality. The quality of foraging habitat was based solely on the distance to security habitat, such that foraging habitat within 400 m of identified escape terrain was valued as high (3), within 400 - 600 m of identified escape terrain was valued as good (2), within 600 - 1000 m of identified escape terrain was valued as fair (1), and foraging habitat greater than 1000 km from identified escape terrain received a value of zero.

Each seasonal habitat model was comprised of the three submodels and the seasonal suitability of any habitat was predicted as the additive score of the submodel ranks:

1. security habitat quality (range 0-3), plus
2. availability of foraging habitat (range 0-3), plus
3. availability of security habitat (range 0-3).

Thus, the final seasonal scores ranged from scores of 0 (unclassified) to 1 (lowest value) through 9 (highest value). The predicted annual habitat suitability is the additive score of the seasonal submodel ranks, with final scores ranging between unclassified (0), and 1 through 15 (Map 8). Seasonal submodel maps can be obtained at the RRCS website (www.roundriver.org).

A.5.3 Model Validation

For validation purposes, we generalized the results of the model outputs by reclassifying the ranked habitats into 4 categories: nil or low, fair quality, good quality and high quality classifications. The nil or low quality habitats did not meet any of the selected habitat criteria, and so remained unclassified (score = 0). The remaining scores (i.e., scores >0) were divided into 3 approximately equal-area classes, based on the total amount of classified habitat. The actual amount of area divided between the 3 categories depended upon the amount of the study area that fell within the nil/low habitat quality category, and the amount within each class varied depending upon the remaining distribution across the scores. The equal-area reclassification resulted in the merging of sequential ranks to approximately divide the predicted habitat into 3 classes. For most models, the "high quality" category spanned the widest range of original scores, as each of these higher scores tend to account for a very small area of actual habitat. For each of the seasonal submodels and for the annual habitat model, the reclassification is summarized in Table A6.

The validity of the model as a predictor sheep habitat quality can be evaluated by comparing the model predictions against the distribution of known sheep habitat use patterns. Unfortunately, little scientific data are available for model validation purposes. To provide a preliminary assessment of the utility of the habitat model predictions, we used the limited radio-telemetry data from the BC Ministry of Sustainable Resources

Table A6. Thinhorn Sheep, summary of annual and seasonal submodel ranks and reclassification of ranks, based on approximate equal-area divisions of habitats ranked > 0.

Model or submodel	Original scores	Reclassified value	Percent of Study Area
Annual Model	0	Nil/Low quality	62.4
Annual Model	1 – 4	Fair quality	20.0
Annual Model	5 – 10	Good quality	10.6
Annual Model	11 – 18	High quality	7.0
Winter Submodel	0	Nil/Low quality	68.0
Winter Submodel	1	Fair quality	10.8
Winter Submodel	2 – 4	Good quality	11.0
Winter Submodel	5 – 9	High quality	10.2
Summer Submodel	0	Nil/Low quality	62.4
Summer Submodel	1 – 2	Fair quality	9.3
Summer Submodel	3	Good quality	14.7
Summer Submodel	4 - 9	High quality	13.6

Management. These data were collected over approximately 9 months, from December 1999 - August, 2000. During this period, 5 sheep were relocated 11 to 12 times each. Of these, there were 4 – 7 locations in each of the winter and summer seasons that could be used for validation purposes. There were 23 locations (of 5 sheep) during the summer and 34 locations (of 5 sheep) during the winter that were overlaid on the predicted seasonal habitats to assess the validity of the models. These locations were combined (n = 58) to evaluate the annual habitat model.

We compared the distribution of predicted summer, winter and annual habitats to the radio-telemetry spatial distribution (Table A7). For validation purposes, the model habitat distributions (representing the proportions of each classification available in the landscape) represent the expected distribution of habitat values, if there was no selection of habitats present in the sheep locations. Thus, for the winter, we would expect that 68.0% of the sheep locations to fall in the nil habitat, 10.8%, 11.0% and 10.2% of the radio telemetry points to fall in fair, good and high quality habitat, respectively. We find that a majority (50.0%) of the goat locations in the winter fall within predicted high quality habitat and only 5.9% fall within unclassified or nil habitat (Table A7). The summer and annual models also validate well. Nearly 63% of the area was predicted to have no or low sheep habitat values in the summer, and only 8.7% of the sheep locations were found to be in these habitats. While only 13.6% of the area was predicted to have high quality habitat during summer, 43.5% of the sheep locations were within these habitats. A total of 93% of the sheep locations fell within predicted good and high quality habitat. This is compared with 17.6 % availability of these habitats. We examined the difference between the expected distribution and the observed distribution for each seasonal model and the annual model using a chi-square test. All distributions were significantly different, with p-values <<0.0001.

Table A7. Preliminary model validation using Stone's sheep radio-telemetry points, collected from December, 1999 to August, 2000. There were five sheep monitored, with a total of 23 relocations in the summer and 34 relocations in the winter. These locations were combined to evaluate the annual habitat suitability model. Expected distribution based on the amount of area covered by each of the habitat classifications. Observed distribution based on the distribution of modeled habitat values at sheep locations.

Model/Category	Expected Distribution (% of Habitat Area)	Observed Distribution (% of Locations)
Summer Nil/Low Quality	62.4	8.7
Summer Fair Quality	9.3	0
Summer Good Quality	14.7	47.8
Summer High Quality	13.6	43.5
Winter Nil/Low Quality	68.0	5.9
Winter Fair Quality	10.8	14.7
Winter Good Quality	11.0	29.4
Winter High Quality	10.2	50.0
Annual Nil/Low Quality	62.4	7.0
Annual Fair Quality	20.0	0
Annual Good Quality	10.6	26.3
Annual High Quality	7.0	66.7

A.6.1 Moose Ecology and Habitat Relations in the Territory

Moose are a principal source of meat for many TRTFN citizens as well as other local residents, and there is significant concern about moose populations in the vicinity of Atlin. This concern stems from the high hunting pressure from multiple sources, particularly in areas with vehicle access. Widespread declines of moose through the Southern Lakes region of the Yukon and British Columbia has resulted in the recent establishment of the Southern Lakes Moose Recovery Effort, a First Nation and Yukon Territory Government partnership.

Traditional and indigenous ecological knowledge. TIEK and other local interviews identify moose as closely associated with habitats that support lush willow growth, as well as other shrubby and herbaceous plants that they forage upon. Wetland habitats, including marshes, river sloughs and "weedy" lakes are used heavily, as are higher elevation (subalpine and alpine) willow patches. Burns and other open, shrubby habitats were identified as important for moose. Moose use forest cover throughout the year, but particularly during fall rutting for protection, and during the winter to escape deep snows. Seasonal habitat descriptions are consistent across the interviews, and identify a diversity of habitats used by moose throughout the year (Table A8). During winter, moose will use high elevation shrubby habitats until the snow drives them out. Through mid-winter and spring, low elevation habitats are important, including wetland associations and other open, shrubby habitats at lower elevations. Additionally, low elevation forests provide snow interception in the winter. Over the summer and through the fall, moose expand their habitat use to a wider diversity of habitats, including high elevation, shrubby habitats in alpine and subalpine areas, open slopes and burns. During this time, some moose continue to use low elevation, aquatic habitats. Security and thermal habitats are important throughout the year, but particularly during fall and winter, when moose can be found close to forest cover or within forests at tree-line or low elevation valley bottoms.

Other information sources. There has been extensive research on moose habitat use across North America, and we do not attempt to provide a thorough literature review here. In general, moose are considered generalist herbivores that browse on a diversity of herbaceous plants, leaves and new growth of shrubs and trees in summer and twigs of woody vegetation during winter (Franzmann 2000; Renecker & Schwartz 1998). Aspen, birch and willow constitute major portions of their diet across their range (Renecker & Schwartz 1998). They occupy a range of habitat types within forested communities, favouring immature forest shrubland for food, with fires creating optimal habitat 11-30 years following a burn (Kelsall et al. 1977; Schwartz & Franzmann 1989). Additionally, open habitats above timberline, along river systems and riparian willow communities are high quality habitats for moose (Coady 1982; Kelsall et al. 1977; Schwartz & Franzmann 1989). Aquatic habitats are particularly important from spring through fall seasons (Peek 1998). Dense, woody forest areas are used for cover (Cairns & Tefler 1980).

In winter, the snow may limit the availability of some habitats (Franzmann 1978; Kelsall 1969). Snow depths greater than 65 – 80 cm are avoided, and moose may move into forested habitats to avoid these deep snows (Eastman 1977). Travel may be impeded at snow depths greater than 71 cm (Kelsall 1969) Moose extensively use floodplains during severe winters, particularly if upland open areas are not present or under deep snow (Sims 1999).

During summer, moose diet includes many aquatics, forbs, grasses, and the foliage of many of the trees eaten in winter. Moose are attracted to weedy lakes, marshes and sluggish streams where they can feed on aquatic vegetation (Jordan 1987).

A.6.2 Model Development

We developed a moose habitat suitability model based primarily on TIEK, supplemented with other local ecological knowledge, and existing research on moose in other, ecologically similar regions. Below, we describe the key habitat features that were incorporated into the model. These assumptions are summarized in Table A9, and were used to develop GIS-based algorithms to identify potential habitats and rank their relative importance in each of 2 seasonal habitat submodels. The 2 seasons were selected based on our ability to differentiate habitat preferences, and combined summer and fall into a single season (summer/fall; June – November) and winter and spring into another season (winter/spring; December – May).

Importance of each predicted habitat association was identified through a numeric ranks or scores which ranged from most important (3) to least important (1). Scores are mutually exclusive such that the highest score takes precedence in the seasonal model algorithms; this rule is invoked if a habitat meets the criteria of multiple queries. We have predicted the relative importance of a diversity of habitats for each of 2 seasons; these correspond to identified seasonal foraging strategies or available resources. The annual habitat suitability is predicted through the additive score of the 2 seasons. We have not included potential human impacts to habitat quality in this model; these impacts were included in a separate analysis in the CAD.

A.6.3 Winter/Spring Habitat (November - May)

Traditional and indigenous ecological knowledge of moose indicates that there is a limited diversity of foraging opportunities during the winter and spring seasons (Table A8). Based on TIEK and other existing information, the model identifies habitats that may provide important winter habitat for moose in the region (Table A9). Early winter habitats were described as higher elevation shrubby habitats, and these were identified as both warm aspect young seral stage forests and alpine tundra adjacent to the security of forests. Warm aspect, open habitats are also used by moose in the spring, as green up proceeds following snow melt. Most highly rated of these

Table A8. Summary of habitat descriptions from TIEK interviews with TRTFN hunters and elders. A total of eight people answered questions regarding moose habitat use.

Habitat Class	Description	Interviewees
Spring habitat	Near water, marshes, thick aquatic vegetation or on islands (for calve protection	BJ, DJ, HC, GT RC, TJ, JW
Spring habitat	Open slopes for green up	AW, BJ, GT, HC, TJ, JW
Summer habitat	Valley bottoms, marshes; aquatic and riparian vegetation including willow	BJ, DJ, GT, RC, TJ
Summer habitat	Higher elevation, open slopes with green up; willow	BJ, GT, RC
Fall habitat	Subalpine and alpine areas for rut and forage on willows	AW, BJ, DJ, GT, TJ, JW
Winter habitat	Low elevation marshes, open areas for alder/willow	AW, GT, TJ
Winter habitat	High elevation open for willow until snow drives out	BJ, DJ, GT, TJ
Winter habitat	Low elevation trees/forest	BJ, TJ
Security/thermal habitat	Inside trees/inside tree-line	AW, BJ, GT, JW

is alpine tundra within 200 m of forest cover, while tundra more distant to forests received lower ratings. It was assumed that alpine tundra habitats greater then 2 km from forest had little or no value for moose.

In mid- to late winter, deep snows may drive moose to lower elevations. Low elevation habitats associated with aquatic habitats are also important in the spring. Valley bottom wetland habitats and young, seral stage forests that support shrub habitats are rated high quality habitat. Valley-bottom forests were also identified as high quality winter habitats. Aspen forests are used, and are identified as good quality habitat for moose during winter. High quality security habitats were identified as mature forests (>80 years old) within 1 km of identified foraging habitats (as described above). Lower quality security habitats were younger forests that were at least 6 m high. These definitions draw upon, and are very similar to, other moose habitat modeling efforts in other regions, including the Mountains and Plateaus, and Northern Canadian Rocky Mountains Ecoregions of northern BC (Sims 1999, BC TEM Web Site, unpublished reports).

A.6.4 Summer/Fall Habitat (mid-June through August)

Traditional and indigenous ecological knowledge and other information indicate that moose occupy a wide range of potential habitats during the summer and fall period. In particular, aquatic habitats are important, and such areas are identified as high quality summer moose habitat. Additionally, open, shrubby (e.g., burns) are used extensively, and are identified, with the highest quality assumed to be in valley bottoms or on warm aspect slopes. During summer and particularly during fall, high elevation habitats are important. Fall rut occurs in these open habitats, and TIEK emphasized the importance of adjacent forests for security. Similar to the early winter season, we identified open alpine tundra habitats adjacent to forests as high quality habitats, with more distant open habitats having less value. Also, mature forests provide security and thermal relieve, and those forests within 1 km of identified summer foraging habitats (as described above) were ranked as additional high quality habitat for moose. Younger forests (>6 m high) have security/thermal values for moose and are identified as a lower quality.

A.6.5. Seasonal and Annual Model Results

The final seasonal scores ranged from scores of 0 (unclassified) to 1 (lowest value) through 3 (highest value). The predicted annual habitat suitability is the additive score of the seasonal submodel ranks, with final scores ranging between unclassified (0), and 1 through 6 (Map 7). Seasonal submodel maps can be obtained at the RRCS website (www.roundriver.org).

A.6.6 Model Validation

For validation purposes, we generalized the results of the model outputs by reclassifying the ranked habitats into four categories: nil or low, fair quality, good quality and high quality classifications. The nil or low quality habitats did not meet any of the selected habitat criteria, and so remained unclassified (score = 0). The remaining scores (i.e., scores >0) were divided into three approximately equal-area classes, based on the total amount of classified habitat (Table A10). The actual amount of area divided between the three categories depended upon the amount of the study area that fell within the nil/low habitat quality category, and the amount within each class varied depending upon the remaining distribution across the scores. The reclassification resulted in the merging of sequential ranks to divide the predicted habitat into three approximately equal-area classes. For most models, the "high quality" category spanned the widest range of original scores, as each of these higher scores tend to account for a very small area of actual habitat.

The validity of the model as a predictor of moose habitat quality can be evaluated by comparing the model predictions against the distribution of known moose habitat use patterns. Unfortunately, little scientific data are available for model validation purposes. To provide a preliminary assessment of the utility of the habitat model predictions, we used the limited radio-telemetry data from the BC Ministry of Sustainable Resources Management. These radio-telemetry data were collected over approximately 9 months, from December 1999 - August, 2000. Locations of animals were obtained approximately every 2- 4 weeks during this period. There were 35 animals in the winter with 2 – 10 relocations each, for a total of 277 pooled locations. In the summer, there were 32 animals with 2 – 5 relocations each, for a total of 156 pooled locations. Combined the 35 animals were relocated 5 – 15 times over the 9 month period, for a total of 433 pooled locations for preliminary validation of the annual habitat model.

For validation purposes, the model habitat distributions (representing the proportions of each classification available in the landscape) represent

Table A9. Seasonal habitat classification rules. Within each seasonal model, rankings are mutually exclusive with highest ranking value taking precedence. The thermal model was applied to each season.

Season	Habitat Description	Rank
Winter/Spring Model	Wetland habitat and other valley bottom open, shrub habitats	3
Winter/Spring Model	Valley-bottom forests	3
Winter/Spring Model	Warm aspect (S/SE-S/SW), open slopes through the subalpine, including early forest seral stages (grass/forb through shrub stages)	2
Winter/Spring Model	Aspen forests (aspen 1st or 2nd leading species)	2
Winter/Spring Model	Alpine tundra within 200m of forest	3
Winter/Spring Model	Alpine tundra within 1 km of forest	2
Winter/Spring Model	Alpine tundra within 2 km of forest	1
Winter/Spring Model	Cool aspect (NE-NW), open slopes through the subalpine, including early forest seral stages (grass/forb through shrub stages)	1
Summer/Fall Model	Wetland habitat and other valley bottom open, shrub habitats	3
Summer/Fall Model	Warm aspect (S/SE-S/SW), open slopes through the subalpine, including early forest seral stages (grass/forb through shrub stages)	3
Summer/Fall Model	Cool aspect (NE-NW), open slopes through the subalpine, including early forest seral stages (grass/forb through shrub stages)	2
Summer/Fall Model	Aspen forests (with aspen as leading or second-leading species)	1
Summer/Fall Model	Alpine tundra within 200m of forest	3
Summer/Fall Model	Alpine tundra within 1 km of forest	2
Summer/Fall Model	Alpine tundra within 2 km of forest	1
Security/Thermal Model	Security habitat: mature forests (>80 years old) within 1 km of identified foraging habitat	3
Security/Thermal Model	Security habitat: >6m high forests within 1 km of identified foraging habitat	1

the expected distribution of moose locations, if the moose were exhibiting no habitat selection (Table A10). For example, for the winter, 27.1% of the landscape remained unclassified (i.e., score = 0), and so the expected distribution of radio-telemetry points in unclassified habitat would be 27.1%. The remaining habitat was classified either as fair, good or high quality, with 13.9%, 15.1%, and 44.0%, respectively. If the model appropriately ranks habitat values, we would hope that a higher than expected number of moose locations falls within the higher value habitat classes.

Indeed, we found only 15.5% of the moose locations located in unclassified habitat in the winter, and the majority of the locations (54.5%) were found in predicted high quality habitat. The summer and annual models also validate well. While 47.7% of the area was predicted to have high quality habitat during summer, 66.7% of the moose locations were within these habitats. For the annual habitat suitability model, a total of 84.5% of the moose locations fell within classified habitat, which constitutes 74.8% of the landscape. The majoring of the relocations (57.7%) fell within predicted annual high quality habitat (44%

Table A10. Preliminary summer submodel and annual model validation using moose radio-telemetry points, collected from December 1999 - August 2000 on 15 moose. There were 433 pooled locations available for validation of the annual model, 156 for the summer submodel and 277 for the winter submodel. Expected distribution based on the amount of area covered by each of the habitat classifications. Observed distribution based on the distribution of modeled habitat values at moose locations.

Model/Category	Original scores	Expected Distribution (% of Habitat Area)	Observed Distribution (% of Locations)
Summer Nil/Low Quality	0	25.2	17.9
Summer Fair Quality	1	12.4	10.3
Summer Good Quality	2	14.6	5.1
Summer High Quality	3	47.7	66.7
Winter Nil/Low Quality	0	27.1	15.5
Winter Fair Quality	1	13.9	17.3
Winter Good Quality	2	15.1	12.6
Winter High Quality	3	44.0	54.5
Annual Nil/Low Quality	0	25.2	15.4
Annual Fair Quality	1-3	17.8	17.8
Annual Good Quality	4-5	13.0	9.0
Annual High Quality	6	44.0	57.7

of landscape). We examined the difference between the expected distribution and the observed distribution for each seasonal model and the annual model using a chi-square test. All distributions were significantly different, with p-values <<0.0001.

A.7.1 Woodland Caribou Ecology and Habitat Relations in the Territory

Caribou in British Columbia belong to the woodland subspecies (Rangifer tarandus caribou), but they can be further divided into two different ecotypes, mountain ecotype and northern ecotype (Cumming 1992; Poole et al. 2000). Mountain caribou are found in southeastern BC and spend much of the year at high elevations in subalpine forest and alpine habitats. Deep snow prevents them from cratering for terrestrial forage in winter so they rely primarily on arboreal lichens for winter food. Northern caribou are found in the northern and west-central areas of the Province. They generally inhabit mountainous areas in summer, and use low elevation pine forests or windswept alpine areas during winter (Wood 1996). The low snow depths in those habitats allow them to crater for terrestrial lichens (Seip & Cichowski 1996).

Traditional, indigenous and local knowledge indicates that all of the caribou in the Taku River Tlingit Traditional Territory are the northern ecotype. These herds rely upon low-elevation mature pine forests in the winter, and use a range of high elevation alpine and subalpine habitats in the summer. Lichens are the critical winter food source for caribou; because lichen are very slow growing, the highest densities of lichen are associated with older pine forests. In years when snow conditions make cratering difficult or unproductive, the caribou may move to high elevation, open habitats that have been wind-cleared of snow.

The ranges of three caribou herds overlap the Territory – the Level-Kawdy, the Atlin, and the Carcross/Squanga herds. The Level-Kawdy herd occurs in the southeastern portion of the Territory (Horn & Tamblyn 2001). The Atlin and Carcross/Squanga herds, along with the Ibex herd in the Yukon, are known as the Southern Lakes caribou population. Widespread declines in the Southern Lakes population prompted a recovery program for these herds in 1992 by First Nations and the Yukon and BC governments to increase numbers to historic levels, which would be in the order of thousands of animals. The Yukon government has protected the Southern Lakes herds from hunting. Additionally, First Nations, including the TRTFN, have voluntarily stopped hunting these caribou in support of the recovery effort initiative. British Columbia issues limited entry permits for bull caribou.

A.7.2 Model Development

We developed a woodland caribou habitat suitability model based primarily on TIEK, supplemented with other local ecological knowledge and existing research on woodland caribou in other, ecologically similar regions. Below, we

Table A11. Seasonal habitat classification rules. Within each seasonal submodel, rankings are mutually exclusive with highest ranking value taking precedence.

Season	Habitat Description	Rank
Summer	Alpine	3
Summer	Subalpine	2
Winter	Old (>80 years old) pine forest	9
Winter	Old (>80 years old) mixed conifer forest within 2 km to old pine forest	6
Winter	Mature (50-80 years old) pine forest	4
Winter	Old (>80 years old) spruce-dominated forest	4
Winter	Warm aspect alpine	3
Winter	Warm aspect subalpine	2

describe the key habitat features that were incorporated into the model. These assumptions are summarized in Table A11, and were used to develop GIS-based algorithms to identify potential habitats and rank their relative importance in each of 2 seasonal habitat submodels. The 2 seasons were selected based on our ability to differentiate habitat preferences, and combined summer and fall into a single season (summer/fall; June – November) and winter and spring into another season (winter/spring; December – May).

Importance of each predicted habitat association was identified through a numeric rank which was weighted based on the season. Because winter habitats have been identified as critical and potentially limiting, we heavily weighted this season compared to the summer/fall season. The ranking ranged from 9 (highest value) to 1(lower quality) in the winter/spring, but only from 3 to 1 in the summer/fall; unclassified habitats received a nil (0) score. We predicted the relative importance of a diversity of habitats for each of the two seasons; these correspond to identified seasonal foraging strategies or available resources. The annual habitat suitability is predicted through the additive score of the seasonal models. The ranking used in each season results in a 3x weighting of winter habitats compared to summer habitats in the annual habitat suitability model. We did not include potential human impacts to habitat quality in this model; these impacts were included in a separate analysis in the CAD.

Caribou distribution is limited in their winter range by snow conditions as well as habitat quality. We used mapping conducted by the Ministry of Environment Lands and Parks (2000) to define the extent of the caribou distribution within the study area. The MELP mapping project identified the relative capacity of habitats to support caribou, based on a benchmark habitat capability. We selected areas in the TRTFN Territory that met or exceeded 25% of the benchmark potential (Figure 2).

A.7.3 Summer/Fall Season (May – November)

All information sources indicate that northern woodland caribou range widely in high elevation open alpine and subalpine habitats during the summer months. While interviews with TRTFN citizens and local Atlin community members indicated that some fine-scale habitat characteristics are important, such as remnant snow and ice patches, we were unable to include these in the habitat model. Therefore, the summer habitat model is very general, and selects alpine habitats as the highest quality potential habitat (3) and subalpine as a moderately valuable (2) habitat (Table A11).

A.7.4 Winter/Spring Season (December – April)

During winter, the northern woodland caribou primarily feed upon terrestrial lichen, found in old lodgepole pine (Pinus contorta) forests in the study area. We selected lodgepole pine forest stands >80 years old from the BC Forest Cover and ranked these forests as high quality (9) winter/spring habitat. Additionally, we selected old (>80 yrs) mixed conifer habitats that were adjacent to these old pine stands as moderately high quality winter habitat (6). Because younger pine stands, as well as old spruce forest can provide forage areas for wintering caribou, we also placed a moderate value on these stands (4). During some time periods over some winters, the lichens in these forests are unavailable to caribou due to snow conditions, or potentially predator or other disturbances. During these times, caribou may move to high elevation open habitats, and forage on terrestrial lichens in wind-exposed areas. We selected south/southwest-south/southeast alpine (3) and, secondarily, subalpine (2) to represent these potential alternative winter habitats. Habitat assumptions and rankings are summarized in Table A11.

A.6.5. Seasonal and Annual Model Results

The final seasonal scores ranged from scores of 0 (unclassified) to 1 (lowest value) through 3 (highest value) for the summer/fall submodel and from 0 (unclassified) to 1 (lowest value) through 9 (highest value) in the winter/spring submodel. The predicted annual habitat suitability is the additive score of the seasonal submodel ranks, with final scores ranging between unclassified (0), and 1 through 12 (Map 6). The annual ranks are biased towards high value winter habitat, reflecting our assumption that these habitats are critical to the maintenance and health of the woodland caribou in the Territory. Seasonal submodel maps can be obtained at the RRCS website (www.roundriver.org).

A.7.5 Model Validation

For validation purposes, we generalized the results of the model outputs by reclassifying the ranked habitats into four categories: nil or low, fair quality, good quality and high quality classifications. The nil or low quality habitats did not meet any of the selected habitat criteria, and so remained unclassified (score = 0). The remaining scores (i.e., scores >0) were divided into three approximately equal-area classes, based on the total amount of classified habitat. The actual amount of area divided between the three categories depended upon the amount of the study area that fell within the nil/low habitat quality category, and the amount within each class varied depending upon the remaining distribution across the scores. The equal-area reclassification resulted in the merging of sequential ranks to approximately divide the predicted habitat into three classes. For most models, the "high quality" category spanned the widest range of original scores, as each of these higher scores tend to account for a very small area of actual habitat. For each of the seasonal submodels and for the annual habitat model, the reclassification is summarized in Table A12.

Table A12. Summary of annual and seasonal submodel ranks and reclassification of ranks, based on approximate equal-area divisions of habitats ranked > 0.

Model or submodel	Original scores	Reclassified value	Percent of Study Area
Annual Model	0	Nil/Low quality	18.9
Annual Model	2 - 3	Fair quality	35.3
Annual Model	4 – 6	Good quality	33.7
Annual Model	7 - 12	High quality	12.1
Summer/Fall Submodel	0	Nil/Low quality	37.5
Summer/Fall Submodel	1	Fair quality	0
Summer/Fall Submodel	2	Good quality	43.3
Summer/Fall Submodel	3	High quality	19.2
Winter/Spring Submodel	0	Nil/Low quality	54.2
Winter/Spring Submodel	2 - 3	Fair quality	16.2
Winter/Spring Submodel	4	Good quality	8.3
Winter/Spring Submodel	6 - 9	High quality	21.4

The validity of the model as a predictor caribou habitat quality can be evaluated by comparing the model predictions against the distribution of known caribou habitat use patterns. Unfortunately, little scientific data are available for model validation purposes. To provide a preliminary assessment of the utility of the habitat model predictions, we used the limited radio-telemetry data that the TRTFN obtained from the BC Ministry of Sustainable Resources Management. These radio-telemetry data were collected over approximately nine months, from December 1999 - August, 2000. Locations of animals were obtained approximately every two to four weeks during this period. There were 17 animals in each season that had at least three locations obtained during the season. We pooled all animal locations within a season for preliminary validation purposes, resulting in 83 summer locations and 110 winter locations.

For validation purposes, the model habitat distributions (representing the proportions of each classification available in the landscape) represent the expected distribution of caribou locations, if the caribou were exhibiting no habitat selection. For example, for the winter, 54.2% of the landscape remained unclassified (i.e., score = 0), and so the expected distribution of radio-telemetry points in unclassified habitat would be 54.2%. The remaining habitat was classified either as fair, good or high quality, with 16.2%, 8.3%, and 21.4%, respectively (Table A13). If the model appropriately ranks habitat values, we would hope that a higher than expected number of caribou locations falls within the higher value habitat classes.

We find that in the winter season, 47.2% of the caribou locations are within predicted high quality habitat, higher than the expected 21.4% (Table A13). There are fewer than expected locations within unclassified habitat, with 40.8% of the locations, though we would have hoped to minimize this further. The summer submodel captured 51.5% of the summer caribou locations within high quality habitat, much higher than the expected 19.2%. The summer model captured a total of 95.6% of the locations within good or high quality habitat, as compared to the expected 62.5%, based on the model distributions. The full model, which is the additive score of the 2 seasonal submodels, captures 20.6% of the radiolocations within high quality habitat, higher than the 12.1% expected, but generally the expected proportions of locations fall within the fair and good quality habitats.

Table A13. Preliminary summer submodel and annual model validation using caribou radio-telemetry points, collected from December 1999 - August 2000. There were 193 locations available for validation of the annual model, 68 for the summer submodel and 125 for the winter submodel. Expected distribution based on the amount of area covered by each of the habitat classifications. Observed distribution based on the distribution of modeled habitat values at caribou locations.

Model/Category	Expected Distribution (% of Habitat Area)	Observed Distribution (% of Locations)
Summer Nil/Low Quality	37.5	4.4
Summer Good Quality	43.3	44.1
Summer High Quality	19.2	51.5
Winter Nil/Low Quality	54.2	40.8
Winter Fair Quality	16.2	7.2
Winter Good Quality	8.3	4.8
Winter High Quality	21.4	47.2
Annual Nil/Low Quality	18.9	14.4
Annual Fair Quality	35.3	32.0
Annual Good Quality	33.7	33.0
Annual High Quality	12.1	20.6

A.8.1 Mountain Goat Ecology and Habitat Relations

The genus Oreamnos is represented by a single extant species, O. americanus, or the mountain goat, found only on the North American continent. The mountain goat is a rupicaprid or goat-antelope, with its closest relatives including the chamoise of the European Alps and the goral and takin of the Asia (Rideout & Hoffmann 1975). This group of ungulates is ancestral to caprids, the sheep and true goats (Peek 2000). The mountain goat occupies steep, rugged terrain in the mountains of northwestern North America, with native populations in British Columbia, the northern Cascades of Washington and the northern Rocky Mountains of Montana and Idaho. Additionally, there are various populations that have been introduced in areas outside the known native range in the United States (Chadwick 1983).

Traditional and indigenous ecological knowledge. TIEK and other local interviews document that mountain goats are distributed across the Territory in suitable habitats. TIEK provided consistent descriptions of mountain goat habitat (Table A14). Generally, goats are found in steep, rocky and rugged mountainous areas. Food includes grasses and forbs, as well as brush such as willows; general foraging habitat was described as open habitats at high elevations and brushy habitats at lower elevations. While foraging, goats remain close to cliffs and rocks for security, and move into these habitats if alarmed. Several TRTFN interviewees described goat habitat use during winter. Goats are described as moving to lower elevations during periods of snow, including selecting areas just below snowline in the early winter and the use of forests, particularly at tree-line when the snow is deep. Additionally, goats are described as using areas of low snow pack, such as on warm aspects, in wind-blown areas or steep terrain. Lambing occurs in the more rugged areas, which provide the kids with security. During summer, goats remained tied to security habitat, but generally use a wider diversity of habitats than are available during the winter months.

Table A14. Summary of habitat descriptions from TIEK interviews with TRTFN hunters and elders. A total of 8 people answered questions regarding goat habitat use.

Habitat Class	Description	Interviewees
General habitat description	Steep, rough, rocky, mountainous terrain	AW, BJ, DJ, GT, HC, RC, TJ, JW
Forage/Forage habitats	Grasses and forbs	AW, DJ, GT, HC, RC
Forage/Forage habitats	Brushy, open habitats	BJ, DJ, GT, HC, RC
Forage/Forage habitats	Open hillsides/grassy openings	HC, GT, JW
Winter habitat	Low snow: windswept, sunny or steep terrain	BJ, GT, HC
Winter habitat	Lower elevation/below snow line	BJ, DJ, GT, HC, TJ
Winter habitat	Trees, tree-line, forest	DJ, TJ, JW
Lambing habitat	Rugged, rocky areas for security	JW, RC, HC, GT
Summer habitat	Wider range of elevations/habitats (than winter)	DJ, HC, GT, JW

Table A15. Characteristics of reported mountain goat winter habitats

Characteristic	Description	Location
Slope	>100% >67%	Interior BC[1,2]; Alaska[3] Montana[4], Washington[5], Wyoming[6]
Aspect	SE-SW E, SW S-W	Alaska[3], Colorado[7] Washington[8] Interior BC[1,2]
Distance to security habitat	<400m <800m	Interior BC[1,2]; Alaska[3]; Wyoming[5]; Alberta[8] Washington[4]

1 (Sims 1999)
2 (Poole & Mowat 1997)
3 (Fox et al. 1989; Lowell et al. 1988; Smith 1986)
4 (Joslin 1986), as cited in Peek (2000)
5 (Johnson 1983), as cited in Peek (2000)
6 (Haynes 1992)
7 (Adams & Bailey 1982; Gross et al. 2002)
8 (McFetridge 1977), as cited in Peek (2000)

Other information sources. The general habitat patterns described by TRTFN TIEK are very similar to those described for goats in other regions. In particular, it has been noted that the availability of winter range may be limited for many mountain goat populations (Fox & Smith 1988; Poole & Mowat 1997; Sims 1999). Winter habitats may be low elevation habitats where snow accumulation is low, or high elevation habitats where wind, sun or precipitous terrain adequately shed snow from foraging habitats. Additionally, in deep snow areas, mature, closed canopy forest adjacent to security habitat may be critical forage and shelter areas for goats in the winter. The characteristics of winter habitat vary across goat range, likely due to the variable conditions that may cause snow to be removed (Table A15; summarized in Peek 2000). Research in other areas have also found that south-facing slopes are heavily used, with variable use of aspects that are westerly or easterly, dependent upon local conditions. Slopes are typically greater than 65% in most studies. The habitats used by goats for foraging are highly variable, but are typically found within 400m of security terrain, and include many types of open habitats. Calving typically occurs in or closely associated with winter range. During the summer, habitats are more widely available, and limited primarily by the need to have security habitat in close approximation to foraging habitats (Fox et al. 1989; Gross et al. 2002; Lowell et al. 1988; Sims 1999).

A.8.2 Model Development

We developed the habitat model based on TIEK, supplemented with information from other sources, where needed. In particular, specific parameters, such as degrees slope to define the "steepness" of security habitats, have been extracted from existing literature. Below, we describe the key habitat features that were incorporated into the model.

A.8.3 Security Terrain

The TIEK describe goat habitat as including steep, rocky slopes that provide security habitat for mountain goats. We adopted slope definitions used in other goat modeling efforts to define these habitat characteristics in the GIS model. We defined high quality security terrain as slopes >100%, and moderate quality as slopes between 67-100%. Slopes less than 67% were considered to not provide suitable security habitat for mountain goats.

A.8.4 Foraging Habitat

A diversity of habitats within proximity of suitable security habitat may be utilized for forage, including open brush, grassland and other unforested habitats. Additionally, in areas with deep snow, mature forests adjacent to security habitat may provide critical shelter from deep snows. We classified foraging habitat using on 2 data bases. Biogeoclimatic "alpine tundra" zone defined as potential foraging habitat, as this zone consists primarily of open habitats interspersed with some small forest patches at lower elevations. Additionally, we used the land cover data to classify other potential foraging habitats located within other biogeoclimatic zones. These included early seral stage forests composed of grasses, forbs, low shrubs and high shrubs, as well as nonforested brush habitats and mature (>80 yo) forests. While we cannot predict the local wind patterns through the study area, we did predict southern exposures to have low snowpack (as described above for TRTFN TIEK and also in other regions). We defined "warm aspects" as south/southwest and south/southeastern slopes (120-240 degrees). During summer, foraging habitat is not limited by aspect.

A.8.5 Spatial Configuration

Goats need both security habitat and suitable adjacent foraging habitats. Consequently, we modeled habitat suitability based on the quality of escape terrain (described above), and the spatial relationships between potential foraging habitats and escape terrain. While TRTFN TIEK acknowledged the importance of foraging habitats to be close to escape terrain, exact distances were not obtained. Therefore, we adopted parameters used in goat habitat modeling efforts for other regions (Sims 1999; Suring et al. 1998).

We calculated the value of any habitat based on the predicted quality of the security terrain, and the adjacency between predicted foraging habitat and security habitat. Three submodels were developed to quantify these values: a security habitat submodel that ranked all habitats based on their potential security value, a submodel that added foraging values to predicted security habitats, and a submodel that valued foraging habitat itself based on its adjacency to security habitat. These submodels were calculated for 2 seasons: winter and summer, and the final habitat suitability for any season was the additive score of the 3 seasonal submodels. The annual habitat suitability was the additive score across all seasons.

Because security habitat is a defining feature of goat habitat, we allowed our model to identify and score security habitat that did not have identified foraging habitat adjacent to it. Other security habitats that did have identified foraging habitats had additional value for this foraging value added to the security score, based on the distance to the foraging habitat. Foraging quality of escape terrain was based on the distance to the nearest foraging habitat, such that the foraging value of escape terrain was high (3) if foraging habitat was locate within 400 m. The foraging quality was classified as good (2) if foraging habitat was within 600 m, and as fair (1) if foraging habitat was within 800 m. Security habitat received a value of zero for its foraging quality if foraging habitat was greater than 800 m away. The foraging score was added to the security score to calculate the overall winter habitat quality of escape terrain.

For foraging habitat, unlike security habitat, we did not add separately scores calculated based on escape terrain and foraging quality. The quality of foraging habitat was based solely on the distance to security habitat, such that foraging habitat within 400 m of identified escape terrain was valued as high (3), within 400 - 600 m of identified escape terrain was valued as good (2), within 600 - 800 m of identified escape terrain was valued as fair (1), and foraging habitat greater than 800 km from identified escape terrain received a value of 0.

Table A16. Summary of annual and seasonal submodel ranks and reclassification of ranks, based on equal-area divisions of habitats ranked > 0.

Model or submodel	Original scores	Reclassified value	Percent of Study Area
Annual Model	0	Nil/Low quality	55.8
Annual Model	1 – 4	Fair quality	26.7
Annual Model	5 – 10	Good quality	13.4
Annual Model	11 – 15	High quality	5.1
Winter Submodel	0	Nil/Low quality	59.7
Winter Submodel	1	Fair quality	17.6
Winter Submodel	2 – 4	Good quality	12.4
Winter Submodel	5 – 9	High quality	10.3
Summer Submodel	0	Nil/Low quality	63.8
Summer Submodel	1 – 2	Fair quality	6.5
Summer Submodel	3	Good quality	17.4
Summer Submodel	4 - 9	High quality	12.3

Table A17. Preliminary summer submodel and annual model validation using mountain goat radio-telemetry points, collected from December 1999 - August 2000. There were 278 locations available for validation of the annual model, 98 for the summer submodel and 180 for the winter submodel. Expected distribution based on the amount of area covered by each of the habitat classifications. Observed distribution based on the distribution of modeled habitat values at caribou locations.

Model/Category	Expected Distribution (% of Habitat Area)	Observed Distribution (% of Locations)
Summer Nil/Low Quality	63.8	20.4
Summer Fair Quality	6.5	3.0
Summer Good Quality	17.4	28.6
Summer High Quality	12.3	48.0
Winter Nil/Low Quality	59.7	8.9
Winter Fair Quality	17.6	10.6
Winter Good Quality	12.4	27.2
Winter High Quality	10.3	53.3
Annual Nil/Low Quality	55.8	11.0
Annual Fair Quality	26.7	27.0
Annual Good Quality	13.4	30.0
Annual High Quality	5.1	32.0

Each seasonal habitat model was comprised of the submodels and the seasonal suitability of any habitat was predicted as the additive score of the submodel ranks:

4. security habitat quality (range 0-3), plus
5. availability of foraging habitat (range 0-3), plus
6. availability of security habitat (range 0-3)

Thus, the final seasonal scores ranged from scores of 0 (unclassified) to 1 (lowest value) through 9 (highest value). The predicted annual habitat suitability is the additive score of the seasonal submodel ranks, with final scores ranging between unclassified (0), and 1 through 15 (Map 9). Seasonal submodel maps can be obtained from the RRCS website (www.roundriver.org).

A.8.6 Model Validation

For validation purposes, we generalized the results of the model outputs by reclassifying the ranked habitats into 4 categories: nil or low, fair quality, good quality and high quality classifications. The nil or low quality habitats did not meet any of the selected habitat criteria, and so remained unclassified (score = 0). The remaining scores (i.e., scores >0) were divided into 3 approximately equal-area classes, based on the total amount of classified habitat. The actual amount of area divided between the 3 categories depended upon the amount of the study area that fell within the nil/low habitat quality category, and the amount within each class varied depending upon the remaining distribution across the scores. The reclassification resulted in the merging of sequential ranks to divide the predicted habitat into 3 approximately equal-area classes. For most models, the “high quality” category spanned the widest range of original scores, as each of these higher scores tend to account for a very small area of actual habitat. For each of the seasonal submodels and for the annual habitat model, the reclassification is summarized in Table A16.

The validity of the model as a predictor of goat habitat quality can be evaluated by comparing the model predictions against the distribution of known goat habitat use patterns. Unfortunately, little scientific data are available for model validation purposes. To provide a preliminary assessment of the utility of the habitat model predictions, we used the limited radio-telemetry data from the BC Ministry of Sustainable Resources Management. These data were collected over approximately 9 months, from December 1999 - August, 2000. Locations of animals were obtained approximately every 2- 4 weeks during this period. During this period, 24 goats were relocated a total of 276 times. Of these, there were 20 goats monitored relatively infrequently over the summer/fall season, for only 56 relocations. During the winter/spring, 24 goats were relocated more frequently, with a total of 217 relocations.

We compared the distribution of predicted summer, winter and annual habitats to the radio-telemetry spatial distribution (Table A17). For validation purposes, the model habitat distributions (representing the proportions of each classification available in the landscape) represent the expected distribution of habitat values, if there was no selection of habitats present in the mountain goat locations. Thus, for the winter, we would expect that 59.7% of the goat locations to fall in the nil habitat, 17.6%, 12.4% and 10.3% of the radio telemetry points to fall in fair, good and high quality habitat, respectively.

We find that a majority (53.3%) of the goat locations in the winter fall within predicted high quality habitat and only 8.9% fall within unclassified or nil habitat (Table 4); a much higher percentage of goat locations fall within predicted high quality habitats than would be expected based on the availability of those habitats. The summer and annual models also validate well. Nearly 64% of the area was predicted to have no or low goat habitat values in the summer, and only 20.4% of the locations were found to be in these habitats. While only 12.3% of the area was predicted to have high quality habitat during summer, 48% of the goat locations were within these habitats. A total of 89% of the goat locations fell within classified habitat in the annual model, of which 62% are within predicted good and high quality habitat. This is compared with 18.5 % availability of these habitats. We examined the difference between the expected distribution and the observed distribution for each seasonal model and the annual model using a chi-square test. All distributions were significantly difference, with p-values <<0.0001.

A.9 Discussion

The purpose of the focal species habitat suitability models is to represents coarse-scale predictions of habitat suitability across broad landscapes, suitable for inclusion in landscape-level analyses such as incorporated into the TRTFN CAD. They may, additionally, provide insights for strategic-level decision-making. The models are not appropriate for localized or site-level evaluations of focal species habitat suitability, and should not be used for these purposes. This is due to the limited spatial environmental data available for the modeling effort, as well as insufficient information on fine-scale habitat associations of the focal species.

Both of the types of data mentioned above have been collected in the study area by the BC Ministry of Sustainable Resources Management: Terrestrial Ecosystem Modeling has been undertaken for a significant portion of the study area, and a multi-year grizzly bear GPS radio-telemetry study was initiated in 1999. The final products have not been released, and data and draft products have not been made available to the TRTFN. The acquisition of these data would obviously greatly enhance both the land planning and CAD efforts, including upgrading the habitat suitability models for all the focal species, as well as other key analyses included in the CAD.

In the case of mountain goat habitat suitability models, other attempts to model winter habitat have been criticized for predicting suitable goat habitat where there are no records of goats presently or historically occupying the predicted habitat (T. Hamilton, pers. comm.). While this may result in some inefficiency for the present use (and the same could be said of the sheep habitat model), it also allows the use of the precautionary principle in the absence of better information on goat or sheep occupancy or habitat use in the study area. Additionally, with regard to modeling woodland caribou habitat, other approaches to predicting suitable habitat, particularly winter habitats, are currently being explored. These include using satellite imagery (LandSat 7) to predict forested habitats that support lichen development; such a model is under development in the Yukon (R. Florkiewicz,

Martin

pers. comm.) and has been used in other areas (Arseneault et al. 1997).

The preliminary model validation completed indicates that all of the focal species habitat suitability models correspond well or moderately well (in the case of woodland caribou) to the habitats used by the species, as indicated by the available radio-telemetry locations. Obviously, more validation work is required. Still, the success of the modeling effort highlights the importance of non-scientific forms of knowledge. The presented model was primarily based on TIEK of the Taku River Tlingit First Nation. The TRTFN members exhibited an in-depth understanding of the habitat requirements of the focal species, and consistent descriptions were provided across most members interviewed. These descriptions contained sufficient detail to allow development of the model. The TIEK was confirmed through existing research from other regions, as well as local ecological knowledge of Atlin residents.

The value of traditional and indigenous ecological knowledge sources to inform natural resource management and conservation is increasingly being acknowledged (Higgins 1998; Huntington 2000; Osemeobo 2001; Ticktin & Johns 2002; Turner et al. 2000). In areas where there exists little or no scientific information, these non-traditional information sources are critical to advance management and conservation efforts. The present effort highlights the utility and value of TIEK. In particular, combining TIEK with standardized approaches of analyses and modeling has proven an effective and novel approach to understanding and predicting habitat suitability for the selected focal species across Taku River Tlingit Territory.

Appendix B: Ecological Communities Predicted in the Territory

PREDICTED ECOLOGICAL COMMUNITY	TOTAL AREA (HA)	BIOGEOCLIMATIC ZONE (BEC)	FOREST GROUPING TYPE	FOREST AGE	ASPECT
ALPINE TUNDRA-Nonforested-cool	544143.5	Alpine Tundra	Lodgepole - Mixed	young	cool
ALPINE TUNDRA-Nonforested-warm	277309.25	Alpine Tundra	Pure Spruce/Spruce Spp Mixes	old	warm
ALPINE TUNDRA-Pure True Fir/True Fir Mixes-cool	3828.5	Alpine Tundra	Pure True Fir/True Fir Mixes	young	cool
ALPINE TUNDRA-Pure True Fir/True Fir Mixes-warm	2265.75	Alpine Tundra	Pure True Fir/True Fir Mixes	mature	warm
BOREAL SUBALPINE-Aspen - Deciduous/Birch-Decidu-cool	2701.25	Boreal Subalpine	Aspen - Deciduous/Birch-Decidu	young	cool
BOREAL SUBALPINE-Aspen - Deciduous/Birch-Decidu-warm	2838.75	Boreal Subalpine	Aspen - Deciduous/Birch-Decidu	mature	warm
BOREAL SUBALPINE-Aspen - Mixed Conifer-cool	4453.75	Boreal Subalpine	Aspen - Mixed Conifer	old	cool
BOREAL SUBALPINE-Aspen - Mixed Conifer-warm	2405.75	Boreal Subalpine	Aspen - Mixed Conifer	mature	warm
BOREAL SUBALPINE-Lodgepole - Mixed-cool-mature	5685.75	Boreal Subalpine	Lodgepole - Mixed	mature	cool
BOREAL SUBALPINE-Lodgepole - Mixed-cool-old	14613.25	Boreal Subalpine	Lodgepole - Mixed	old	cool
BOREAL SUBALPINE-Lodgepole - Mixed-cool-young	8879.5	Boreal Subalpine	Lodgepole - Mixed	young	cool
BOREAL SUBALPINE-Lodgepole - Mixed-warm-mature	2962.5	Boreal Subalpine	Lodgepole - Mixed	mature	warm
BOREAL SUBALPINE-Lodgepole - Mixed-warm-old	6305.5	Boreal Subalpine	Lodgepole - Mixed	old	warm
BOREAL SUBALPINE-Lodgepole - Mixed-warm-young	2610.5	Boreal Subalpine	Lodgepole - Mixed	young	warm
BOREAL SUBALPINE-Nonforested-cool	403420.25	Boreal Subalpine	NA		cool
BOREAL SUBALPINE-Nonforested-warm	163686	Boreal Subalpine	NA		warm
BOREAL SUBALPINE-Pure Lodgepole Pine-cool-mature	10501.5	Boreal Subalpine	Pure Lodgepole Pine	mature	cool
BOREAL SUBALPINE-Pure Lodgepole Pine-cool-old	7093.75	Boreal Subalpine	Pure Lodgepole Pine	old	cool
BOREAL SUBALPINE-Pure Lodgepole Pine-cool-young	7598.5	Boreal Subalpine	Pure Lodgepole Pine	young	cool
BOREAL SUBALPINE-Pure Lodgepole Pine-warm-mature	4078.25	Boreal Subalpine	Pure Lodgepole Pine	mature	warm
BOREAL SUBALPINE-Pure Lodgepole Pine-warm-old	2885.5	Boreal Subalpine	Pure Lodgepole Pine	old	warm
BOREAL SUBALPINE-Pure Lodgepole Pine-warm-young	3332.25	Boreal Subalpine	Pure Lodgepole Pine	young	warm
BOREAL SUBALPINE-Pure Spruce/Spruce Spp Mixes-cool-mature	3638.5	Boreal Subalpine	Pure Spruce/Spruce Spp Mixes	mature	cool
BOREAL SUBALPINE-Pure Spruce/Spruce Spp Mixes-cool-old	70011.5	Boreal Subalpine	Pure Spruce/Spruce Spp Mixes	old	cool
BOREAL SUBALPINE-Pure Spruce/Spruce Spp Mixes-cool-young	3678	Boreal Subalpine	Pure Spruce/Spruce Spp Mixes	young	cool
BOREAL SUBALPINE-Pure Spruce/Spruce Spp Mixes-warm-mature	715.75	Boreal Subalpine	Pure Spruce/Spruce Spp Mixes	mature	warm
BOREAL SUBALPINE-Pure Spruce/Spruce Spp Mixes-warm-old	27499.5	Boreal Subalpine	Pure Spruce/Spruce Spp Mixes	old	warm

PREDICTED ECOLOGICAL COMMUNITY	HA	BEC	FOREST GROUPING TYPE	FOREST AGE	ASPECT
BOREAL SUBALPINE-Pure Spruce/Spruce Spp Mixes-warm-young	1507.5	Boreal Subalpine	Pure Spruce/Spruce Spp Mixes	young	warm
BOREAL SUBALPINE-Pure True Fir/True Fir Mixes-cool-mature	12210.75	Boreal Subalpine	Pure True Fir/True Fir Mixes	mature	cool
BOREAL SUBALPINE-Pure True Fir/True Fir Mixes-cool-old	186627.5	Boreal Subalpine	Pure True Fir/True Fir Mixes	old	cool
BOREAL SUBALPINE-Pure True Fir/True Fir Mixes-cool-young	11126.5	Boreal Subalpine	Pure True Fir/True Fir Mixes	young	cool
BOREAL SUBALPINE-Pure True Fir/True Fir Mixes-warm-mature	2923	Boreal Subalpine	Pure True Fir/True Fir Mixes	mature	warm
BOREAL SUBALPINE-Pure True Fir/True Fir Mixes-warm-old	67093.75	Boreal Subalpine	Pure True Fir/True Fir Mixes	old	warm
BOREAL SUBALPINE-Pure True Fir/True Fir Mixes-warm-young	3395.5	Boreal Subalpine	Pure True Fir/True Fir Mixes	young	warm
BOREAL SUBALPINE-Riparian Forest and Shrubland	394	Boreal Subalpine	Riparian Forest and Shrubland	young	cool
BOREAL SUBALPINE-Spruce - Lodgepole Pine/Spruce-cool-mature	1912.25	Boreal Subalpine	Spruce - Lodgepole Pine/Spruce	mature	cool
BOREAL SUBALPINE-Spruce - Lodgepole Pine/Spruce-cool-old	10253.25	Boreal Subalpine	Spruce - Lodgepole Pine/Spruce	old	cool
BOREAL SUBALPINE-Spruce - Lodgepole Pine/Spruce-cool-young	3279.5	Boreal Subalpine	Spruce - Lodgepole Pine/Spruce	young	cool
BOREAL SUBALPINE-Spruce - Lodgepole Pine/Spruce-warm-mature	923.25	Boreal Subalpine	Spruce - Lodgepole Pine/Spruce	mature	warm
BOREAL SUBALPINE-Spruce - Lodgepole Pine/Spruce-warm-old	5442	Boreal Subalpine	Spruce - Lodgepole Pine/Spruce	old	warm
BOREAL SUBALPINE-Spruce - Lodgepole Pine/Spruce-warm-young	1685.25	Boreal Subalpine	Spruce - Lodgepole Pine/Spruce	young	warm
BOREAL SUBALPINE-Spruce - Mixed Conifer-cool-mature	2235.75	Boreal Subalpine	Spruce - Mixed Conifer	mature	cool
BOREAL SUBALPINE-Spruce - Mixed Conifer-cool-old	33959.5	Boreal Subalpine	Spruce - Mixed Conifer	old	cool
BOREAL SUBALPINE-Spruce - Mixed Conifer-cool-young	2435.75	Boreal Subalpine	Spruce - Mixed Conifer	young	cool
BOREAL SUBALPINE-Spruce - Mixed Conifer-warm-mature	617.5	Boreal Subalpine	Spruce - Mixed Conifer	mature	warm
BOREAL SUBALPINE-Spruce - Mixed Conifer-warm-old	13175	Boreal Subalpine	Spruce - Mixed Conifer	old	warm
BOREAL SUBALPINE-Spruce - Mixed Conifer-warm-young	902.25	Boreal Subalpine	Spruce - Mixed Conifer	young	warm
GLACIERS	309499.75	na	na	na	na
INTERIOR SUBALPINE FOREST-Aspen - Deciduous/Birch-Decidu-coo	1087	Interior Subalpine Forest	Aspen - Deciduous/Birch-Decidu	mature	cool
INTERIOR SUBALPINE FOREST-Aspen - Deciduous/Birch-Decidu-war	385.75	Interior Subalpine Forest	Aspen - Deciduous/Birch-Decidu	mature	warm
INTERIOR SUBALPINE FOREST-Aspen - Mixed Conifer-cool	1526.25	Interior Subalpine Forest	Aspen - Mixed Conifer	young	cool
INTERIOR SUBALPINE FOREST-Aspen - Mixed Conifer-warm	1119.25	Interior Subalpine Forest	Aspen - Mixed Conifer	mature	warm
INTERIOR SUBALPINE FOREST-Hemlock-cool-old	6	Interior Subalpine Forest	Hemlock	old	cool
INTERIOR SUBALPINE FOREST-Hemlock-warm-old	8	Interior Subalpine Forest	Hemlock	old	warm
INTERIOR SUBALPINE FOREST-Lodgepole - Mixed-cool-mature	1313.75	Interior Subalpine Forest	Lodgepole - Mixed	mature	cool
INTERIOR SUBALPINE FOREST-Lodgepole - Mixed-cool-old	4487.25	Interior Subalpine Forest	Lodgepole - Mixed	old	cool
INTERIOR SUBALPINE FOREST-Lodgepole - Mixed-cool-young	758.25	Interior Subalpine Forest	Lodgepole - Mixed	young	cool
INTERIOR SUBALPINE FOREST-Lodgepole - Mixed-warm-mature	389.25	Interior Subalpine Forest	Lodgepole - Mixed	mature	warm
INTERIOR SUBALPINE FOREST-Lodgepole - Mixed-warm-old	789.5	Interior Subalpine Forest	Lodgepole - Mixed	old	warm
INTERIOR SUBALPINE FOREST-Lodgepole - Mixed-warm-young	47.75	Interior Subalpine Forest	Lodgepole - Mixed	young	warm
INTERIOR SUBALPINE FOREST-Nonforested-cool	114801	Interior Subalpine Forest	NA		cool
INTERIOR SUBALPINE FOREST-Nonforested-warm	58509.25	Interior Subalpine Forest	NA		warm

PREDICTED ECOLOGICAL COMMUNITY	HA	BEC	FOREST GROUPING TYPE	FOREST AGE	ASPECT
INTERIOR SUBALPINE FOREST-Pure Lodgepole Pine-cool-mature	1315	Interior Subalpine Forest	Pure Lodgepole Pine	mature	cool
INTERIOR SUBALPINE FOREST-Pure Lodgepole Pine-cool-old	1946.5	Interior Subalpine Forest	Pure Lodgepole Pine	old	cool
INTERIOR SUBALPINE FOREST-Pure Lodgepole Pine-cool-young	702	Interior Subalpine Forest	Pure Lodgepole Pine	young	cool
INTERIOR SUBALPINE FOREST-Pure Lodgepole Pine-warm-mature	341.25	Interior Subalpine Forest	Pure Lodgepole Pine	mature	warm
INTERIOR SUBALPINE FOREST-Pure Lodgepole Pine-warm-old	628	Interior Subalpine Forest	Pure Lodgepole Pine	old	warm
INTERIOR SUBALPINE FOREST-Pure Lodgepole Pine-warm-young	156.5	Interior Subalpine Forest	Pure Lodgepole Pine	young	warm
INTERIOR SUBALPINE FOREST-Pure Spruce/Spruce Spp Mixes-cool-	217	Interior Subalpine Forest	Pure Spruce/Spruce Spp Mixes	old	cool
INTERIOR SUBALPINE FOREST-Pure Spruce/Spruce Spp Mixes-warm-	101.75	Interior Subalpine Forest	Pure Spruce/Spruce Spp Mixes	old	warm
INTERIOR SUBALPINE FOREST-Pure True Fir/True Fir Mixes-cool-	3542	Interior Subalpine Forest	Pure True Fir/True Fir Mixes	young	cool
INTERIOR SUBALPINE FOREST-Pure True Fir/True Fir Mixes-cool-	58884.75	Interior Subalpine Forest	Pure True Fir/True Fir Mixes	old	cool
INTERIOR SUBALPINE FOREST-Pure True Fir/True Fir Mixes-cool-	3845.5	Interior Subalpine Forest	Pure True Fir/True Fir Mixes	mature	cool
INTERIOR SUBALPINE FOREST-Pure True Fir/True Fir Mixes-warm-	1164.25	Interior Subalpine Forest	Pure True Fir/True Fir Mixes	young	warm
INTERIOR SUBALPINE FOREST-Pure True Fir/True Fir Mixes-warm-	18417.5	Interior Subalpine Forest	Pure True Fir/True Fir Mixes	old	warm
INTERIOR SUBALPINE FOREST-Pure True Fir/True Fir Mixes-warm-	1959.25	Interior Subalpine Forest	Pure True Fir/True Fir Mixes	mature	warm
INTERIOR SUBALPINE FOREST-Riparian Forest and Shrubland	73.5	Interior Subalpine Forest	Riparian Forest and Shrubland	young	cool
INTERIOR SUBALPINE FOREST-Spruce - Lodgepole Pine/Spruce-coo	1071	Interior Subalpine Forest	Spruce - Lodgepole Pine/Spruce	old	cool
INTERIOR SUBALPINE FOREST-Spruce - Lodgepole Pine/Spruce-coo	12	Interior Subalpine Forest	Spruce - Lodgepole Pine/Spruce	young	cool
INTERIOR SUBALPINE FOREST-Spruce - Lodgepole Pine/Spruce-war	109.75	Interior Subalpine Forest	Spruce - Lodgepole Pine/Spruce	old	warm
INTERIOR SUBALPINE FOREST-Spruce - Lodgepole Pine/Spruce-war	53.5	Interior Subalpine Forest	Spruce - Lodgepole Pine/Spruce	young	warm
INTERIOR SUBALPINE FOREST-Spruce - Mixed Conifer-cool-mature	107.25	Interior Subalpine Forest	Spruce - Mixed Conifer	mature	cool
INTERIOR SUBALPINE FOREST-Spruce - Mixed Conifer-cool-old	2069.75	Interior Subalpine Forest	Spruce - Mixed Conifer	old	cool
INTERIOR SUBALPINE FOREST-Spruce - Mixed Conifer-warm-mature	39	Interior Subalpine Forest	Spruce - Mixed Conifer	mature	warm
INTERIOR SUBALPINE FOREST-Spruce - Mixed Conifer-warm-old	475	Interior Subalpine Forest	Spruce - Mixed Conifer	old	warm
LAKES	176912.25	na	na	na	na
MOUNTAIN BOREAL-Aspen - Deciduous/Birch-Decidu-cool	12011.5	Mountain Boreal	Aspen - Deciduous/Birch-Decidu	young	cool
MOUNTAIN BOREAL-Aspen - Deciduous/Birch-Decidu-warm	11523.5	Mountain Boreal	Aspen - Deciduous/Birch-Decidu	old	warm
MOUNTAIN BOREAL-Aspen - Mixed Conifer-cool	22092.5	Mountain Boreal	Aspen - Mixed Conifer	mature	cool
MOUNTAIN BOREAL-Aspen - Mixed Conifer-warm	17249.25	Mountain Boreal	Aspen - Mixed Conifer	mature	warm
MOUNTAIN BOREAL-Lodgepole - Mixed-cool-mature	25163.75	Mountain Boreal	Lodgepole - Mixed	mature	cool
MOUNTAIN BOREAL-Lodgepole - Mixed-cool-old	19755.25	Mountain Boreal	Lodgepole - Mixed	old	cool
MOUNTAIN BOREAL-Lodgepole - Mixed-cool-young	14763.5	Mountain Boreal	Lodgepole - Mixed	young	cool
MOUNTAIN BOREAL-Lodgepole - Mixed-warm-mature	12241.25	Mountain Boreal	Lodgepole - Mixed	mature	warm
MOUNTAIN BOREAL-Lodgepole - Mixed-warm-old	10056.75	Mountain Boreal	Lodgepole - Mixed	old	warm
MOUNTAIN BOREAL-Lodgepole - Mixed-warm-young	5298.75	Mountain Boreal	Lodgepole - Mixed	young	warm
MOUNTAIN BOREAL-Nonforested-cool	127782.5	Mountain Boreal	NA		cool

PREDICTED ECOLOGICAL COMMUNITY	HA	BEC	FOREST GROUPING TYPE	FOREST AGE	ASPECT
MOUNTAIN BOREAL-Nonforested-warm	61718.75	Mountain Boreal	NA		warm
MOUNTAIN BOREAL-Pure Lodgepole Pine-cool-mature	38500.25	Mountain Boreal	Pure Lodgepole Pine	mature	cool
MOUNTAIN BOREAL-Pure Lodgepole Pine-cool-old	20479	Mountain Boreal	Pure Lodgepole Pine	old	cool
MOUNTAIN BOREAL-Pure Lodgepole Pine-cool-young	21175.75	Mountain Boreal	Pure Lodgepole Pine	young	cool
MOUNTAIN BOREAL-Pure Lodgepole Pine-warm-mature	17949.5	Mountain Boreal	Pure Lodgepole Pine	mature	warm
MOUNTAIN BOREAL-Pure Lodgepole Pine-warm-old	11053.75	Mountain Boreal	Pure Lodgepole Pine	old	warm
MOUNTAIN BOREAL-Pure Lodgepole Pine-warm-young	10713	Mountain Boreal	Pure Lodgepole Pine	young	warm
MOUNTAIN BOREAL-Pure Spruce/Spruce Spp Mixes-cool-mature	15336.5	Mountain Boreal	Pure Spruce/Spruce Spp Mixes	mature	cool
MOUNTAIN BOREAL-Pure Spruce/Spruce Spp Mixes-cool-old	93125	Mountain Boreal	Pure Spruce/Spruce Spp Mixes	old	cool
MOUNTAIN BOREAL-Pure Spruce/Spruce Spp Mixes-cool-young	15139.5	Mountain Boreal	Pure Spruce/Spruce Spp Mixes	young	cool
MOUNTAIN BOREAL-Pure Spruce/Spruce Spp Mixes-warm-mature	7413.25	Mountain Boreal	Pure Spruce/Spruce Spp Mixes	mature	warm
MOUNTAIN BOREAL-Pure Spruce/Spruce Spp Mixes-warm-old	33510.25	Mountain Boreal	Pure Spruce/Spruce Spp Mixes	old	warm
MOUNTAIN BOREAL-Pure Spruce/Spruce Spp Mixes-warm-young	4013.25	Mountain Boreal	Pure Spruce/Spruce Spp Mixes	young	warm
MOUNTAIN BOREAL-Pure True Fir/True Fir Mixes-cool-mature	8793.25	Mountain Boreal	Pure True Fir/True Fir Mixes	mature	cool
MOUNTAIN BOREAL-Pure True Fir/True Fir Mixes-cool-old	83589.5	Mountain Boreal	Pure True Fir/True Fir Mixes	old	cool
MOUNTAIN BOREAL-Pure True Fir/True Fir Mixes-cool-young	8072.75	Mountain Boreal	Pure True Fir/True Fir Mixes	young	cool
MOUNTAIN BOREAL-Pure True Fir/True Fir Mixes-warm-mature	2068.5	Mountain Boreal	Pure True Fir/True Fir Mixes	mature	warm
MOUNTAIN BOREAL-Pure True Fir/True Fir Mixes-warm-old	28631.25	Mountain Boreal	Pure True Fir/True Fir Mixes	old	warm
MOUNTAIN BOREAL-Pure True Fir/True Fir Mixes-warm-young	2091.25	Mountain Boreal	Pure True Fir/True Fir Mixes	young	warm
MOUNTAIN BOREAL-Riparian Forest and Shrubland	3593	Mountain Boreal	Riparian Forest and Shrubland	mature	cool
MOUNTAIN BOREAL-Spruce - Lodgepole Pine/Spruce-cool-mature	12858.75	Mountain Boreal	Spruce - Lodgepole Pine/Spruce	mature	cool
MOUNTAIN BOREAL-Spruce - Lodgepole Pine/Spruce-cool-old	35378.75	Mountain Boreal	Spruce - Lodgepole Pine/Spruce	old	cool
MOUNTAIN BOREAL-Spruce - Lodgepole Pine/Spruce-cool-young	4844.25	Mountain Boreal	Spruce - Lodgepole Pine/Spruce	young	cool
MOUNTAIN BOREAL-Spruce - Lodgepole Pine/Spruce-warm-mature	4356.5	Mountain Boreal	Spruce - Lodgepole Pine/Spruce	mature	warm
MOUNTAIN BOREAL-Spruce - Lodgepole Pine/Spruce-warm-old	14589.75	Mountain Boreal	Spruce - Lodgepole Pine/Spruce	old	warm
MOUNTAIN BOREAL-Spruce - Lodgepole Pine/Spruce-warm-young	1188.25	Mountain Boreal	Spruce - Lodgepole Pine/Spruce	young	warm
MOUNTAIN BOREAL-Spruce - Mixed Conifer-cool-mature	3087.5	Mountain Boreal	Spruce - Mixed Conifer	mature	cool
MOUNTAIN BOREAL-Spruce - Mixed Conifer-cool-old	36415	Mountain Boreal	Spruce - Mixed Conifer	old	cool
MOUNTAIN BOREAL-Spruce - Mixed Conifer-cool-young	4249.75	Mountain Boreal	Spruce - Mixed Conifer	young	cool
MOUNTAIN BOREAL-Spruce - Mixed Conifer-warm-mature	910.5	Mountain Boreal	Spruce - Mixed Conifer	mature	warm
MOUNTAIN BOREAL-Spruce - Mixed Conifer-warm-old	11740	Mountain Boreal	Spruce - Mixed Conifer	old	warm
MOUNTAIN BOREAL-Spruce - Mixed Conifer-warm-young	1228.25	Mountain Boreal	Spruce - Mixed Conifer	young	warm
MOUNTAIN HEMLOCK-Aspen - Mixed Conifer-cool	17.5	Mountain Hemlock	Aspen - Mixed Conifer	mature	cool
MOUNTAIN HEMLOCK-Aspen - Mixed Conifer-warm	139.5	Mountain Hemlock	Aspen - Mixed Conifer	mature	warm
MOUNTAIN HEMLOCK-Hemlock-cool-mature	5.75	Mountain Hemlock	Hemlock	mature	cool

PREDICTED ECOLOGICAL COMMUNITY	HA	BEC	FOREST GROUPING TYPE	FOREST AGE	ASPECT
MOUNTAIN HEMLOCK-Hemlock-cool-old	1352.25	Mountain Hemlock	Hemlock	old	cool
MOUNTAIN HEMLOCK-Hemlock-cool-young	6.25	Mountain Hemlock	Hemlock	young	cool
MOUNTAIN HEMLOCK-Hemlock-warm-old	400	Mountain Hemlock	Hemlock	old	warm
MOUNTAIN HEMLOCK-Nonforested-cool	36272.25	Mountain Hemlock	NA		cool
MOUNTAIN HEMLOCK-Nonforested-warm	18916.25	Mountain Hemlock	NA		warm
MOUNTAIN HEMLOCK-Pure Lodgepole Pine-cool-old	11.25	Mountain Hemlock	Pure Lodgepole Pine	old	cool
MOUNTAIN HEMLOCK-Pure Lodgepole Pine-warm-old	48.5	Mountain Hemlock	Pure Lodgepole Pine	old	warm
MOUNTAIN HEMLOCK-Pure True Fir/True Fir Mixes-cool-old	2704.25	Mountain Hemlock	Pure True Fir/True Fir Mixes	old	cool
MOUNTAIN HEMLOCK-Pure True Fir/True Fir Mixes-cool-young	12	Mountain Hemlock	Pure True Fir/True Fir Mixes	young	cool
MOUNTAIN HEMLOCK-Pure True Fir/True Fir Mixes-warm-old	1413	Mountain Hemlock	Pure True Fir/True Fir Mixes	old	warm
MOUNTAIN HEMLOCK-Riparian Forest and Shrubland	205	Mountain Hemlock	Riparian Forest and Shrubland	mature	cool
NORTHERN COASTAL HEMLOCK-Hemlock-cool-mature	76	Northern Coastal Hemlock	Hemlock	mature	cool
NORTHERN COASTAL HEMLOCK-Hemlock-cool-old	9029.5	Northern Coastal Hemlock	Hemlock	old	cool
NORTHERN COASTAL HEMLOCK-Hemlock-cool-young	38.75	Northern Coastal Hemlock	Hemlock	young	cool
NORTHERN COASTAL HEMLOCK-Hemlock-warm-mature	104.5	Northern Coastal Hemlock	Hemlock	mature	warm
NORTHERN COASTAL HEMLOCK-Hemlock-warm-old	4677.25	Northern Coastal Hemlock	Hemlock	old	warm
NORTHERN COASTAL HEMLOCK-Hemlock-warm-young	6.25	Northern Coastal Hemlock	Hemlock	young	warm
NORTHERN COASTAL HEMLOCK-Nonforested-cool	23677.25	Northern Coastal Hemlock	NA		cool
NORTHERN COASTAL HEMLOCK-Nonforested-warm	13987.5	Northern Coastal Hemlock	NA		warm
NORTHERN COASTAL HEMLOCK-Pure Spruce/Spruce Spp Mixes-cool-o	68.25	Northern Coastal Hemlock	Pure Spruce/Spruce Spp Mixes	old	cool
NORTHERN COASTAL HEMLOCK-Pure Spruce/Spruce Spp Mixes-warm-o	38.5	Northern Coastal Hemlock	Pure Spruce/Spruce Spp Mixes	old	warm
NORTHERN COASTAL HEMLOCK-Pure True Fir/True Fir Mixes-cool-m	12	Northern Coastal Hemlock	Pure True Fir/True Fir Mixes	mature	cool
NORTHERN COASTAL HEMLOCK-Pure True Fir/True Fir Mixes-cool-o	1457.5	Northern Coastal Hemlock	Pure True Fir/True Fir Mixes	old	cool
NORTHERN COASTAL HEMLOCK-Pure True Fir/True Fir Mixes-warm-m	62.25	Northern Coastal Hemlock	Pure True Fir/True Fir Mixes	mature	warm
NORTHERN COASTAL HEMLOCK-Pure True Fir/True Fir Mixes-warm-o	930	Northern Coastal Hemlock	Pure True Fir/True Fir Mixes	old	warm
NORTHERN COASTAL HEMLOCK-Riparian Forest and Shrubland	5296.75	Northern Coastal Hemlock	Riparian Forest and Shrubland	mature	warm
NORTHERN COASTAL HEMLOCK-Spruce - Mixed Conifer-cool-old	63.25	Northern Coastal Hemlock	Spruce - Mixed Conifer	old	cool
NORTHERN COASTAL HEMLOCK-Spruce - Mixed Conifer-warm-old	11	Northern Coastal Hemlock	Spruce - Mixed Conifer	old	warm
SUB-BOREAL SPRUCE-Aspen - Deciduous/Birch-Decidu-cool	1536.25	Sub-Boreal Spruce	Aspen - Deciduous/Birch-Decidu	mature	cool
SUB-BOREAL SPRUCE-Aspen - Deciduous/Birch-Decidu-warm	910	Sub-Boreal Spruce	Aspen - Deciduous/Birch-Decidu	mature	warm
SUB-BOREAL SPRUCE-Aspen - Mixed Conifer-cool	5749.75	Sub-Boreal Spruce	Aspen - Mixed Conifer	mature	cool
SUB-BOREAL SPRUCE-Aspen - Mixed Conifer-warm	4932.75	Sub-Boreal Spruce	Aspen - Mixed Conifer	mature	warm
SUB-BOREAL SPRUCE-Lodgepole - Mixed-cool-mature	5664.75	Sub-Boreal Spruce	Lodgepole - Mixed	mature	cool
SUB-BOREAL SPRUCE-Lodgepole - Mixed-cool-old	3408.25	Sub-Boreal Spruce	Lodgepole - Mixed	old	cool
SUB-BOREAL SPRUCE-Lodgepole - Mixed-cool-young	3086.75	Sub-Boreal Spruce	Lodgepole - Mixed	young	cool

PREDICTED ECOLOGICAL COMMUNITY	HA	BEC	FOREST GROUPING TYPE	FOREST AGE	ASPECT
SUB-BOREAL SPRUCE-Lodgepole - Mixed-warm-mature	2398	Sub-Boreal Spruce	Lodgepole - Mixed	mature	warm
SUB-BOREAL SPRUCE-Lodgepole - Mixed-warm-old	1865.5	Sub-Boreal Spruce	Lodgepole - Mixed	old	warm
SUB-BOREAL SPRUCE-Lodgepole - Mixed-warm-young	377	Sub-Boreal Spruce	Lodgepole - Mixed	young	warm
SUB-BOREAL SPRUCE-Nonforested-cool	37906	Sub-Boreal Spruce	NA		cool
SUB-BOREAL SPRUCE-Nonforested-warm	22125.5	Sub-Boreal Spruce	NA		warm
SUB-BOREAL SPRUCE-Pure Lodgepole Pine-cool-mature	1695.25	Sub-Boreal Spruce	Pure Lodgepole Pine	mature	cool
SUB-BOREAL SPRUCE-Pure Lodgepole Pine-cool-old	2425.25	Sub-Boreal Spruce	Pure Lodgepole Pine	old	cool
SUB-BOREAL SPRUCE-Pure Lodgepole Pine-cool-young	330.5	Sub-Boreal Spruce	Pure Lodgepole Pine	young	cool
SUB-BOREAL SPRUCE-Pure Lodgepole Pine-warm-mature	454.25	Sub-Boreal Spruce	Pure Lodgepole Pine	mature	warm
SUB-BOREAL SPRUCE-Pure Lodgepole Pine-warm-old	850	Sub-Boreal Spruce	Pure Lodgepole Pine	old	warm
SUB-BOREAL SPRUCE-Pure Lodgepole Pine-warm-young	526	Sub-Boreal Spruce	Pure Lodgepole Pine	young	warm
SUB-BOREAL SPRUCE-Pure Spruce/Spruce Spp Mixes-cool-mature	93.25	Sub-Boreal Spruce	Pure Spruce/Spruce Spp Mixes	mature	cool
SUB-BOREAL SPRUCE-Pure Spruce/Spruce Spp Mixes-cool-old	851	Sub-Boreal Spruce	Pure Spruce/Spruce Spp Mixes	old	cool
SUB-BOREAL SPRUCE-Pure Spruce/Spruce Spp Mixes-cool-young	57.5	Sub-Boreal Spruce	Pure Spruce/Spruce Spp Mixes	young	cool
SUB-BOREAL SPRUCE-Pure Spruce/Spruce Spp Mixes-warm-mature	186.75	Sub-Boreal Spruce	Pure Spruce/Spruce Spp Mixes	mature	warm
SUB-BOREAL SPRUCE-Pure Spruce/Spruce Spp Mixes-warm-old	672	Sub-Boreal Spruce	Pure Spruce/Spruce Spp Mixes	old	warm
SUB-BOREAL SPRUCE-Pure Spruce/Spruce Spp Mixes-warm-young	27	Sub-Boreal Spruce	Pure Spruce/Spruce Spp Mixes	young	warm
SUB-BOREAL SPRUCE-Pure True Fir/True Fir Mixes-cool-mature	2999.75	Sub-Boreal Spruce	Pure True Fir/True Fir Mixes	mature	cool
SUB-BOREAL SPRUCE-Pure True Fir/True Fir Mixes-cool-old	43016.25	Sub-Boreal Spruce	Pure True Fir/True Fir Mixes	old	cool
SUB-BOREAL SPRUCE-Pure True Fir/True Fir Mixes-cool-young	2237.75	Sub-Boreal Spruce	Pure True Fir/True Fir Mixes	young	cool
SUB-BOREAL SPRUCE-Pure True Fir/True Fir Mixes-warm-mature	1238	Sub-Boreal Spruce	Pure True Fir/True Fir Mixes	mature	warm
SUB-BOREAL SPRUCE-Pure True Fir/True Fir Mixes-warm-old	14946.75	Sub-Boreal Spruce	Pure True Fir/True Fir Mixes	old	warm
SUB-BOREAL SPRUCE-Pure True Fir/True Fir Mixes-warm-young	896.25	Sub-Boreal Spruce	Pure True Fir/True Fir Mixes	young	warm
SUB-BOREAL SPRUCE-Riparian Forest and Shrubland	5969.25	Sub-Boreal Spruce	Riparian Forest and Shrubland	mature	warm
SUB-BOREAL SPRUCE-Spruce - Lodgepole Pine/Spruce-cool-mature	263.75	Sub-Boreal Spruce	Spruce - Lodgepole Pine/Spruce	mature	cool
SUB-BOREAL SPRUCE-Spruce - Lodgepole Pine/Spruce-cool-old	1721.5	Sub-Boreal Spruce	Spruce - Lodgepole Pine/Spruce	old	cool
SUB-BOREAL SPRUCE-Spruce - Lodgepole Pine/Spruce-cool-young	28.5	Sub-Boreal Spruce	Spruce - Lodgepole Pine/Spruce	young	cool
SUB-BOREAL SPRUCE-Spruce - Lodgepole Pine/Spruce-warm-mature	75.25	Sub-Boreal Spruce	Spruce - Lodgepole Pine/Spruce	mature	warm
SUB-BOREAL SPRUCE-Spruce - Lodgepole Pine/Spruce-warm-old	427	Sub-Boreal Spruce	Spruce - Lodgepole Pine/Spruce	old	warm
SUB-BOREAL SPRUCE-Spruce - Lodgepole Pine/Spruce-warm-young	171.75	Sub-Boreal Spruce	Spruce - Lodgepole Pine/Spruce	young	warm
SUB-BOREAL SPRUCE-Spruce - Mixed Conifer-cool-mature	180.25	Sub-Boreal Spruce	Spruce - Mixed Conifer	mature	cool
SUB-BOREAL SPRUCE-Spruce - Mixed Conifer-cool-old	2769.5	Sub-Boreal Spruce	Spruce - Mixed Conifer	old	cool
SUB-BOREAL SPRUCE-Spruce - Mixed Conifer-warm-mature	158.25	Sub-Boreal Spruce	Spruce - Mixed Conifer	mature	warm
SUB-BOREAL SPRUCE-Spruce - Mixed Conifer-warm-old	730	Sub-Boreal Spruce	Spruce - Mixed Conifer	old	warm

Appendix C: Summary Wildlife Field Research Efforts

Field efforts to collect baseline ecological information were initiated by RRCS and TRTFN in 1999, and expanded to a broad suite of wildlife field research efforts in the summer 2000. This research is focused on gathering information on key species for which there are critical information gaps. The species selected for study include those that will provide indicators of the ecological health and integrity of the Territory. The development and implementation of long-term monitoring regimes on these and other ecological indicators will provide measures of successful conservation and management, as well as guide potential development activities. In addition to long-term ecological monitoring, many of the research efforts provide immediate utility for CAD validation and for land-planning and project development.

C.1 Grizzly bear population and movements

One of the most intensive of the field efforts, the population study on grizzly bears focuses on non-invasive sampling and "marking" of individuals through the collection of hair follicle DNA. Sampling stations have been established across the Taku River watershed and northern portions of the Territory and monitored for three summer/fall seasons (2000, 2001, 2003). This work "marked" 100 grizzly bears in the region during the first two years of sampling, several of which have been identified in both years. Analyses of the 2003 samples are on-going. Identification of individuals allows us to document seasonal habitat use and movements of individuals, with a focus on documenting the use of high quality habitats, particularly salmon spawning areas. These efforts are continuing, and with additional data collection, we hope to be able to estimate relative population densities across the Territory, and potentially, estimate population abundance within some areas. As part of this work, we also collect black bear hair samples, and have the opportunity to expand the work to this species, for which we have already identified 45 individuals. Our work consults with and utilizes a well-established DNA laboratory for the fingerprinting of the DNA.

C.2 Winter wildlife population monitoring

Winter snow track surveys were established to document the relative abundance of key wildlife species, including Canada lynx, wolverine, marten, wolf, caribou, moose and a diversity of smaller prey species such as snowshoe hare, squirrel and ptarmigan. This program is aimed at providing long-term measures of relative abundance of species across the landscape, as well as providing habitat-specific information for the development of habitat management guidelines.

C.3 Swan productivity surveys

Annual trumpeter swan productivity surveys were initiated to document the use of key wetland habitats for nesting swans in the Territory. Additionally, this effort allows us to collect information on the annual reproductive success of this rare and sensitive species. Trumpeter swans represent a key indicator species for the status and health of wetland systems. Our surveys to date have documented swan nesting through the wetland habitats of the main stem Taku River, as well as some headwater lake wetland systems. Our preliminary data suggests that the Taku supports a very productive population of swans that has been previously unrecognized. We have worked in collaboration with Alaska Department of Fish and Game, who conduct extensive swan productivity surveys in adjacent Alaska systems.

C.4 Amphibian population surveys

Amphibians provide another key indicator of the health and integrity of wetland systems. Prior to our survey efforts, there had not been standardized surveys of amphibian presence and distribution in the Taku River watershed. We have documented the presence of sensitive species such as the spotted frog and long-toed salamander. Indeed, our finding of long-toed salamanders as far inland as the Nakina River extends the known distribution of this amphibian substantially north and east of prior documented locations. Our efforts have collaborated with Yukon and BC amphibian ecologists who have conducted surveys in the northern portions of the Territory.

C.5 Woodland caribou winter ecology: ice mineral licks.

Caribou habitat use during winter has been identified as a key concern for the long-term recovery of this species. The Atlin herd is recognized a part of the Sourthern Lakes population; concerns for the widespread decline of this herd sparked the development of the Southern Lakes Caribou Recovery Effort. We have monitored the distribution of caribou during winter wildlife surveys. Additionally, the importance of select frozen lakes are being examined that are extensively used by the caribou. These lakes have been found to provide key predator refugia for caribou, and they may also represent potentially critical sources of trace minerals. We are sampling the use of "ice mineral licks" by caribou, and hope to be able to pursue analyses and modeling that will allow us to identify and predict lakes that may provide these potentially limiting resources.

Northern Spotted Frog

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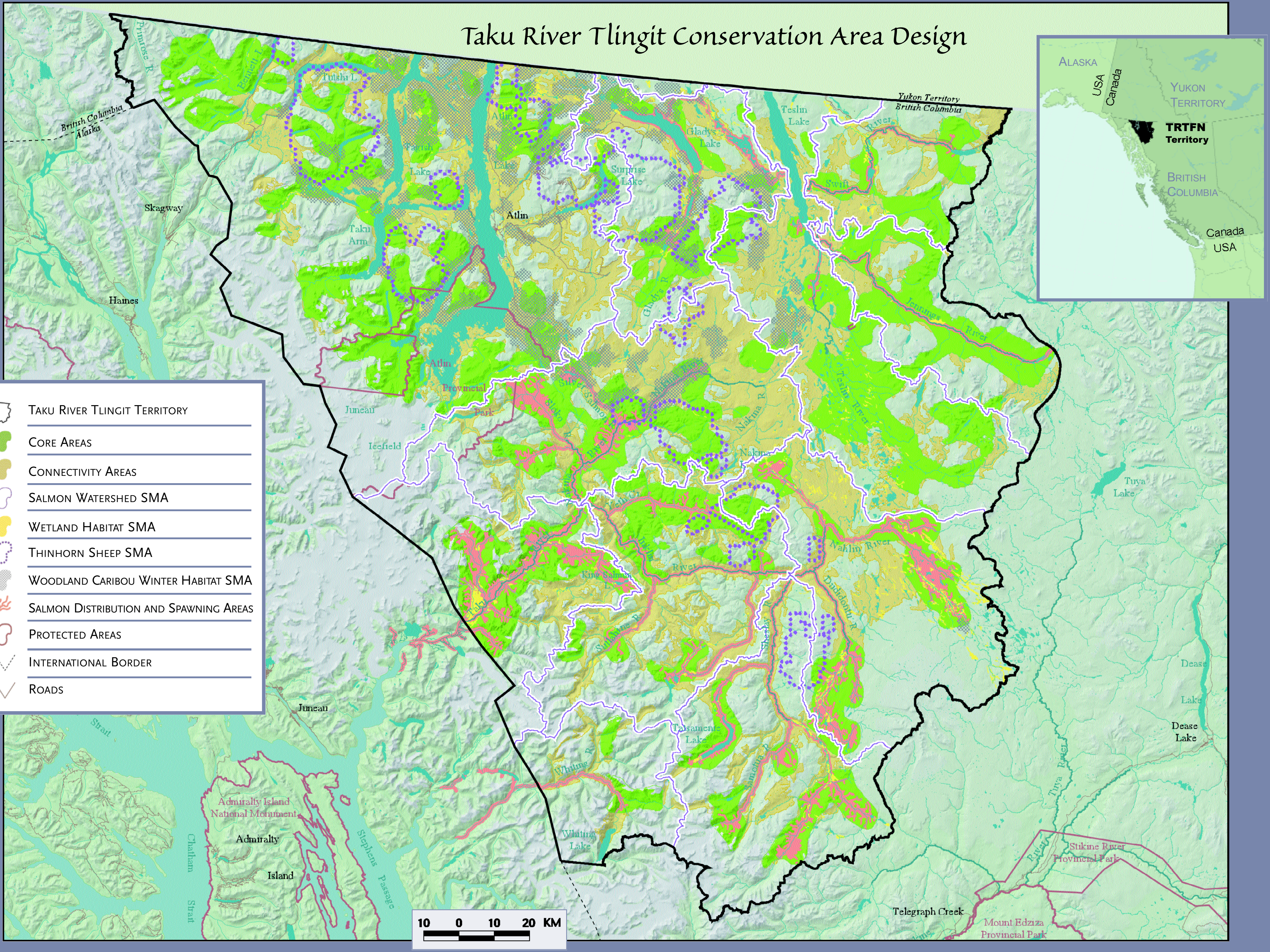
Taku River Tlingit Conservation Area Design
Alaska
USA
Canada
Yukon Territory
TRTFN Territory
British Columbia
Canada
USA
Taku River Tlingit Territory
Core Areas
Connectivity Areas
Salmon Watershed SMA
Wetland Habitat SMA
Thinhorn Sheep SMA
Woodland Caribou Winter Habitat SMA
Salmon Distribution and Spawning Areas
Protected Areas
International Border
Roads
Yukon Territory
British Columbia
British Columbia
Alaska
Skagway
Haines
Atlin
Atlin
Provincial
Park
Juneau
Icefield
Juneau
Teslin Lake
Gladys Lake
Surprise Lake
Taku Arm
Tutshi L.
Swift
Jennings River
Teslin River
Nakina R.
Nakina
Nahlin River
Dudidontu R.
King Salmon L.
Whiting R.
Whiting Lake
Tatsamenie Lake
Tuya Lake
Tuya River
Dease Lake
Dease Lake
Telegraph Creek
Stikine River Provincial Park
Mount Edziza Provincial Park
Admiralty Island National Monument
Admiralty
Island
Chatham Strait
Stephens Passage
10 0 10 20 KM

"My vision for the future is that my people do not have to worry what could happen to the land, or what outside interests might do to it. The land is such a big part of our being Tlingit. We wake up every morning, walk out into the bush. The future is so unknown, I know the young people will take care of the land just like we do. The most important thing to me is that we belong to the earth and the earth doesn't belong to us. The earth belongs to the animals. Once this land is gone for the animals, you can't bring it back. They say extinction is forever. Mother nature has a plan, and it's what we see out our window today."

Jerry Jack

Chief Taku Jack

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