Conserving Opportunities for Traditional Activities by the Community of Fort McKay amongst the Industrial Landscape of northeast Alberta

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This Technical Report provides a complete description of methods, results, and conclusions from the scenario modeling component of the Moose Lake Buffer Study. The scenario modeling was conducted based upon simulations in the cumulative effects model – ALCES®. This report highlights the basic model assumptions, results, and conclusions of the scenario analyses.

*"Hunting and fishing is addictive, you crave it.
We are hunter-gatherers. It is inside of us."*

(Fort McKay Cultural Heritage Assessment 2009)

*"We are people of the land – hunters and gatherers.
Without the land we feel lost. Without the land we are nothing."*

(HEG 2009:1)

"You know, native people, they watch everything. They don't destroy stuff for nothing. They don't go chop down a bunch of trees or anything like that. They down what they need. And the same thing in the bush. It there's twenty beavers out there, they don't go and kill twenty. They might kill fifteen, or fourteen. They leave six for seed. So they multiply. You know? And yet, they keep harvesting so that they don't get overpopulated and get sick."

(Fort McKay Elder, quoted in Garibaldi, 2006)

*[I]t's our way of life. Moose was always our favourite diet.
… ever since, far back as I can remember*

(Fort McKay Industry Relations Corporation (FM IRC)

"Moose is the most important staple food, diet for us First Nations because it keeps me strong, it keeps me healthy and I use part of the moose, even for keeping our bodies warm we use the hide…every aspect of our of our life as a First Nations person depends on moose. Without the moose our very existence as a First Nations person is compromised."

(Jean L'Hommecourt)

Executive Summary

Extensive regions of the traditional lands of the community of Fort McKay have undergone a profound transformation as caused by past exponential growth of oilsand mines and associated infrastructure. With their settlement of Fort McKay located in the center of the surface mining region, increasing community anxiety has emerged about prospects for maintaining current and future traditional activities. The results of the Fort McKay Cumulative Effects Study (ALCES Group and IEG Group, 2013) reveal that the future scale of landscape transformation, as caused by the emerging in-situ bitumen sector, will exceed the amount of boreal forest landscape directly and indirectly altered to date by the surface mine sector.

The simulated performance of all ecological indicators (moose, caribou, native fish, edible berries) under a "Business as Usual" scenario indicate a significant and lasting reduction in performance in those regions affected by either oilsand surface mining or in-situ activity (Fort McKay Cumulative Effects Study; ALCES Group and IEG Group, 2013). Of the traditional territory of Fort McKay, ~57% is within a 500 m buffer of industrial footprint today and nearly all regions outside of designated protected areas will be within a 500 m buffer as the in-situ sector transforms this region during the next century.

Against the backdrop of industrialization unfolding across most of their Traditional Territory, the community of Fort McKay is seeking a historically relevant and accessible region that will allow future generations to participate in traditional activities. To be effective, this traditional use area needs to be of adequate size, cultural relevance, proximity to Fort McKay, and be non-industrial. The key principles for selecting this region are discussed in Protected Area Needs for Maintaining Ecological Integrity in the Moose Lake Region (ALCES Group and IEG Group, 2013).

Of the areas eligible for consideration as a conservation area, the region centered by the Buffalo and Moose Lake Reserves offers the best option. The current Dover Corp. proposal is one of many in-situ developments that are anticipated to occur adjacent to the Reserves or in the general region during the next few decades (Figure 4).

The analyses presented in this report outline issues and opportunities relating to the size and representation of the protected area, the need for an effective non-industrial buffer adjacent to the Reserves, and the critical role of access management[1] and best management practices (BMP) to conserving key ecological indicators such as moose. Indicators of cultural and ecological importance to the Community of Fort McKay were used to illustrate these relationships. These indicators include moose habitat quality, moose populations, and moose harvest.

[1] For the purposes of this report, the term "access management" refers to the broad strategic discussion about the full range of management tools for affecting movement of people along the transportation network (roads, pipelines, seismic lines) and across landscapes and not the specific issue of gating a specific road leading to a specific wellpad.

The results of this report, in combination with the Fort McKay Cumulative Effects Study, emphasize the scope and pace of the unfolding bitumen sector and its industrial footprint. The window of opportunity for the community of Fort McKay to seek and ratify a traditional use region for purposes of conserving traditional activities is closing quickly.

The aboriginal population prior to the arrival of the oilsand sector was ~230 individuals (Tanner 2001). This population would have fluctuated on an inter-annual and decadal scale depending on food availability and severity of winters. Based on interviews with elders, the range in per-capita harvest of moose varied from 1.1 to 1.7 (Tanner et al.. 2001). As a reference point, a population of 230 Fort McKay people harvesting ~1.4 moose/person/year would have killed 322 moose per year, which would have equated to ~6% of the standing moose population. The results of these analyses indicate that a boreal landscape approximately the size of the Fort McKay study area (~3.2 M ha) would have been required to support a moose population of sufficient size to allow a harvest rate required to provision a population of ~230 Fort McKay individuals during the pre-oilsand era.

From the perspective of maintaining traditional aboriginal practices, the people of Fort McKay wish to maintain the opportunities and treaty rights to continue to harvest moose. Their treaty rights are protected by the Constitution of Canada. During the past several decades, however, their population has grown significantly and is now ~800 community members. Within the biological limits that determine moose productivity in the boreal region, the community of Fort McKay wants, at minimum, the opportunity to harvest moose at rates (322/yr) equivalent to those experienced by their populations (~230) at time of arrival of the oilsand sector.

Achieving this goal will not be easy. During the past several decades, regional-scale moose densities have generally declined from ~0.20 to less than 0.10 moose/km^2. Explanations for this decline are many but generally focus on habitat loss to industry and elevated moose harvest rates caused by higher hunter populations (aboriginal, non-aboriginal), higher encounter rates between moose hunters and moose because of a ubiquitous linear edge network (roads, pipelines, seismic lines), and elevated moose mortalities related to collisions with vehicles along the road network that services the surface mines and in-situ wellpads. Simulations in the ALCES model indicated that the adoption of “best management” practices by the hydrocarbon sector, including the adoption of access management principles, can assist in the reduction of moose harvest rates and hence a recovery in moose densities.

The people of Fort McKay seek a setting within their traditional territory where they can conduct traditional activities (including moose hunting) without being subjected to the smell, sounds and sights of bitumen extraction, processing, and translocation. Against all options considered, the Buffalo and Moose Lake Reserves offer the best opportunity to achieve such an objective. The Buffalo and Moose Lake Reserves are designated by the community for traditional land use purposes, are culturally relevant because of the traditional activities practiced there for many generations, are adjacent to the protected areas of the Birch Mountains, and the area in which they are located is not underlain by the most favorable bitumen deposits.

Unfortunately, these Reserves are not large in size. The Reserves themselves are ~147 km^2, an area that has the capacity to support ~30 moose and a harvest of ~3.0 moose/year. By placing a 20 km “no-industry” buffer around the Reserves, however, the total non-industrial area would increase to 2,700 km^2, a region sufficient to support ~546 moose and an annual harvest of ~54 moose annually. If an additional 20 km “industry with best management practices” buffer were applied to the outside of the “no-go” buffer, the total area would increase to 10,084 km^2. Full rates of bitumen recovery would be permitted in the outer 20 km buffer, but the highest standards of footprint construction and reclamation would be applied. If the 20 km “intensive management buffer” were to be managed by industry in a manner that minimized rate of footprint development through ILM practices, maximized rate of footprint reclamation, and aggressively applied principles of access management, an additional population of ~1,270 moose would be supported and this population could contribute ~127 moose to be harvested annually.

In total, a conservation strategy built on an architecture of the core Buffalo and Moose Lakes Reserves, a 20 km “no-go” buffer, and an additional 20 km industry buffer where best management practices are applied, could sustainably support a population of ~1,819 moose on which a sustainable offtake of 182 moose could be realized. Based on the current population of the Fort McKay community, this is equivalent to one moose being harvested annually for every four members of the Fort McKay community. In terms of the estimated Fort McKay population size at onset of the oilsand sector, this harvest rate would be equivalent to 0.79 moose per capita per year, slightly more than half of the rate in the pre-oilsands period that occurred across the Traditional Territory. The analyses above assume that there is moose harvesting by non-aboriginal hunters in these specific regions.

In contrast, if the 20 km “no-go” buffer is not implemented, and the outer 20 km industrial buffer is managed without access management principles and adopts the “business as usual” practices are deployed elsewhere in the in-situ industry of northeast Alberta, the moose population is simulated to be 611 individuals with an average annual harvest of ~61 moose. In this scenario, the harvest of moose in the region surrounding Buffalo and Moose Lake Reserves would likely occur from both aboriginal and non-aboriginal hunters.

In summary, a decision to implement these two buffers around Buffalo and Moose Lake Reserves would result in an increase in moose population and harvest of ~3 times relative to a scenario where these buffers to not exist and the in-situ sector unfolds in a “business as usual” manner.

Although our analyses focused on moose (population and harvest), the benefits of this conservation strategy would extend to a broader suite of ecological indicators, including furbearers, fish and edible berries.

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Caveat and Disclaimer

This report was prepared by the ALCES Group and the IEG Group for the Fort McKay Sustainability Department.

Glossary

Aboriginal rights - Unique rights that First Nation, Metis and Inuit people of Canada hold by reason of having been independent, self-governing societies prior to the establishment of Canadian sovereignty. These rights are recognized and protected under Section 35 of the Constitution Act, 1982 and are part of the Common law in Canada. Aboriginal rights include the harvesting rights of the Métis, and the right to site-specific cultural practices and features.

access management - A land use management tool that is directed to engage the public and stakeholders in consideration of future road development and management of use (motor vehicle and off-road-vehicle traffic) on existing roads and linear features. Effective access management is implemented as a systematic and regional coordinated plan to reduce access across the regional landbase, and would require government enforcement.

ALCES® - A Landscape Cumulative Effects Simulator - a landscape model which can simulate environmental and human-related changes and track a wide variety of environmental, biological, and socio-economic indicators as landscape change unfolds. ALCES is designed to explore and represent changes in land base composition caused by land uses and ecological processes.

Anthropogenic footprint – human-made permanent or temporary disturbance features that occupy space on the landscape such as roads, well-sites, transmission lines, towns, cities, mines, industrial plants.

BMP - Best Management Practices (BMP). A best practice is a method or technique that has consistently shown results superior to those achieved with other means, and that is used as a benchmark. In addition, a "best" management practice can evolve to become better as improvements are discovered. Best management practices are used to maintain quality as an alternative to mandatory legislated standards and can be based on self-assessment or benchmarking.

CEMA - Cumulative Environmental Management Association (www.cemaonline.ca), a multi-stakeholder group operating in the Regional Municipality of Wood Buffalo, Alberta. CEMA is a key advisor to the provincial and federal governments committed to respectful, inclusive dialogue to make recommendations to manage the cumulative environmental effects of regional development on air, land, water and biodiversity.

Community - The entire Community of Fort McKay includes First Nations members, Metis members and non-status members.

EIA - Environmental Impact Assessment. An assessment of the possible positive or negative impacts that a proposed project may have on the environment, together consisting of the environmental, social and economic aspects.

Enhanced Approval Process (EAP) - To aid the Integrated Operational Guidelines task team with project management support, and to assess and consolidate current guidelines, identify gaps, develop land use standards where required, and assemble a Consolidated Standards and Guidelines document to become a part of the development of a enhanced AOA.

FMSD - Fort McKay Sustainability Department

Focus Group - a selected group of Fort McKay Community members to participate in the Fort McKay Cumulative Effects Project

Footprint type (FT) – an anthropogenic disturbance type (anthropogenic or human-made) classifications in ALCES

Fort McKay Study Area – The main study area for the Fort McKay Cumulative Effects Project, including most of the Fort McKay traditional territory, with the exception of the northern portions located in Wood Buffalo National Park.

In situ operation - (i) a scheme or operation ordinarily involving the use of well production operations for the recovery of crude bitumen from oil sands, or (ii) a scheme or operation designated by the Board as an in situ operation but does not include a mining operation;

Industrial Study Area - The intensive oil sands industrial zone in and around the hamlet of Fort McKay, set as the Industrial Study Area for the Fort McKay Cumulative Effects Study, See Figure 5.

Integrated Land Management (ILM) - A strategic, planned approach to manage and reduce human footprint on the landscape.

Integrated Resource Management (IRM) - A coordinated approach to land and resource management, which encourages multiple-use practices.

Landscape type (LT) – discrete ecosystem (or broad habitat) classes used by the ALCES model that are not disturbed by development.

LARP - Lower Athabasca Regional Plan (Government of Alberta 2012), or pertaining to the land use plan for the Lower Athabasca Region.

MOSA - mineable oil sands area in northeastern Alberta (see Figure 5).

RMWB - Regional Municipality of Wood Buffalo. A specialized municipality located in northeastern Alberta, home to vast oil sand deposits, also known as the Athabasca Oil Sands, helping to make the region one of the fastest growing industrial areas in Canada. (http://www.woodbuffalo.ab.ca/).

RNV - Range of Natural Variation. The normal variation of a specific ecological indicator that occurs in response to the full suite of natural and episodic disturbances that characterize an ecological system.

SAGD - steam assisted gravity drainage - an in situ production process using two closely spaced horizontal wells: one for steam injection and the other for production of the bitumen/water emulsion

SEWG Sustainable Ecosystems Working Group, previously a working group in the Cumulative Environmental Management Association, now the Land Working Group

Simulation – the imitation of the operation of a real-world process or system over time. Computer models such as ALCES are designed to simulate real-world landscape changes due to natural fires and industrial activities.

Stochastic – A stochastic process is one whose behavior is non-deterministic; it can be thought of as a sequence of random variables.

TEMF - Terrestrial Ecosystem Management Framework (CEMA-SEWG 2008), a framework provided to the Government of Alberta that documented cumulative effects in the Regional Municipality of Wood Buffalo and recommended management actions to improve indicator performance following a triad land management approach.

Traditional land use study (TLUS) – Also known as "Traditional Use Studies"(TUS) and "Use and Occupancy Map Surveys" (UOM), TLUS are a form of social science investigation that brings together community knowledge with ethnographic, archival and sometimes archaeological information to provide clarity on places and values of cultural, economic, heritage or community importance. This is usually accomplished through the recording of oral history and map biographies in interviews with community elders and sometimes a larger representative sample of the community.

Treaty rights - (Treaty 8) Include the First Nation's right to hunt, trap and harvest natural resources within Fort McKay's Traditional Territory, the right to pursue their way of life, the right to the use, enjoyment and control of lands reserved for them and the right to a livelihood from their traditional land. While Alberta has the ability to "take up" lands for mining and other purposes pursuant to Treaty 8, this right is limited by Fort McKay's right to sufficient lands, and access to them, within their Traditional Territory, of a quality and nature sufficient to support the meaningful exercise of their treaty rights.

Context and Project Objectives

The Traditional Territory of Fort McKay has been transformed by industrial activity at a rate and magnitude that is unparalleled. The community of Fort McKay is located at the geographic center of an oil sand surface mining area with a current direct footprint that is greater than 100,000 ha today and that will fundamentally transform landform and plant community structure at a scale of ~400,000 hectares (CEMA Sustainable Ecosystems Working Group, 2008) within the next several decades. The magnitude of the current footprint in Figure 1 illustrates the direct unbuffered footprint and highlights the extent of the mineable oil sands area. In comparison, Figure 2 and Figure 3 show the influence and extent of the indirect footprint based on 100 m, 200 m, 300 m, or 500 m buffers[2] that is associated with all anthropogenic footprints; it better illustrates the geographic extent of influence from roads, pipelines, seismic lines, wells, well pads, and processing facilities that are tied to in-situ bitumen development.

The community of Fort McKay is now awakening to a broader understanding of the future spatial extent of in-situ oilsand extraction in northeast Alberta. By most estimates (In-situ Oilsand Alliance, 2010), in-situ extraction of bitumen will ultimately account for ~80% of total production and will unfold over an area ~4 times the size of the MOSA (mineable oilsand area) region. In combination, the footprints of surface mining (active mine site, overburden dump, tailing ponds, refineries) and in-situ extraction (seismic lines, wellsites, wellpads, access roads, pipelines, processing facilities) will affect an area exceeding 2 million ha in northeast Alberta (independently confirmed by CEMA (Sustainable Ecosystems Working Group, 2008 and the Fort McKay Cumulative Effects Study (2013)). Whereas the community of Fort McKay has benefitted from its economic involvement in the bitumen sector, it is also highly concerned that current and future levels of oilsand development have caused significant and adverse effects on its ability to practice traditional activities and has infringed on its Treaty Rights.

Among the people of Fort McKay, moose are among the most highly valued wildlife species - a list that includes caribou, beaver, black bear, mink, and marten . Moose hunting, and the meat and hides it provides, has cultural, historic, and subsistence significance.

"ours is a hunting economy…(and) although we focus on getting wild meat and fish to eat, we are bound by the natural productivity of the animal and fish species that exist in our hunting lands. We have always managed and continue to manage our harvesting of the animals and to safeguard species that are at low points in their cycles. We do this to ensure the long-term survival and abundance of the species upon which our very lives depend…We take what we need to feed our people. We use everything of what we harvest. All we leave behind are our tracks." (From Where We Stand, Fort McKay Tribal Administration, 1983)

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[2] The 100, 200, 300 m and 500 meter buffer distances were selected for illustrative purposes as a plausible range of distances that reflect avoidance distances of large mammals to roads and other anthropogenic footprints (see Dyer et al. 2001, Frair et al. 2008, Environment Canada 2011, Shanley and Pyare 2011)

"Moose is the most important staple food, diet for us First Nations because it keeps me strong, it keeps me healthy and I use part of the moose, even for keeping our bodies warm we use the hide…every aspect of our of our life as a First Nations person depends on moose. Without the moose our very existence as a First Nations person is compromised." (Jean L'Hommecourt, Fort McKay, 2013)

Based on interviews with elders in Fort McKay, Tanner et al. (2001) estimated that annual moose harvest in the period of 1950-1990 averaged 1.40 moose/individual in the community. In a separate and independent assessment, Reeve and McCabe 2007 estimated that for a one-year period, 142.4 adult moose was an approximate maximum number hypothetically necessary to support a band of 100 Dane-zaa (aboriginal people of the Beaver tribe whose traditional territory was around the Peace River in northern British Columbia and Alberta); this estimate was equivalent to an average annual consumption rate of 1.42 moose per person, and similar to results from Tanner et al. (2001).

The continuation of moose hunting in wildland settings remains a key objective of the Fort McKay. During the past five decades, the rapid expansion of surface mining in the immediate vicinity of Fort McKay has altered significant areas of high-quality moose habitat (particularly along the Athabasca River Valley) and displaced moose hunting to areas distant to surface mining.

Much of the contemporary moose hunting of both aboriginal and non-aboriginal people occurs along the extensive road network unfolding in association with the in-situ oilsand industry. The combination of increasing hunter population (non-aboriginal, aboriginal) and linear feature network is associated with a higher probability of overharvest of wildlife species, which is likely to result in substantially reduced abundance of moose in the region. With the emerging footprint of the broad-scale in-situ industry, the community of Fort McKay has fewer geographic options to hunt moose in non-industrial settings. One such location is the small Buffalo and Moose Lake Reserves (comprised of Moose (Gardiner) and Buffalo (Namur) Lakes Reserves) ~60 km north-west of the community of Fort McKay (Figure 4). These reserves have provided historic opportunities for traditional activities and have become increasingly important as a retreat for community members to escape the noise, smells, and sights of the oilsand sector.

In response to the increasing industrialization in the region surrounding the Fort McKay townsite, the people of Fort McKay are increasingly discussing the importance of the Buffalo and Moose Lake Reserves as a permanent settlement location from which the community can satisfy their demand for traditional activities.

The recently completed Fort McKay Cumulative Effects Study (ALCES and IEG 2013) quantified historic, current, and future expected changes in effective moose habitat based on a "business-as-usual" land use scenario (Figure 5). These analyses describe a significant and long-lasting reduction in effective moose habitat on the industrial landbase (Figure 6) and reveal that high-quality wildland-based moose hunting is restricted to those areas without industry and where access management principles are developed, implemented, and enforced. The simulated reductions in past moose habitat effectiveness in the region is supported by government and industry surveys of moose that indicate the regional moose population is currently in decline and has been reduced by ~50% in the past 15 years (Morgan and Powell 2009, Morgan and Powell 2010; Dover Operating Corp. 2011). Knowledge of life history of moose, and simulations conducted using the ALCES model, suggest that the key determinants of declining moose populations are not simply the footprints of the hydrocarbon sector per se, but rather the increase in number and mobility of moose hunters across the regional landscape as enabled by the rapid and widespread increase in transportation networks and linear edge densities. The "business-as-usual" scenario was contrasted against a "Fort McKay" scenario, which revealed that adoption of best management practices by the hydrocarbon sector, access management, and expanded protected area could significantly mitigate risk to key ecological indicators including moose (Figure 7). A summary table of best management practices adopted in this project is provided in Table 10 and a more complete description is provided in the Fort McKay Cumulative Effects Study (ALCES Group and IEG Group, 2013).

The proposal by Dover Corp. to develop a large in-situ project (maximum predicted production of ~250,000 barrels/day) adjacent to the Buffalo and Buffalo and Moose Lake Reserves has underscored the pace by which the in-situ sector is expanding, and how quickly the Moose/Buffalo Lake Reserves are becoming affected by surrounding industrial activity. Based on Dover's estimated cumulative bitumen production (4.0 M barrels; 640 M m^3) over their proposed 50-year lifespan, the total production from this project represents ~3.8% of the total estimated bitumen production for the Traditional Territory of Fort McKay. Although the Dover project is currently topical, of acute concern to the community of Fort McKay, and the focus of an ERCB hearing, it is but one of an estimated 9.1 similarly scaled in-situ projects that will emerge in the Traditional Territory of Fort McKay to achieve future bitumen production curves as published by Alberta Energy, CEMA, and LARP.

In 2012, the Fort McKay Sustainability Department commissioned the ALCES Group to quantify the effects of past, current, and future bitumen extraction activity on moose (habitat area, habitat quality, population size, and harvest) for different conservation area options anchored at the Buffalo and Moose Lake Reserves.

The central questions being examined were:

1. To what extent will the large-scale bitumen industry affect moose population size, viability, and opportunities for moose hunting?
2. Are the current reserves of Moose Lake and Buffalo Lake adequate to meet the moose harvest demands of Fort McKay?
3. How much "non-industrial" area is required to provide sufficient habitat to meet the moose harvest requirement of the Fort McKay community?
4. What is the relationship between study area size and the effects of fire regimes on forest age class structure, and hence moose populations?
5. How do different moose harvest strategies (variable by age and gender) affect moose populations and sustainable harvest?

6. What are the general spatial rules relating to protected areas that inform the Fort McKay community about conservation and maintenance of a broader range of wildlife species and ecological processes?

In addition to addressing the specific questions above, we provide an overview to the key “drivers” that have, are, and will likely shape moose populations within the Traditional Territory of Fort McKay. Through better understanding of these dynamics, it is hoped that it will become evident to the Government of Alberta, and the oilsand sector, why a greater degree of active involvement by the Fort McKay community in moose management is required. This community has statutory rights to harvest moose, is the priority allocation stakeholder in situations where moose harvest demand exceeds moose harvest supply, and is a large, though undocumented, source of moose mortality. Any moose management strategy developed by the Government of Alberta that does not incorporate the objectives, constraints, and active participation of the First Nation community is highly unlikely to succeed over the longterm.

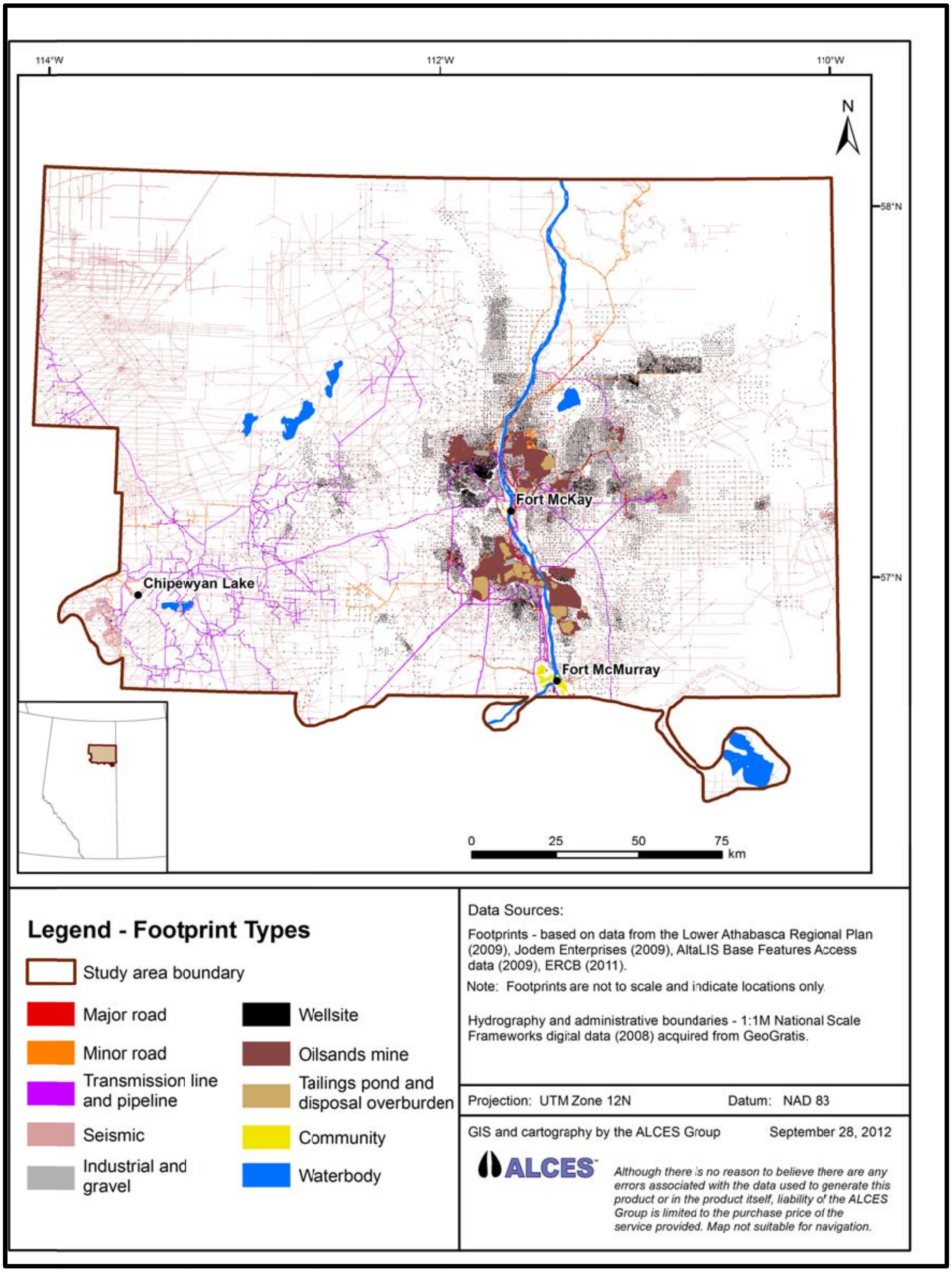
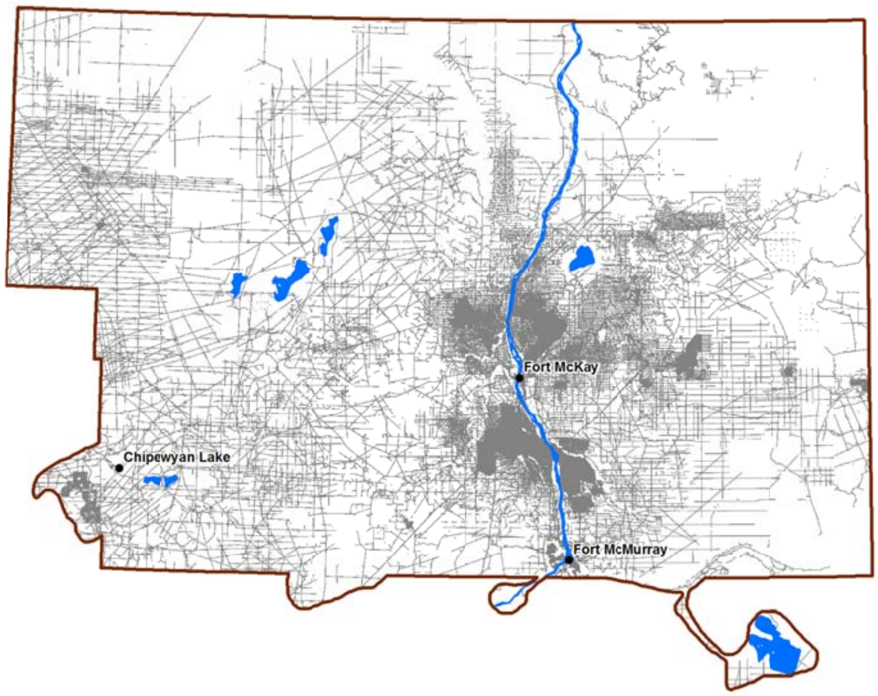


Figure 1. Current industrial footprint on the Fort McKay Study Area.

100 m buffer (20%)



200 m buffer (33%)

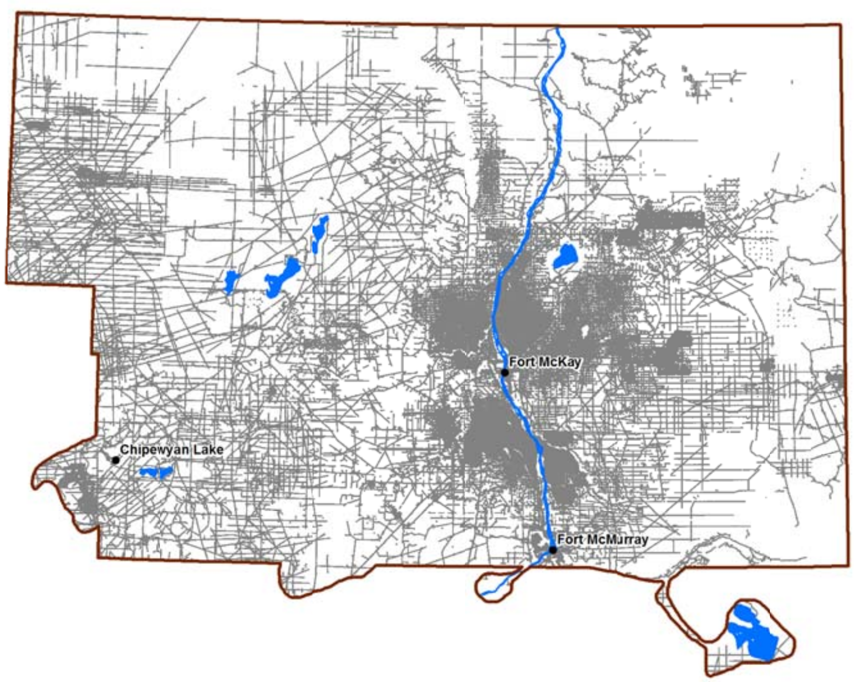
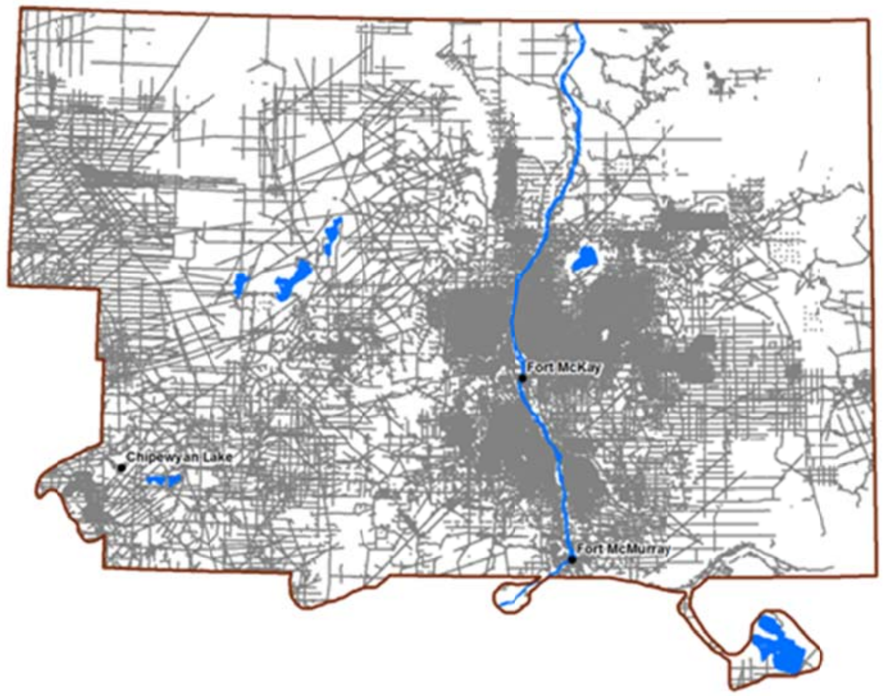


Figure 2. Effect of 100 and 200 m buffer width distances applied to current anthropogenic footprints in Fort McKay study area. The numbers in parentheses indicate the percentage of the study area that is taken up by the direct footprint (~3%) and associated buffered areas.

300 m buffer (43%)



500 m buffer (57%)

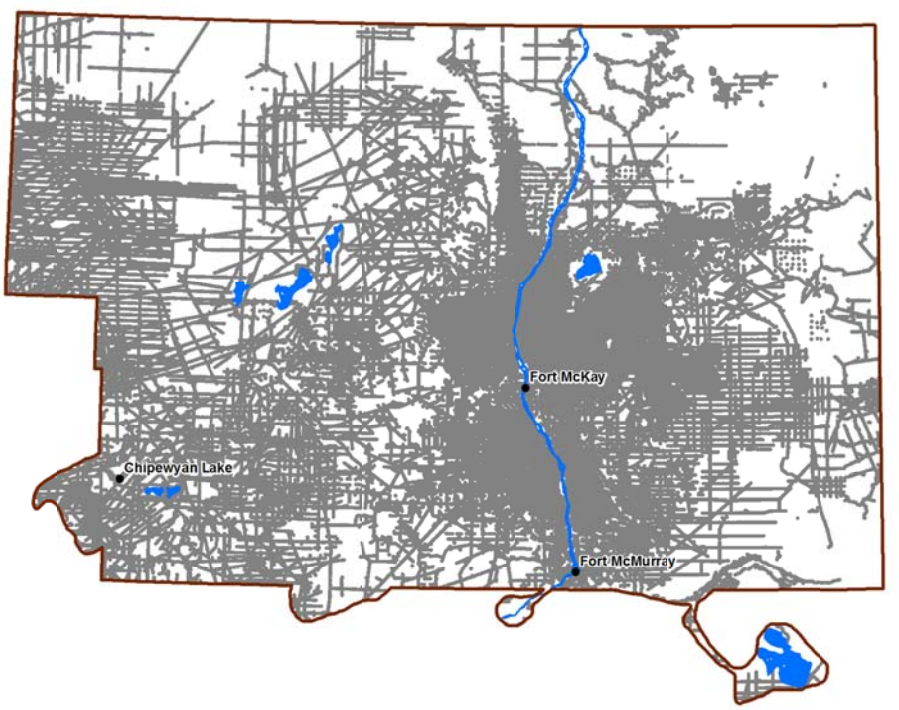


Figure 3. Effect of 300 and 500 m buffer width distances applied to current anthropogenic footprints in Fort McKay study area. The numbers in parentheses indicate the percentage of the study area that is taken up by the direct footprint (~3%) and associated buffered areas.

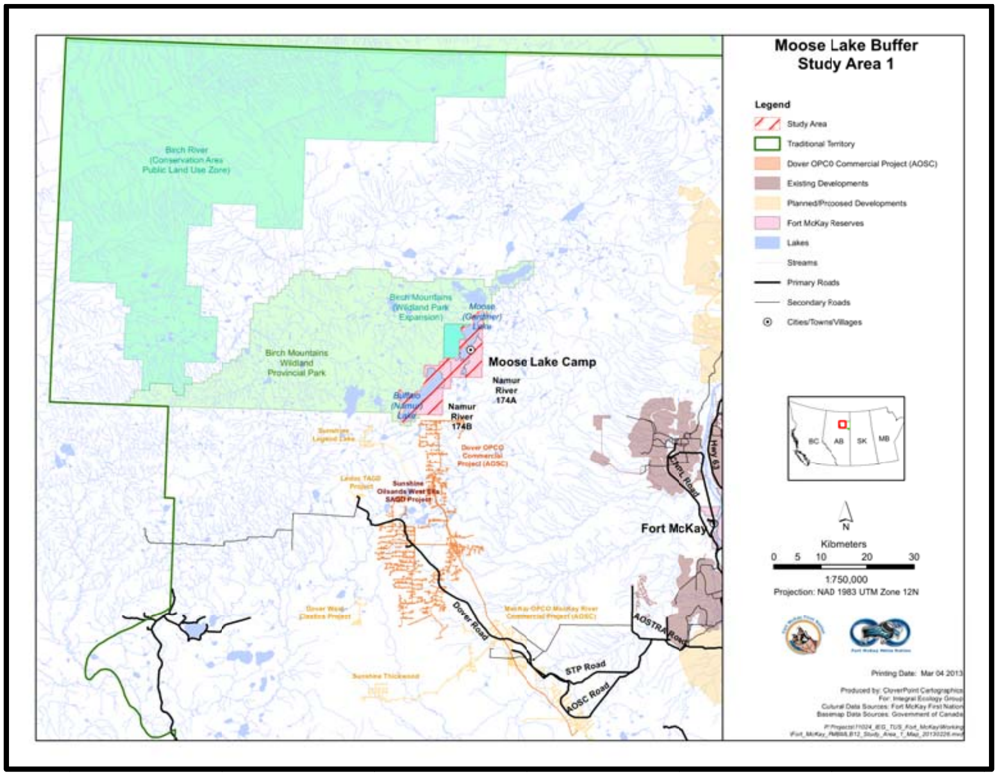


Figure 4. Location of the Buffalo and Moose Lake Reserves west of the community of Fort McKay and the location of the proposed Dover Corp In-situ proposal immediately south of the Reserves.

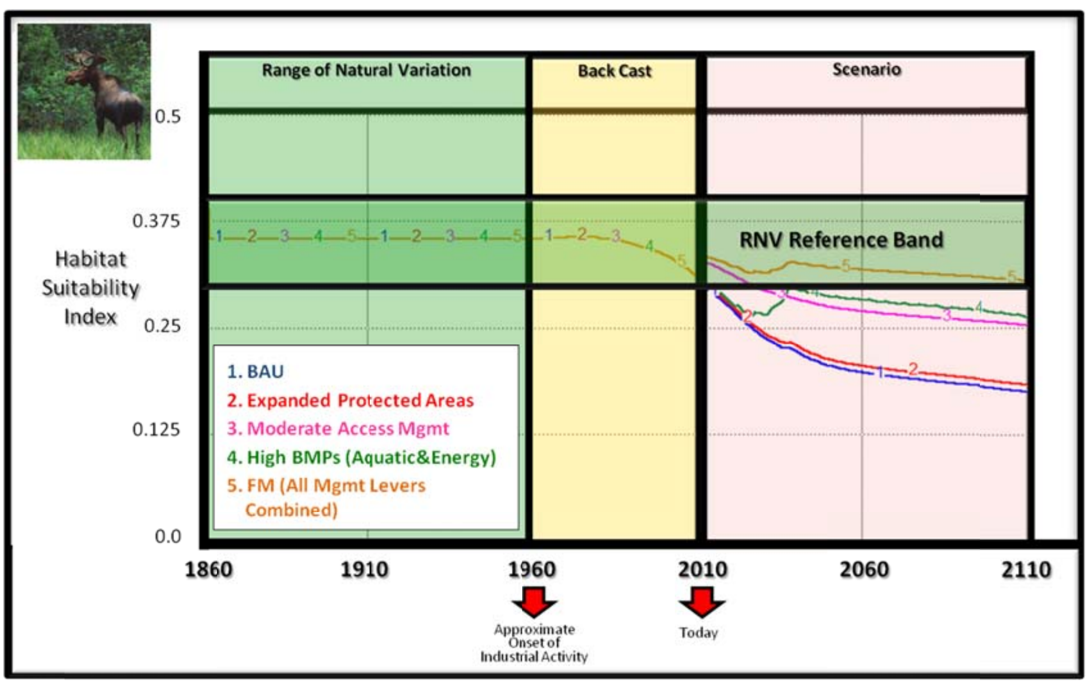


Figure 5. Simulated changes in moose habitat effectiveness in the Fort McKay study area. Business as Usual scenario suggest that moose habitat effectiveness will be reduced by ~50% at the scale of the study area

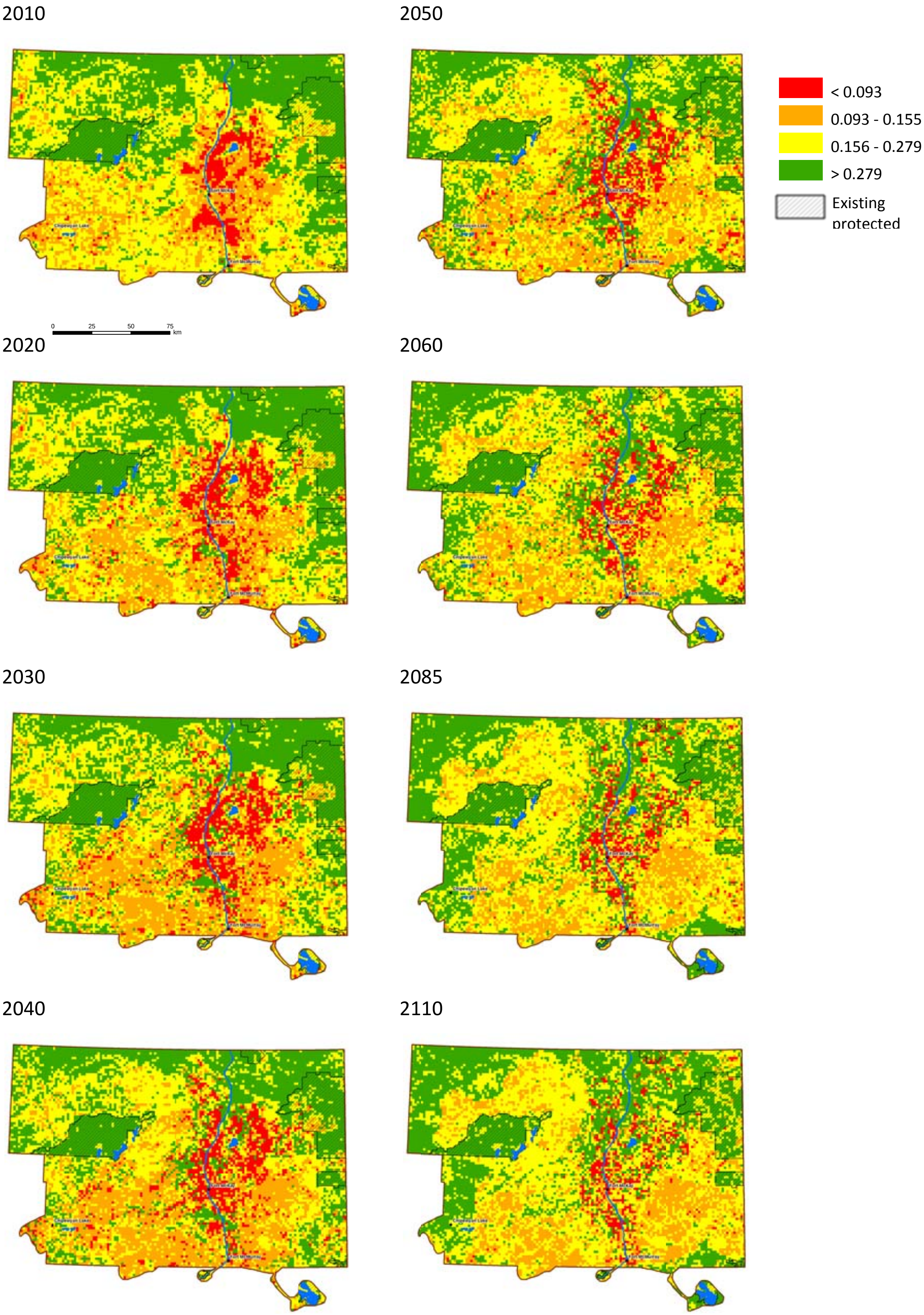


Figure 6. Simulated changes in the performance of moose habitat integrity under a "business-as-usual scenario.

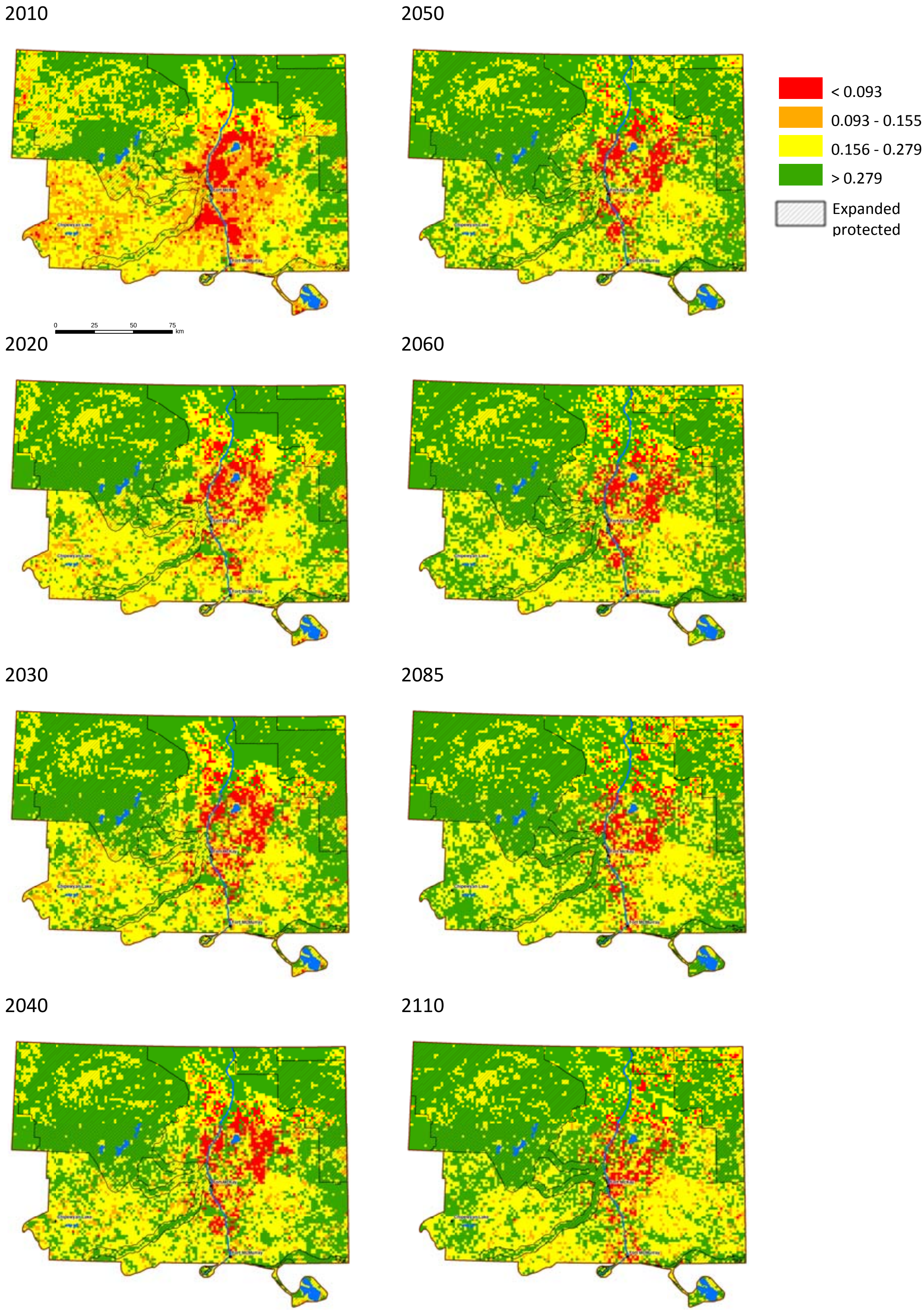


Figure 7. Simulated changes in the performance of moose habitat integrity under the "Fort McKay" beneficial management practice scenario.

Introduction

The Pre-Industrial History

Moose habitat, moose populations, and the Dene and Cree people each arrived on the landscapes of northeast Alberta about the same time and shortly after glacial ice sheets retreated from this region ~8-10 thousand years ago. Oral and archeological evidence confirm that the Cree and Dene people of this region depended on and hunted a diversity of wildlife species for subsistence purposes prior to European contact. Moose have always been an important and core species to subsistence to the Fort McKay community because of their meat and hides. To most elders of this community, moose hunting defined their culture.

During this era, the basic dynamics of predator/prey systems applied to moose and aboriginal peoples of northeast Alberta. As a major source of energy (subsistence) to people, moose were an important prey species and hence changes in moose numbers would have affected (possibly regulated) the population size of people (predator). In turn, the harvest (predation) of moose by people would have affected (possibly regulated) the numbers of moose. Although moose were a key food source to aboriginal people, they were not the only one, as evidenced by the importance of fish and other species in their diet. As described later, moose populations are highly variable through time, and as such First Nations would have developed foraging strategies that allowed for them to change their dependency on moose for food as moose densities changed. Similarly, people were not the only prey of moose, as wolves, bear, and other natural mortality elements (disease, specifically winter tick outbreaks) occurred. The above description suggests that moose and human populations likely changed through time, and that changes in either human or moose populations likely affected each other. This aboriginal/moose relationship is important to understand because the arrival of Europeans would have altered this dynamic to some meaningful extent.

Prior to the arrival of Europeans and their land uses, the First Nation peoples of this region were highly nomadic, moving in (multi) family groups in seasonal and inter-annual patterns that enabled people to locate and harvest ungulates, fish, furbearers, medicinal plants, and edible berries. This spatial-temporal pattern of dispersion and movement was sustainably deployed for thousands of years and enabled a low-density First Nation population to utilize (and potentially exhaust) local resources while moving to new locations as previous habitation sites replenish their stocks (populations) of traditional foods.

Arrival of Europeans and Altered Activity Patterns of First Nations

The arrival of Europeans to northeast Alberta in the 1700s, and the land uses they introduced, markedly altered the traditional nomadic patterns of the Dene/Cree people. The introduction of the trapping industry attracted First Nation families to trading forts (Ft. McKay was established in 1820) to exchange pelts for a broad suite of commodities including food, firearms, and ammunition. With passing decades, more families resided at Fort McKay for a great proportion of the year. Following the signing of Treaty 8 in 1899, the traditional movement patterns of the Fort McKay people were further constrained by the establishment of specific “reserves”. An increase in spatial permanence was re-enforced by Government of Canada and Government of Alberta requirements for children to attend schools (residential or community).

In addition to introducing new land uses (such as trapping for trade), Europeans also introduced new foods to the diet of aboriginal people of northeast Alberta. Although still using native foods extensively, the people of Fort McKay also had access to the many foods made available at the Fort. This introduction of alternative foodstuffs would be an important consideration in the predator/prey (human/moose) dynamic of the region, as regional reductions in moose numbers would not necessarily cause a significant reduction in populations of aboriginal people. The increase in the non-aboriginal population would have increased the regional human population and their food requirements, including demand for moose harvest.

The size of the aboriginal community would have varied through time, and experienced multiple and significant die-offs associated with influenza outbreaks in the late 1800s and early 1900s. As the population of Fort McKay recovered numerically following the influenza die-offs, so did the hunting pressure for moose in the vicinity of the townsite and reserve. The arrival of advanced firearms and vehicles (trucks, snow-mobiles, and eventually all-terrain vehicles) would have increased the mobility and efficiency of hunters to find and harvest moose. A pre-European hunting strategy that involved low-densities of dispersed hunting families had been replaced by an aboriginal population largely residing in a single (or few) location(s) that became the center from which moose hunting activity emanated.

The Emergence of the Bitumen Sector

The development of cost-effective technologies to extract and process bitumen (oilsands) catalyzed economic and ecological changes of scale that few could have foreseen. Since the inception of this industry in the 1960s, ~ 1.294 B m^3 of bitumen have been extracted (ERCB 2011), 26.8 B m^3 of established bitumen reserves remain to be extracted (ERCB 2011), and the human population has grown from ~2,000 in the mid-1960s to over 100,000 currently residing in the regional municipality of Wood Buffalo (Overview TLU, 2010). Almost all of this population growth has occurred among the oilsand workforce located in Ft. McMurray and surrounding work camps, fueling a non-aboriginal population that is young, affluent, outdoor-oriented, and with a strong demand for hunting and fishing.

The Fort McKay Cumulative Effects Project (2013) describes the historic, current, and future spatial and temporal patterns in performance of key ecological indicators. From the perspective of ecological indicators, the analyses are clear and largely unfavorable. The current and projected volume of bitumen extraction requires a profound level of anthropogenic footprint and this footprint, and the human population and activity it supports, has and will adversely affect the relative abundance and performance of all ecological indicators (moose, fisher, native fish).

Future simulations of the energy sector in this region demonstrate the spatial trajectory that will unfold and those areas that are most likely to retain a reasonable level of ecological integrity because of either non-commercial deposits of bitumen or because of their non-industrial status (reserves, parks). Of these patches of ecological intactness, the Buffalo and Moose Lake Reserves, and their adjacent regions are relatively unique in terms of ecological integrity, proximity to the community of Fort McKay and its cultural relevance.

Moose as Country Food for First Nations

Assuming that the pre-industrial moose harvest rates estimated by Tanner et al. (2001) are reasonable, it is possible to estimate the 1st-order habitat area required to support and harvest this number of moose on a sustained basis. The key assumptions are:

1. Average pre-industrial per-capita annual moose harvest of 1.4 (range of 1.1 to 1.7). This value might seem high to the un-informed but equates to an average per-capita daily meat (dry weight) consumption of 0.16 kg.
2. Population estimate (in 1966) of 230 prior to the arrival of the oilsand sector (Tanner et al. 2001). The Fort McKay community has subsequently grown to a population of approximately 800.
3. Average long-term moose density of ~0.17 – 0.20 moose/km^2. (Hauge and Keith 1981, Schneider and Wasel 2000, Gould 2012, also results of the simulations presented in this report). These densities levels are generally not sustained on boreal forest landscapes that become progressively more industrial.
4. Average annual sustainable offtake fraction of ~7-10% of the moose population. (Crete and Daigle 1999, Hauge and Keith 1981). These rates apply to situations where moose are sympatric with predator communities.

This mathematical approach reveals that a significant area would have been required to meet the subsistence moose requirements of a Fort McKay population of 230. Using an equation where per capita offtake is lowest (1.1 moose/person/yr) and densities (0.20/km^2), and offtake (10%) is maximal, a minimal area of 1.26 M ha would have been required. In contrast, a situation where offtake is highest (1.7 moose/person/year) , moose densities (0.10 moose/km^2) and offtake is 7%/yr are lower, a maximum area of 5.58 M ha would have been required. Given the range in these two numbers, it is interesting to note that the estimated size of the Traditional Territory of Fort McKay is 3.9 M ha.

General Ecology of Moose

Moose are important culturally and provide a subsistence source of country food for northern aboriginal communities (Pyc 1999, Wein et al. 1991). Management of moose in northern Alberta is largely focussed on stabilizing and increasing moose densities in order to provide optimal hunting opportunities (ASRD 2002). Moose surveys are conducted every 5 to 20 years for a given wildlife management unit (WMU).

Moose are browsers as opposed to grazers and prefer early successional habitats that typically provide abundant food. Under good habitat conditions, female moose may give birth as 2 year olds (Schwartz 1992, Boer 1992) and twins are more common when food availability is high (Franzmann and Schwartz 1985, Boer 1992). Moose have a high reproductive output compared to other similar sized ungulates (Gaillard 2007), making the species adaptive and resilient to natural environmental variation and able to reproduce quickly when food resources are abundant (Ferguson 2002).

Moose are well adapted morphologically and behaviourally to winter snow conditions in northern boreal forests (Telfer and Kelsall 1984). Moose populations can be limited or regulated by interactions of ecological and climatic factors, but the main factors affecting resilience of moose populations are primarily related to 1) overall habitat productivity, i.e., food abundance (Ferguson et al. 2000), and 2) total mortality from natural predation and human caused deaths (Messier 1994). For example, moose populations that live in productive habitats have high reproductive output and may be regulated by food abundance despite natural predation by wolves (Messier 1994). Conversely, moose that live in habitats with poor productivity have reduced reproductive potential and the population will likely be regulated at low densities by wolf predation (Messier and Crete 1985). Consequently, direct and indirect loss in habitat quantity and quality can reduce resilience of moose populations. Resilience of a moose population may also be reduced when total mortality increases due to natural predation from more than one species, i.e., wolves and bears, combined with the effects of human harvest (Gasaway et al. 1992, Messier 1994).

Determinants of Moose Population and Harvest

The combination of increasing densities of human population, roads, linear features (seismic lines, pipelines), and cutblocks have all contributed to greater demand for moose hunting and greater access by hunters to moose habitat in northeast Alberta. This pattern is profiled clearly by trends in moose harvest for WMUs 530 and 531 (Table 2, Table 3, Figure 8) during the period 1997 to 2008. These data are only relevant to non-aboriginal moose hunters, whose fall hunting season extends from September through November in length, whose participation is governed by a draw, and is preferential to gender (primarily bulls). In contrast, aboriginal moose hunters are entitled to harvest moose year-round and are not legislatively constrained by either the number or gender they harvest.

Moose populations can be vulnerable to excessive mortality and as such all forms of natural (predation, disease) and anthropogenic (aboriginal, sport hunt, outfitters, poaching, vehicular) mortality must be carefully addressed if moose population levels are to remain at desired densities. Excessive cumulative levels of mortality have been shown to cause significant reduction in moose populations and hence harvest levels. Prior to the era of high non-aboriginal populations and extensive road networks in northeast Alberta, the majority of moose hunting would have been done by aboriginal peoples. The contemporary situation in the Traditional Territory of Fort McKay is different, as regional moose populations experience significant harvest rates from a more diverse hunting community.

Whereas the non-aboriginal harvest of moose is regulated by the Government of Alberta under the auspices of the Alberta Public Lands Act (revised 2000), harvest of moose by First Nations is self-directed. Given the finite capacity of moose to support harvest, it is clear that an integrated approach to moose harvest is required in northeast Alberta.

From a moose population management perspective, key questions need to be addressed:

1. Given key assumptions on natural mortality and poaching of moose, what level of moose harvest can be sustained in the region?
2. How are sustainable moose harvest rates affected by overlapping land uses that include energy, forestry, transportation and settlements?
3. How are sustainable moose harvest rates affected by different harvesting strategies relating to age class and gender class?
4. If total desired or regulated harvest rates exceed the capacity of moose populations to sustain these rates, what allocation rules should apply?

The community of Fort McKay desires a management role in the harvest and monitoring of moose in their traditional territory. They have been the dominant historical harvesters of moose, are an important agent of moose harvest today, and intend to continue their traditional rights of harvesting moose in the future. With rights comes responsibilities, and the community of Fort McKay recognizes that they must also understand the effects of their harvesting strategies on moose population dynamics and management actions.

Moose Population Surveys and Density

Moose surveys in Canadian boreal forest systems generally indicate highly variable densities, with local values (and often seasonal) in preferred habitat types capable of exceeding 1.0 moose/km^2 and larger area-weighted densities generally below 0.20 moose/km^2 in boreal landscapes that are not intensively industrialized. Most moose survey methodologies have significant detection and measurement errors (Steinhorst and Samuel 1989, Gasaway et al. 1996) and as such some of the temporal variation reported (such as in Figure 9) can be attributed to survey design and not population response. Maximum moose densities (K) are theoretically defined by forage availability in systems where total predation is low or absent. Observed densities of moose in northern Alberta seldom, however, achieve levels defined by food availability, as combined mortality from natural predators (wolves and bears), disease, sport harvest, subsistence harvest, poaching, and vehicle collisions maintain populations at levels generally below 0.20 moose/km^2 (Hauge and Keith 1981, Schneider and Wasel 2000).

Several studies have shown declining moose densities in regions where industry has caused increases in linear feature density and human populations (Rempel et al. 1997). These trends, correlative in nature, are generally explained by elevated human-related mortality rates that numerically overwhelm natality, and lead to lower moose population densities. Recent (2009 - 2010) moose surveys by Morgan and Powell (2009 and 2010) reveal that regional moose populations in the Fort McKay area have declined by ~50% over the past 15 years from densities observed from surveys completed in 1993. Unlike other cervid species (white-tailed deer, elk) that are wary and challenging to hunt, moose are more vulnerable to moderate hunting pressure especially when road and trail densities facilitate vehicle and off-highway vehicle access (Ferguson et al. 1989, Ferguson et al. 2005, McLaren and Mercer 2005, Shanley and Pyare 2011). Where moose are abundant, they are comparatively easy to locate, track, and shoot.

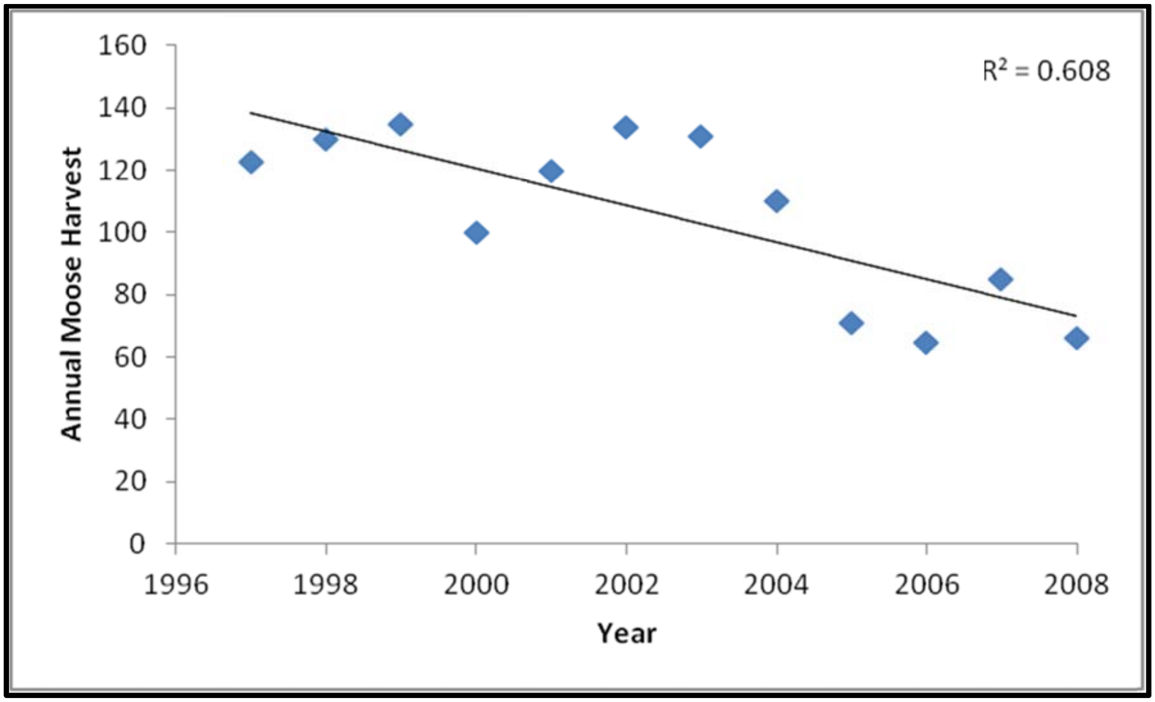


Figure 8. Annual moose harvest by Alberta Residents and Non-Residents in WMUs 530 and 531, from 1997-2008. Data sources are Morgan and Powell (2009 and 2010).

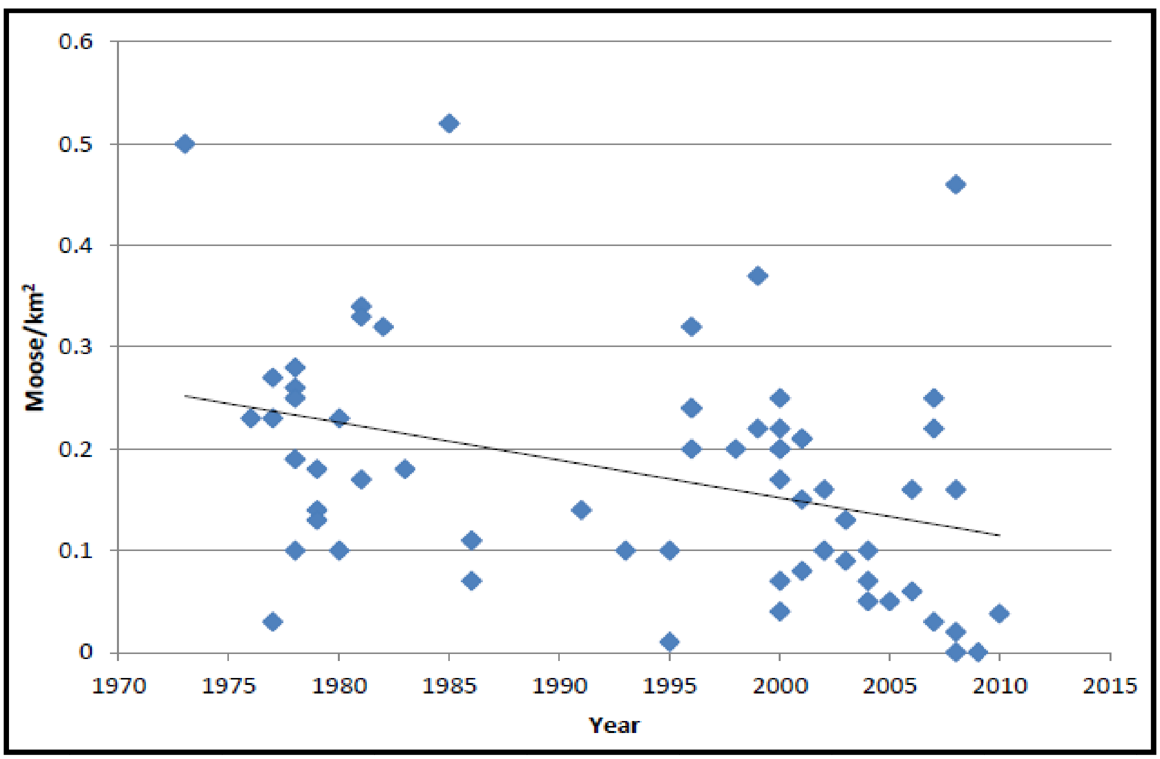


Figure 9. Estimates of moose density from surveys completed in the oil sands region and within Fort McKay's Traditional lands between 1972 and 2008 (from Gould 2012).

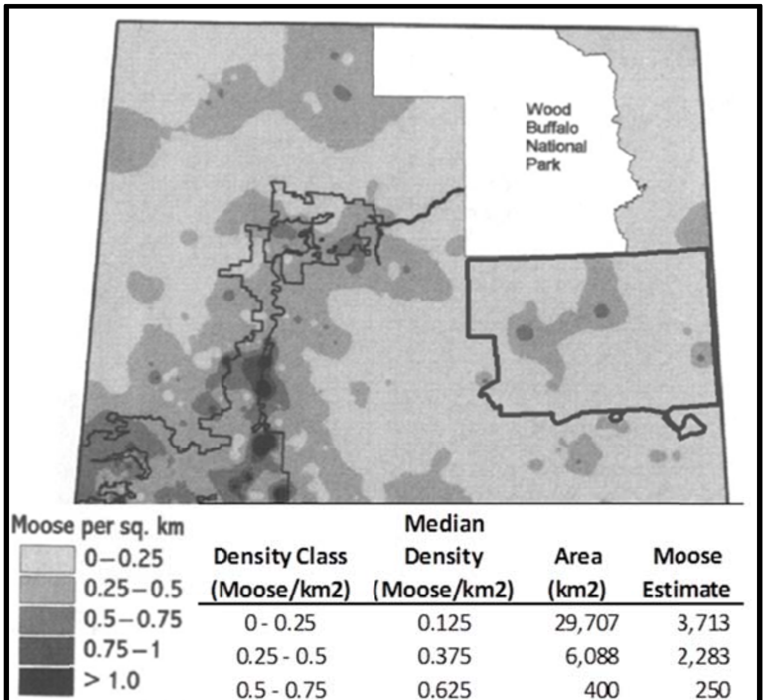
The earliest published data on moose densities in the Fort McKay area comes from research done by Hauge and Keith (1981) from 1976 to 1978; their work was part of the Alberta Oil Sands Environmental Research Program (AOSERP)[3] which was conducted from 1975-1985 as a result of public concern over potential environmental consequences of oil sands development. They estimated 4,595 moose (0.18/km^2) for the entire 25,000 km^2 AOSERP study area in the winter of 1977-78, and concluded that the moose population was stable or slowly declining. From 1973 to 1978 and within a smaller portion of the study area known as the Bitumont Area (1,685 km^2), they observed an average density of 0.237 moose/km^2 (Hauge and Keith 1981: Table 1, p.577), Recently, Gould (2012) reviewed 53 EIAs and reports in the Fort McKay area from 1973 to 2010, and found that moose density ranged from 0-0.52 moose/km^2 with a mean density of 0.17 moose/km^2 (n=65) (Figure 9).

In the early 1990s, an extensive program of aerial surveys of northern Alberta resulted in an estimated 87,000 moose at an overall density of 0.25 moose/km^2 (see Pybus 1999). The regional moose population of northern Alberta was generally thought to be stable, with densities of moose being greater in the southern portion (~ 0.20-0.37 moose/km^2) compared to the northern WMUs (~ 0.05-0.18 moose/km^2; ASRD unpublished data). The higher densities in the south were likely due to agricultural influences and reduced number of predators in farming areas (Schneider and Wasel 2000); wood lots, riparian areas and grain alfalfa/hay fields associated with agricultural land-use in the southern area provide desirable forage and likely influence moose distribution.

To anchor assumptions for simulation modeling in ALCES, we used available data to extrapolate baseline and current moose population densities and estimates. Due to its extensive coverage, we used available data from Schneider and Wasel (2000) to interpolate a baseline estimate circa 1993 for moose density and abundance in the Fort McKay area, which resulted in an estimate of ~6,200 and an overall density of ~0.17 moose/km^2 (Figure 10).

Recent data suggest that moose abundance in the Fort McKay area is currently in decline and has been reduced by ~50% in the past 15 years (Morgan and Powell 2009, Morgan and Powell 2010, Dover Operating Corp. 2011). We compiled the most recent available moose survey data for the respective WMUs in the Fort McKay study area (Figure 11), and calculated an area-weighted estimate of ~2,200 moose and an associated density of 0.06 moose/km^2 (Table 1).

[3] http://www.osrin.ualberta.ca/Resources/DigitizedReports.aspx



Density Class (Moose/km2)	Median Density (Moose/km2)	Area (km2)	Moose Estimate
0 - 0.25	0.125	29,707	3,713
0.25 - 0.5	0.375	6,088	2,283
0.5 - 0.75	0.625	400	250
		36,194	6,246

Figure 10. Estimate of moose populations in Fort McKay study area based on area-weighted median densities from Schneider and Wasel (2000). Overall moose density for the study area was ~0.17 moose/km^2.

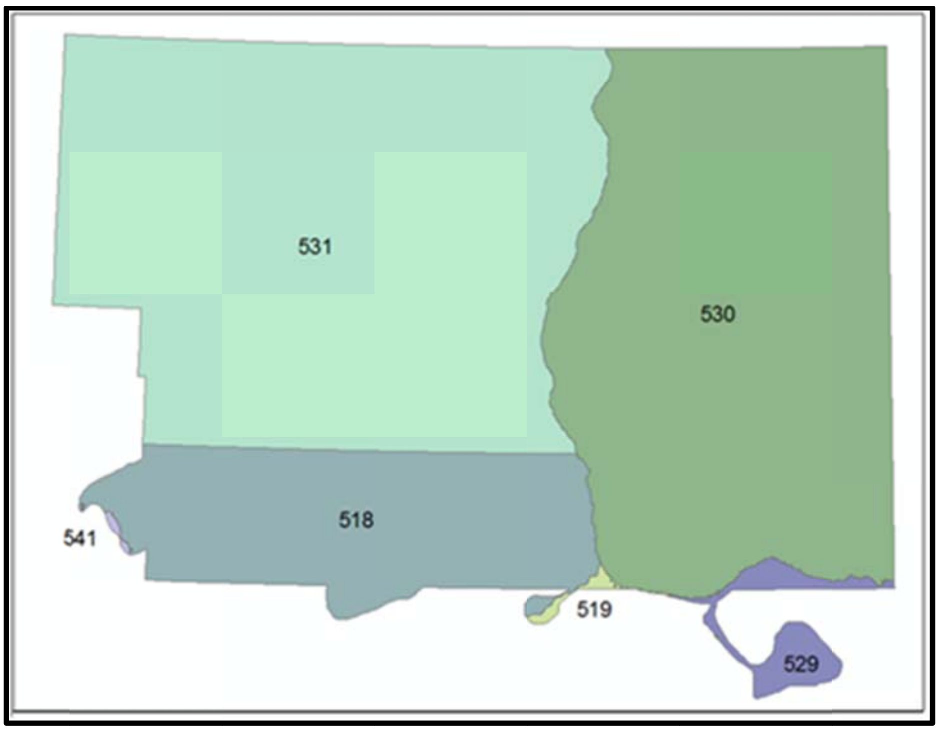


Figure 11. Wildlife Management Units (WMUs) that occur within the Fort McKay study area. Area of each WMU that comprises the study area is summarized in Table 1.

Table 1. Area-weighted estimate of moose populations in Fort McKay study area based on moose densities observed in respective Wildlife Management Units from most recent survey data (2009, 2010) from Alberta Environment and Sustainable Resource Development.

						Fort McKay Study Area		
	WMU	ASRD Survey Year	Area (km^2)	Survey Estimate	Density (Moose/km^2)	Area (km^2)	Area-weighted Moose Estimate	Density (Moose/km^2)
Thickwood Hills	518	2003/04	11,859	1685	0.142	5,466	777	
Algar Lake	519	2007/08	7,506	1107	0.147	79	12	
Gordon Lake	529	2009	4,408	157	0.036	629	22	
Delta	530	2009/10	21,397	1211	0.057	13,568	768	
Birch Mountains	531	2008/09	16,955	662	0.039	16,428	641	
Panny River*	541				0.084	24	2	
						36,194	2,222	0.061

*A moose density estimate for WMU 541 was calculated as an average of moose densities in WMUs 518, 519, 529, 530, and 531. Moose density estimates in WMUs 518 and 519 were provided as unpublished data from Alberta Environment and Sustainable Resource Development. Data sources for WMUs 529, 530, and 531 were from Powell and Blackwood 2009, Morgan and Powell 2010, and Morgan and Powell 2009, respectively.

We reviewed available information to provide additional context on the magnitude of moose hunting in the Fort McKay area starting in the mid 1970s. Socioeconomic research by Phillips et al. (1978) on recreational use of fish and wildlife resources in the AOSERP study area provided an estimate of annual harvest of moose by Alberta residents in 1975-76. Table 3 shows that the total numbers of resident hunters who travelled to the area or lived in the area were 1,542 and 988 respectively. With success rates of 14% and 18% respectively, the total numbers of big game animals harvested by Alberta residents living outside and within the AOSERP were 216 and 176 respectively. Since most of the harvested big game was moose, the total estimated annual harvest by Alberta residents in the AOSERP study area for the 1975-76 hunting season was 312. In a separate evaluation of moose harvesting in the area, Hauge and Keith (1981) used license sales and estimates of hunters residing within and outside the study area to calculate an annual harvest by residents ranging from 287 to 369 moose (Table 2, Table 3). Based on active trappers and interviews with the Chief of Fort McKay at the time, they estimated that an additional 64 moose were harvested for subsistence, which represented ~15-18% of the total annual harvest (Table 2, Table 3).

Moose harvesting by resident and non-resident hunters from 1997 to 2008 were summarized by Morgan and Powell (2009 and 2010) for WMUs 530 and 531. The total combined annual harvest of moose for those two WMUs ranged from 65 to 135, had an average of 106, and showed a declining trend over time (Table 2, Table 3, Figure 8).

Table 2 Estimated annual moose harvest from 1997 – 2008, by Resident and Non-Resident hunters in Wildlife Management Units (WMUs) 530 and 531. Harvest data were extrapolated from bar graphs in Morgan and Powell (2009 and 2010).

Year	WMU 530			WMU 531			Total
	Resident	Non-Resident	Sum	Resident	Non-Resident	Sum	
1997	62	8	70	45	8	53	123
1998	68	9	77	28	25	53	130
1999	57	15	72	44	19	63	135
2000	37	20	57	20	23	43	100
2001	49	0	49	71	0	71	120
2002	69	7	76	52	6	58	134
2003	42	7	49	71	11	82	131
2004	50	7	57	49	4	53	110
2005	31	0	31	40	0	40	71
2006	13	5	18	40	7	47	65
2007	45	0	45	40	0	40	85
2008	26	2	28	32	6	38	66
2009	35	0	35				n/a
Mean			51			53	106
SD			19.3			13.4	27.5

Table 3 Estimate of annual moose harvested by people within the Alberta Oil Sands Environmental Research Program study area (circa 1975-1977). Data sources were Phillips et al. (1978) and Hauge and Keith (1981).

		AB residents in AOSERP	Study Area residents in AOSERP	Sum	Trappers	Natives (Fort McKay & Anzac)	Sum	Total
Assumptions based on Phillips et al. 1978 (p.45)	Total Big Game Hur	1542	988	2530	-	-	-	2530
	% success	0.14	0.18		-	-	-	
	Total Kill	216	176	392	-	-	-	392
	% Moose*	0.800	0.791		-	-	-	
	# Moose Harvested	173	139	312	-	-	-	312
Assumptions based on Hauge and Keith 1981 (p. 585)	# Moose Harvested	177	192	369	28	36	64	433
				85.2%			14.8%	100%
	# Moose Harvested	95	192	287	28	36	64	351
				81.8%			18.2%	100%

* Phillips et al. (1978) stated that Alberta Residents hunting in the AOSERP area took "primarily moose" but did not provide an estimate. We used a value of 0.8, which was similar to the proportion of moose taken by residents living in the AOSERP study area.

The Loss of a Traditional Landscape – The Search for a New Opportunity

Amongst the ongoing industrial transformation of northeast Alberta, the community of Fort McKay is seeking a dialogue with government and industry that allows current and future generations to participate in traditional activities within a non-industrial setting of adequate size, location, ecological integrity, and historic cultural relevance. Until the past few decades, the historic "cultural" reference point for traditional practices was their homelands centered by Fort McKay – a geographic solution that no longer exists and is unlikely to be re-instated in the next century. It is now obvious to the community of Fort McKay that an alternative solution must be sought.

There are numerous criteria that need to be considered and satisfied to provide Fort McKay with a viable opportunity to maintain their traditional activities at a level of quality that is meaningful and provide value for multiple generations. The following elements are important:

1. Size of the traditional use conservation area.
   a. Maintenance of ecological integrity is positively related to the size of the non-industrial area.
2. Representativeness of landform and habitat type
   a. The composition of plant communities in the proposed non-industrial area should be similar to those historically responsible for maintaining ecological integrity.
3. Cultural relevance.
   a. If the proposed non-industrial area is to have value as a venue for conducting traditional activities by Fort McKay, it must be culturally "anchored". It needs to possess historical and cultural importance if it is to provide a temporal continuity between "what was" and "what could be".
4. Accessibility.
   a. To realize its potential as a site for practicing traditional activities, the non-industrial "traditional use" zone needs to accessible to the community of Fort McKay. The town of Fort McKay, surrounded by industrial activity, will likely remain in future decades an important economic home for community members. The "conservation" zone needs to sufficiently close to be accessible, yet sufficiently insulated from industrial activity to maintain its ecological integrity.

Based on the above principles, there are relatively few geographic options available for consideration by the community of Fort McKay. Of the options considered, the value of the Buffalo and Moose Lake Reserves (comprised of the separate Moose and Gardiner Lake Reserves) is comparatively high. Its significant features include:

1. Long history of traditional use by the community of Fort McKay
2. Adjoins the Birch Mountain Provincial Park to the west and as such benefits from the ecological services of the Park
3. Is located within a portion of the Traditional Territory of Fort McKay that currently has relatively low levels of anthropogenic disturbance.

4. Based on the Fort McKay Cumulative Effects Study, this region currently contains high levels of ecological goods and services.
5. Is reasonably close (~50 km) to the settlement of Fort McKay and as such is accessible.

Background on Buffalo and Moose Lake Reserves

Reserves 174a and 174b were set aside adjacent to Buffalo and Moose Lake (now called Namur and Gardiner Lakes) for the use and benefit of the Fort McKay First Nation in 1915 pursuant to the terms of Treaty 8. They are collectively referred to in this document as the Buffalo and Moose Lake Reserves. Reserves at Moose and Buffalo lakes were selected due the importance of the area to the livelihood and way of life of the people who later compromised the Fort McKay Indian Band as defined by Treaty 'paylists' and eventually membership lists created by the federal government. Several local "bands" consisting of extended families gathered at the lakes in summer to fish, hunt and preserve food for winter. The lakes and surrounding area has been a rich source of fish, berries, moose, ducks and other wildlife. Trapping areas were, and are, located adjacent to the lakes and extend south and east to the Athabasca River to Fort McKay's other reserves at and near the Hamlet of Fort MacKay.

The gathering of the local bands at the lakes was also a time when the large collective or regional band would conduct social and political activities, such as marriages and leadership selection. A historical trail links the reserves at the hamlet of Fort MacKay to the reserves at the lakes. Cabins have been built at the lakes before and after the creation of the reserves. The Fort McKay First Nation members have deep cultural, historical and economic ties to the Buffalo and Moose Lake Reserves, which remain an important traditional land area for the Community. The reserves and surrounding areas have more recently, in the past decade, been valued by Fort McKay as a place of refuge and cultural and residential land use in the face of increasing industrialization and disturbance of the lands surrounding the hamlet of Fort McKay.

The future capacity of the Buffalo and Moose Lake Reserves to provide a refuge for the community of Fort McKay from the intense surface mining is threatened. The area surrounding the Buffalo and Moose Lake Reserves is now the subject of multiple *in-situ* project applications and plans, and related development, which threaten to encroach upon the reserves and Fort McKay's land uses. These developments include: The Dover Commercial Project, the Athabasca Oil Corporation (AOC) TAGD Project, the AOC Clastics Project, Sunshine West Ells Projects, the Sunshine Legend Lake Project, the Southern Pacific McKay River Project, the BP Terre De Grace Project, the Dover Road, and others. A more complete description of the existing and proposed in-situ projects I the vicinity of the Buffalo and Moose Lake Reserves is provided in Appendix C.

Community members, when consulted about the proposed projects, and options to reduce the impacts on their traditional lands and reserves, identified the need for a buffer zone around the Buffalo and Moose Lake Reserves. At minimum, the buffer zone is intended to protect the current and future land uses on the Buffalo and Moose Lake

Reserves. The above context helps explain the basis for the results presented in this report.

Several studies have examined the empirical relationships between size of protected areas and abundance or persistence of wildlife species in North America. These relationships are discussed in detail in the companion report: Protected Area Needs for Maintaining Ecological Integrity in the Moose Lake Region (ALCES Group and IEG Group, 2013).

These types of analyses have applied significance, because many protected areas established to retain high ecological integrity do not meet their conservation goals (Gaston et al. 2008, McDonald et al. 2008). Gaston et al. (2008) emphasize the importance of understanding the dynamics between the core conservation area and the surrounding industrial landscapes.

Study Areas

The Physical Landscape

The Buffalo and Moose Lake Buffer study area is located within the large Fort McKay Cumulative Effects Study Area (3.62 M ha), hereafter referred to as the Fort McKay Study Area. This region is located within the boreal mixedwood forests of northeast Alberta (Figure 12) and includes the traditional lands of Fort McKay that occur south of Wood Buffalo National Park. The study area varies in elevation from generally 650 to 700 m above sea level.

The biota of the region reflects the diverse landforms and plant communities of northeast Alberta, including 40 fish species (Nelson and Paetz 1992), five amphibians (Russell and Bauer 1993), one reptile (Russell and Bauer 1993), 236 birds (Semenchuk 1992), and 45 mammals (Pattie and Hoffman 1992, Smith 1993). Based on distribution maps (Moss 1983, Vitt et al 1988), conservative estimates indicate a rich diversity of plants, including 600 vascular species, 17 ferns, 104 mosses, 13 liverworts, and 118 lichen species.

Plant Community Structure

The boreal mixedwood forest is a mosaic landscape comprised of stands that vary in tree composition, age, size, shape, and dispersion (Peterson and Peterson 1992). Trembling aspen and white spruce dominate boreal mixedwood on upland mesic sites with medium-textured soils. Past vegetation classifications in Alberta have largely focused on aspen as a seral stage for conifer-dominated climax communities (La Roi and Ostafichuk 1982). However, aspen can also occur as a climax community throughout the low and mid mixedwood ecoregion. Balsam poplar, paper birch, black spruce, jack pine, tamarack, and balsam fir can be locally abundant throughout the boreal mixedwood forest. Topographically depressed areas with impaired drainage are generally dominated by black spruce and tamarack, whereas willow communities are common near lake margins and continuous and intermittent streams. Pines are found primarily in xeric sites.

Natural Disturbances

Fire was the primary disturbance that shaped boreal forests (Johnson 1992). Vegetation patterns created by fire on the boreal landscape are complex and dynamic because fire cycles vary both in space (Payette et al. 1989) and time (Bergeron 1991). In the absence of land use, fire has a dominant role on the age class distribution of plant communities in many terrestrial ecosystems. The area burned frequently varies across years, resulting in plant communities with age class distributions that fluctuate over time. It is often important to capture this fluctuation in landscape simulations as it has implications for ecosystem attributes that are influenced by forest age, such as wildlife habitat.

During recent decades, the role of natural disturbances in boreal forest systems has changed as human land-use practices have altered the intensity, recurrence, and geographic extent of flooding, fire, and insect infestations. Improved fire suppression may have reduced the rate of wildfire in the boreal mixedwood forests of Alberta during the last several decades (Murphy 1985). In the boreal forests of Alberta, fire return interval increased from 38 years in pre-settlement times to 90 years by the late 1960s (Murphy 1985). However, anthropogenic disturbances are now common and growing in prevalence in Alberta's boreal forests (Dancik et al. 1990).

The Buffers

This project examined three study areas that were each geographically centered by the Buffalo and Moose Lake Reserves northwest of the community of Ft. McKay. The variance in size of the study area allowed the project to explore the relationships between area and population size and sustainable harvest of moose. The three study areas (SA) were:

Study Area 1: Moose Lake and Buffalo Reserves without any adjoining buffer

Study Area 2: #1 and 20 km “no go” industry buffer

Study Area 3: #2 and 20 km “intensive management buffer”

The results of these 3 study areas were compared to results generated from examining moose population dynamics at the scale of the Fort McKay Study Area.

**For the purpose of these analyses, intensive management buffer is defined as a region in which concerted efforts are made to minimize the construction of in-situ footprints and maximize the rate at which they are reclaimed. New industrial footprints are not allowed within the “No go” buffers but these regions are eligible for moose harvest by the community of Fort McKay.

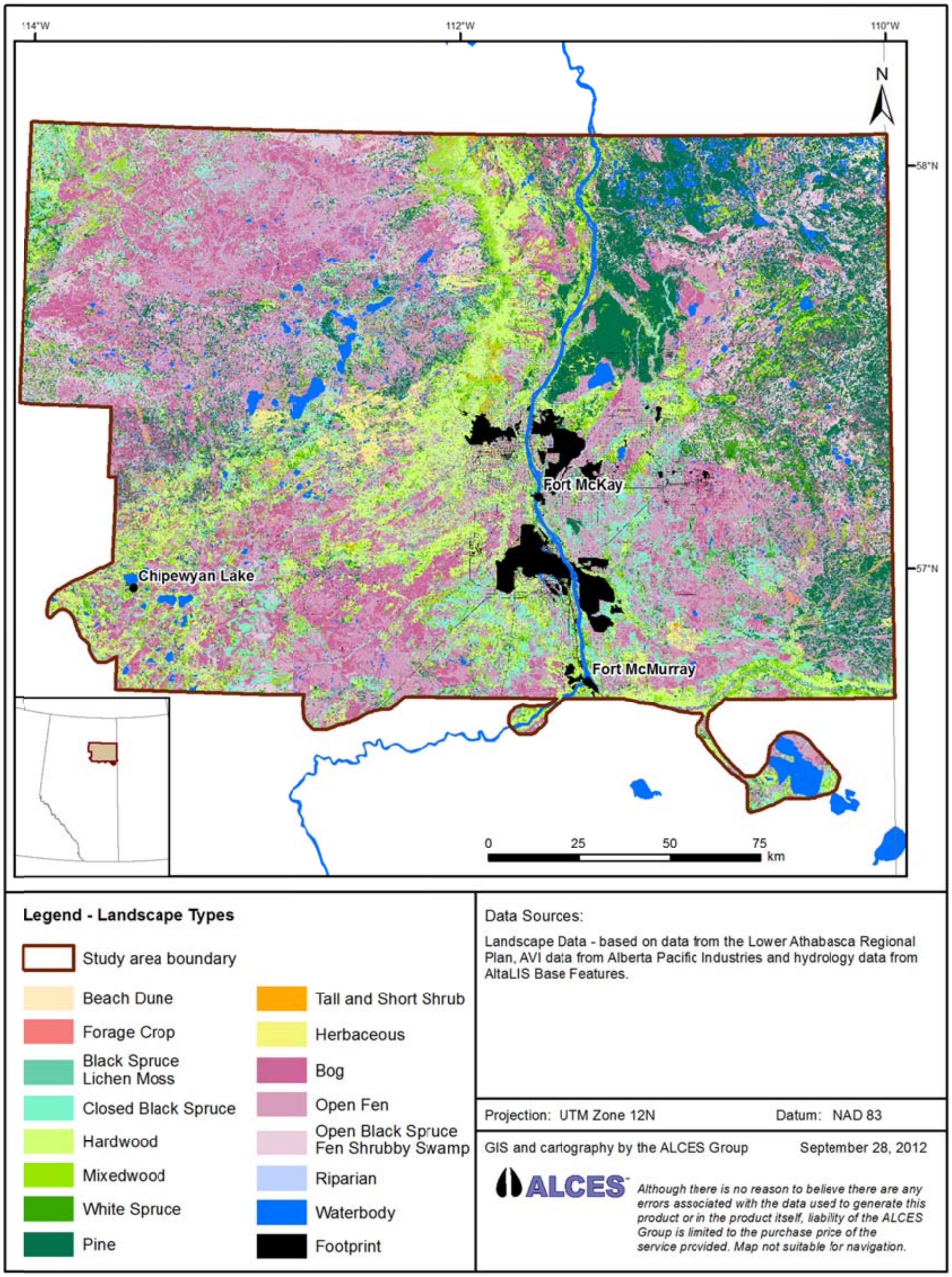


Figure 12. The major landscape types comprising the Fort McKay cumulative effects study area and region surrounding the Buffalo and Moose Lake Reserves.

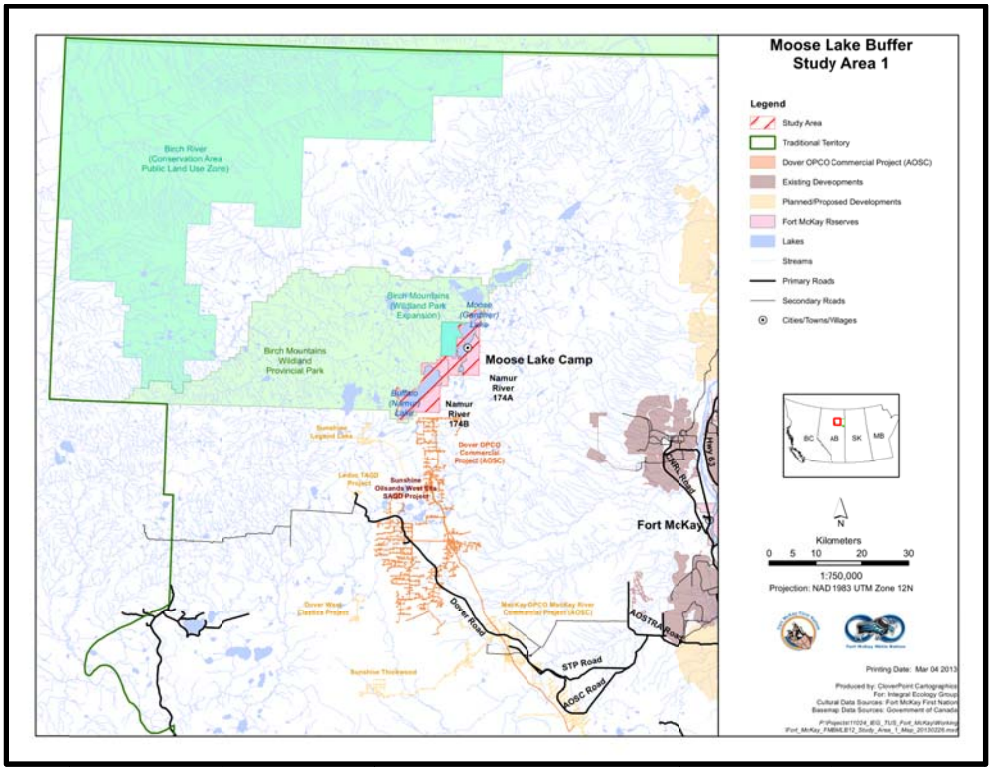


Figure 13. Study Area 1 is restricted to the area within the Buffalo and Moose Lake Reserves (and is inclusive of surface water).

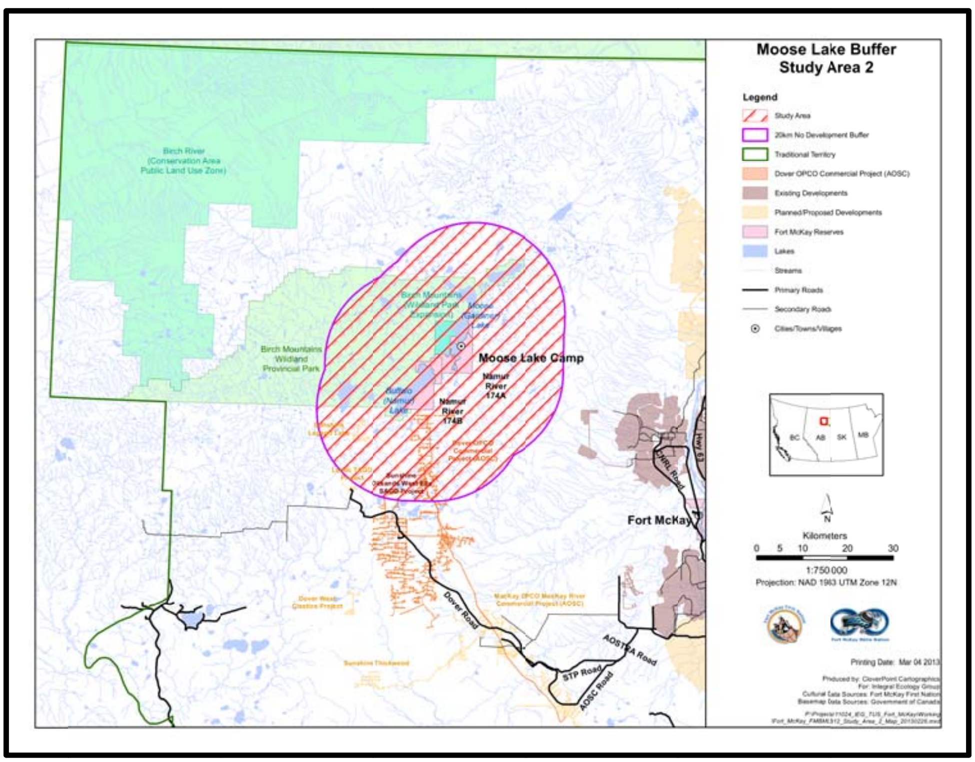


Figure 14. Study Area 2 includes all of Study Area 1 and a 20 km “no-go” industry buffer.

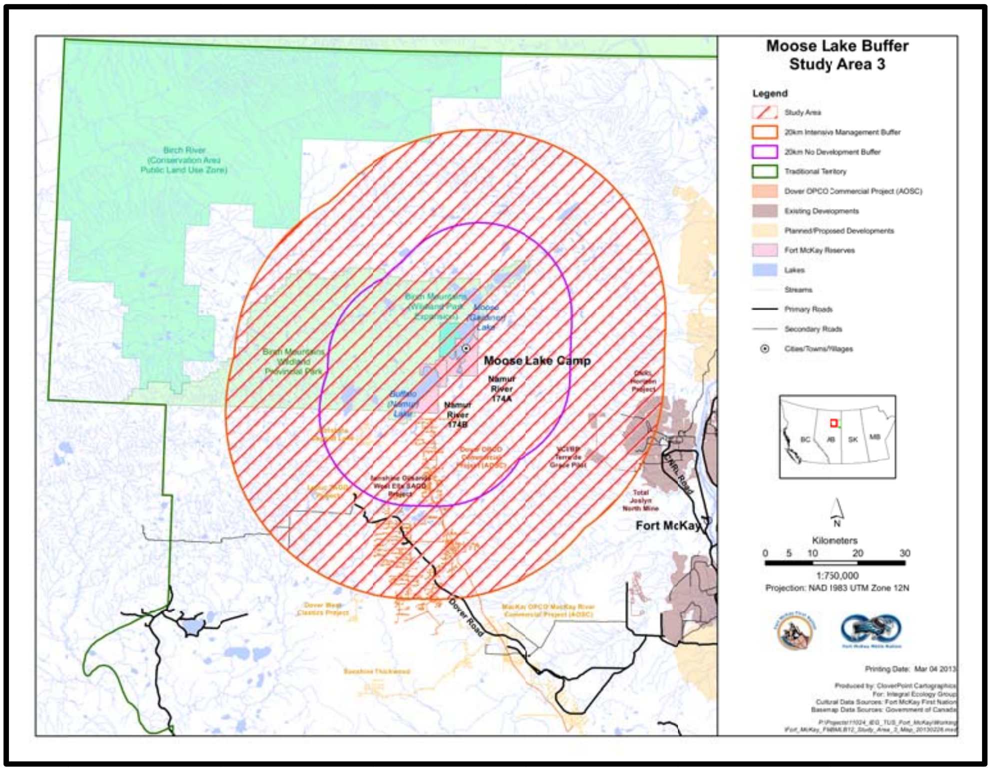


Figure 15. Study Area 3 includes all of Study Areas 1 and 2 and an additional 20 km "intensive management" buffer of 20 km.

Table 4. Areal composition of landscape types and footprint types of study areas.

	Study Areas		
Landscape Types	Study Area 1 ha	Study Area 2 ha	Study Area 3 ha
Hardwood	423	18,181	93,279
Mixedwood	591	12,343	38,124
White Spruce	529	5,742	13,560
Pine	1,038	33,885	72,825
Riparian	987	26,820	77,911
Closed Black Spruce	916	15,532	35,067
Open Black Spruce Fen Shrub	1,154	22,722	56,944
Black Spruce Lichen Moss	0	0	4
Open Fen	1,369	53,032	156,154
Bog	626	25,396	132,932
Herbaceous	63	18,362	23,821
T Shrubland	5	1,397	1,701
S Shrubland	0	64	2,521
Small Lotic	11	349	1,045
Large Lotic	1	248	625
End Pit Lake	0	0	0
Lentic	6,944	19,844	31,504
Beach Dune	0	0	20
Cultivated	0	0	0
Forage Crop	0	0	0
Total LT Area (ha)	14,657	253,917	738,037
Footprint Types	ha	ha	ha
Major Road	0	0	0
Minor Road	0	0	58
Rail	0	0	0
Inblock Road	0	0	0
Transmission Line	0	0	31
Gravel Pits	0	0	144
Tailings Pond	0	0	54
Disposal/Overburden	0	0	9
Rural Res Camp	0	0	0
Town	0	0	0
Industrial	0	73	159
Seismic	26	943	2,736
Well Site	2	454	1,619
Pipeline	0	325	772
Oilsand Mine	0	0	3,784
Total Footprint Area (ha)	28	1,795	9,366
Total Area (ha)	14,685	255,712	747,403
Total Area (km^2)	147	2,557	7,474

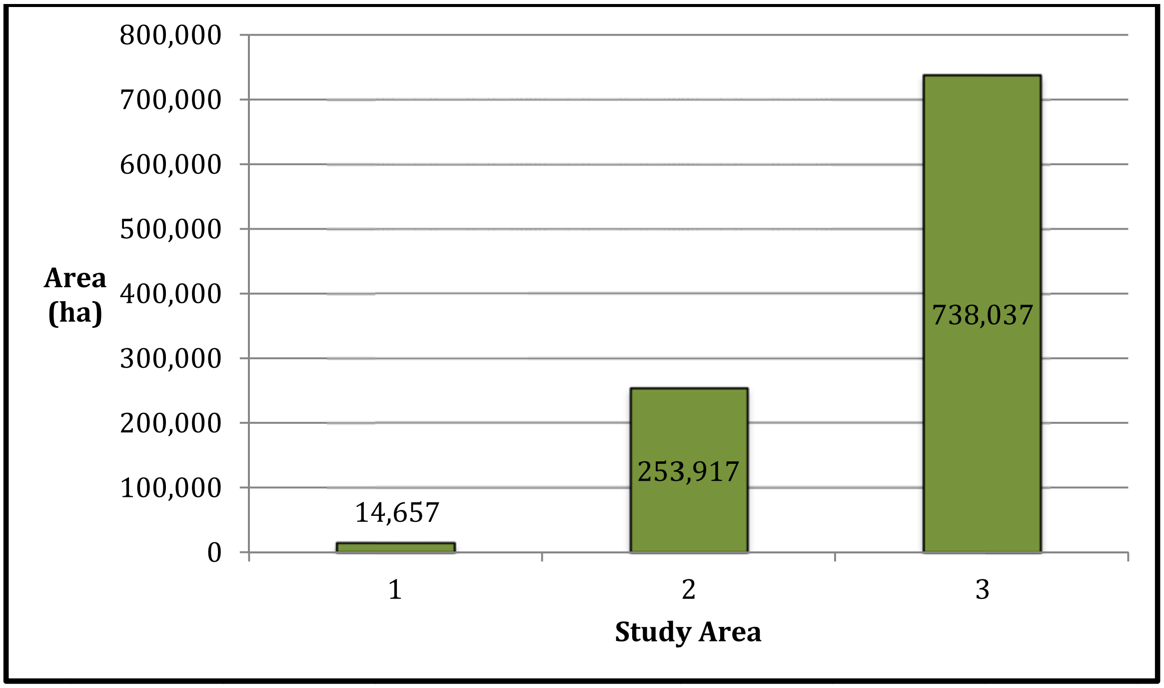


Figure 16. Relative size of three study areas. 1= Buffalo and Moose Lake Reserves, 2 = 20 km "no-industry" buffer, and 3 = 20 km intensive management buffer.

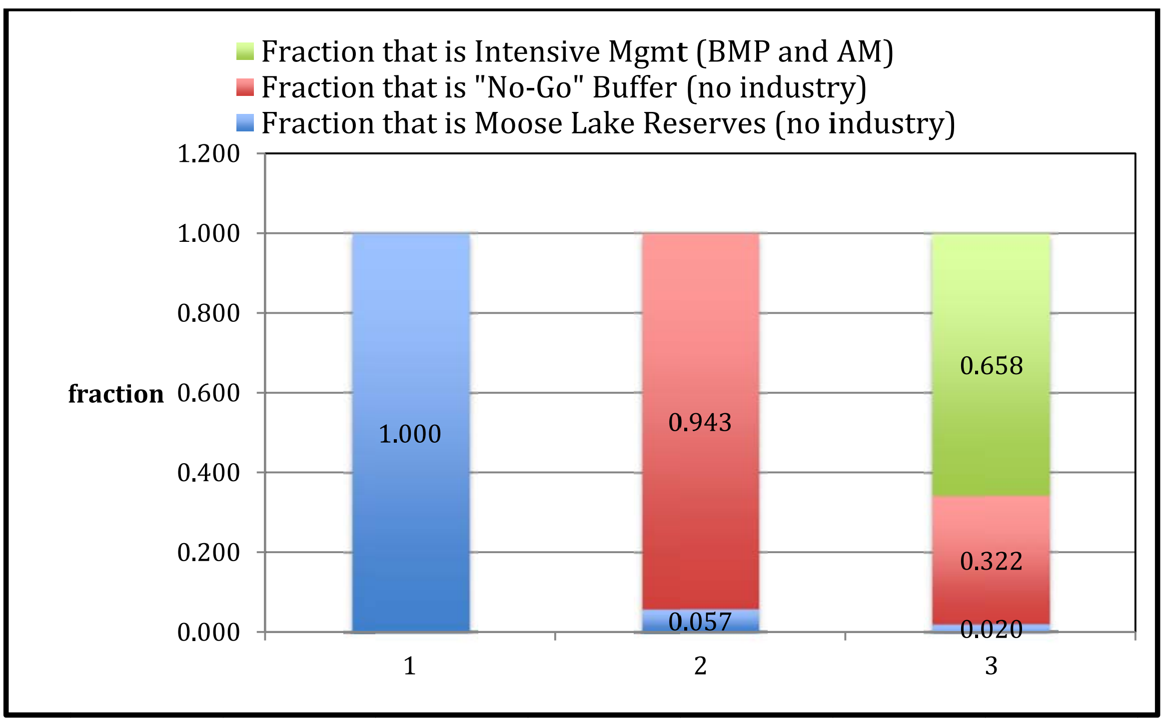


Figure 17. Comparison of fractional contribution of different management zones within each study area.

Table 5. Fractional composition of landscape types within Study Areas.

Landscape Type	Study Area 1	Study Area 2	Study Area 3
Mixedwood	0.0403	0.0486	0.0517
White Spruce	0.0361	0.0226	0.0184
Pine	0.0708	0.1334	0.0987
Riparian	0.0673	0.1056	0.1056
Closed Black Spruce	0.0625	0.0612	0.0475
Open Black Spruce Fen Shrub Swamp	0.0787	0.0895	0.0772
Black Spruce Lichen Moss	0.0000	0.0000	0.0000
Open Fen	0.0934	0.2089	0.2116
Bog	0.0427	0.1000	0.1801
Herbaceous	0.0043	0.0723	0.0323
Tall Shrubland	0.0003	0.0055	0.0023
Short Shrubland	0.0000	0.0003	0.0034
Small Lotic	0.0008	0.0014	0.0014
Large Lotic	0.0001	0.0010	0.0008
Endpit Lake	0.0000	0.0000	0.0000
Lentic	0.4738	0.0782	0.0427
Beach Dune	0.0000	0.0000	0.0000
Cultivated	0.0000	0.0000	0.0000
Forage Crop	0.0000	0.0000	0.0000
Total LT Area	**1.0000**	**1.0000**	**1.0000**

Methodology Relating to Assessing Moose Performance Metrics

Analyses relating to moose habitat and population dynamics were completed using both the wildlife habitat module and the population dynamics module within the Fort McKay ALCES landscape simulator. A parallel set of analyses was completed using spreadsheets as an error check. Where possible, results are presented in simple tabular or graphic results. Additional information on model simulations are available in Appendix A (wildlife habitat modeling) and Appendix B (wildlife population dynamics modeling).

To explore the numerical dynamics of moose, the first set of analyses were conducted on the entire Fort McKay Study area of 3.2 M ha. These analyses allowed the analysts to compare changes in simulated moose habitat and moose population dynamics. By first examining the Traditional Territory of Fort McKay it was possible to explore the magnitude and variance in moose populations, density and potential harvest offtake that could have been experienced by First Nation communities prior to the arrival of Europeans and industrial land use.

Determinants of Moose Habitat Effectiveness

The response of moose habitat to changes in landscape composition was assessed using a habitat suitability index (HSI) model developed for northeastern Alberta. Although wildlife indicators in ALCES are generally assessed using Resource Selection Function (RSF) models, HSI models were chosen for this project to be consistent with model structure and coefficients used by the CEMA TEMF (Cumulative Effects Management Association Terrestrial Ecosystem Management Framework) initiative and the Lower Athabasca Regional Plan (LARP) initiative of the Alberta Land Use Framework. HSI models are knowledge-based (as opposed to empirical) models that can incorporate information from a variety of sources. The moose HSI is based on literature review and expert opinion. The model was originally developed for the Cumulative Environmental Management Association (www.cemaonline.ca), and subsequently revised through the Lower Athabasca Regional Planning process.

The HSI model combines information related to habitat availability and quality to calculate an index that ranges from 0 to 1. Steps required to calculate the index are summarized below.

a) For each cover type (including footprints), habitat availability is assessed as the product of its proportional abundance and its habitat value. Habitat value is a parameter that expresses the utility of a cover type to the species, where 0 indicates no utility and 1 indicates capacity to support the species' maximum density. To account for avoidance and mortality, the habitat value of landcover in proximity of anthropogenic footprints such as roads can be reduced by applying buffers to footprint and down-weighting the value of habitat within the buffer by a proportional use coefficient, i.e., the proportion of habitat within the buffer that is used. The width of the buffers can be reduced to account for strategies that limit human access and therefore the impact of anthropogenic footprints.

b) Habitat quality is a value ranging from 0 to 1 that incorporates the effect of other landscape attributes on habitat such as forest age and human population density. For each relevant landscape attribute, a response surface ranging from 0 to 1 dictates the relationship between habitat quality and the status of the attribute. Each attribute is given a weight, whereby the sum of weights equals 1. Habitat quality for each landcover type is then calculated as the sum of the products of the quality of each habitat attribute and its weight.
c) Habitat suitability (i.e., HSI) is then calculated as the sum of the products of each cover type's habitat availability and habitat quality.

The moose HSI assumes that deciduous forest has the highest habitat value, followed by mixedwood forest and shrubland due to the capacity of these cover types to provide browse and cover. To account for the impact of human access, especially hunting, anthropogenic footprints are buffered by 50 to 200 m when calculating habitat availability (Table 8). Buffer widths are reduced in scenarios where access management is applied based on interviews with Alberta wildlife management experts (Sullivan 2011). In addition, the 200 m buffer associated with existing seismic lines was reduced by 50% for future (i.e., simulated) seismic lines which are assumed to be low impact. An objective of low impact seismic is to reduce their use as trails by people. Although the extent to which human access is reduced along low impact seismic is yet to be assessed by research, it seems likely that motorized access will be more challenging along the narrow lines. We assume a 50% reduction in human access (and therefore impacts to moose) along low impact seismic in the absence of empirical data.

Forest age is assumed to be the only determinant of habitat quality (Table 9). Although linear disturbance density and human density were also included as habitat quality attributes in the original model developed for CEMA, they were removed here to avoid double counting (i.e., exaggerating) the impact of human access which is already represented by footprint buffers. The moose HSI is assessed separately in ALCES for protected and unprotected portions of the landscape, and an overall average HSI value is then calculated as an area weighted average. When calculating HSI in protected portions of the landscape, anthropogenic footprint is considered to be negligible.

Status of the moose HSI is assessed relative to an estimated range of natural variation. Departure from RNV was used to infer risk to species (e.g., moose) by applying a set of risk categories that are proposed Alberta's Biodiversity Management System and based on those used by International Union for the Conservation of Nature (Michael Sullivan, ASRD, pers comm).

Assumptions relating to moose habitat and populations used in these analyses are consistent with those used in the recently completed Fort McKay Cumulative Effects Study (2013). Key assumption categories include:

- Landscape-specific moose habitat quality coefficients
- Historical, current, and future land use trajectories of surface mining and in-situ extraction of bitumen
- Area, width and lifespan of all footprints relating to oilsand extraction

- Historical, current and future fire regime metrics

In these analyses, moose habitat potential was computed based on landscape composition and forest age class structure (demography). Habitat effectiveness values in turn discounted habitat potential based on abundance and frequency of anthropogenic features (polygonal or linear), based on the inferred effects on providing access to moose hunters. The indirect effects of land use footprints were computed based on adjoining buffers that had reduced use by moose.

In the context of the larger Fort McKay cumulative effects study, the influence of human land use on moose was assessed using both habitat and population models. From a habitat perspective, the ALCES land use and landscape simulator tracks the area and age of each plant community and the direct footprints of each land use. The general methodology for simulating wildlife habitat in ALCES is provided in Appendix A. Each landscape types and footprint type is given a coefficient that quantifies its utility function to moose habitat. Based primarily on unpublished aerial survey data (Government of Alberta), the “indirect” buffer effects of linear and polygonal footprints on moose density in adjacent plant communities can be quantified. These values are used in ALCES to place a non-use (or reduced-use) buffer adjacent to footprints and to use this “indirect” effect to alter the performance of the landscape in terms of moose integrity. In reality, the reduced performance of moose in buffers adjacent to land use footprints often reflects the higher probability of moose experiencing a mortality event, and not deterioration in forage or climatic conditions. As such, habitat models often use habitat buffers as a proxy for the actual mechanism of altered mortality or fecundity.

Table 6. Area-weighted moose habitat potential based on calculations that multiplied fractional area by habitat potential value1.

Landscape Type	Study Area 1 [2]	Study Area 2	Study Area 3	Habitat Effectiveness
Hardwood	0.0268	0.0666	0.1175	0.93
Mixedwood	0.0282	0.0340	0.0362	0.70
White Spruce	0.0177	0.0111	0.0090	0.49
Pine	0.0347	0.0654	0.0484	0.49
Riparian	0.0626	0.0982	0.0982	0.93
Closed Black Spruce	0.0306	0.0300	0.0233	0.49
Open Black Spruce Fen Shrub Swamp	0.0394	0.0447	0.0386	0.50
Black Spruce Lichen Moss	0.0000	0.0000	0.0000	0.20
Open Fen	0.0187	0.0418	0.0423	0.20
Bog	0.0085	0.0200	0.0360	0.20
Herbaceous	0.0021	0.0362	0.0161	0.50
Tall Shrubland	0.0002	0.0039	0.0016	0.70
Short Shrubland	0.0000	0.0002	0.0024	0.70
Small Lotic	0.0002	0.0003	0.0003	0.20
Large Lotic	0.0000	0.0002	0.0002	0.20
End Pit Lake	0.0000	0.0000	0.0000	0.00
Lentic	0.0948	0.0156	0.0085	0.20
Beach Dune	0.0000	0.0000	0.0000	0.00
Cultivated	0.0000	0.0000	0.0000	0.00
Forage Crop	0.0000	0.0000	0.0000	0.00
Area-Weighted Average	0.3646	0.4681	0.4786	

[1] Habitat potential values in above table do not include effects caused by sub-optimal forest age class structure.

[2] Note that the lower overall habitat potential of Study Area 1 (Buffalo and Moose Lake Reserves) reflects the large fractional contributions of surface water.

Table 7. Habitat Potential Value of Land Use Footprints.

Cover or footprint type	Corresponding class from model developed for CEMA	Value
Road	Minor road	0.40
Inblock road	Inblock road	0.60
Transmission line	Transmission line	0.50
Seismic line	Seismic line	0.60
Wellsite	Wellsite	0.10

Table 8. The width of non-use buffers placed around industrial footprints.

Footprint type	Buffer width (m)
Road and rail	200
Inblock road	100
Transmission corridor	200
Pipeline	100
Seismic	200
Wellsite	100
Industrial plant	200
Oilsands mine	200
Gravel pits	200
Settlements	500
Rural residential/camp	500

Table 9. Habitat quality by age class for moose.

Forest age class	Relative Habitat quality
0-20	1.0
21-40	0.9
41-60	0.4
61-80	0.2
81-100	0.1
101-120	0.1
121-140	0.2
141-160	0.3
161-180	0.4
>180	0.8

Table 10. Examples of best (beneficial) management practices (BMPs) and quantitative assumptions used in the Fort McKay scenario

Aquatic Management Levers	Intent and Description	Units	Business as Usual (BAU)	High BMP (FM)
Hung culvert replacement	Reduce the level of lotic discontinuity on the landscape by removing and replacing "hung" culverts	Percent of hung culverts replaced annually	0%	10%
Energy Sector Levers	**Intent and Description**	**Units**	**Business as Usual (BAU)**	**High BMP (FM)**
Seismic line width	Narrower seismic lines will occupy less direct area of forest and will be faster to reclaim	meters	2.75	0.75
Seismic line pulse reclamation	Pulse reclamation of seismic lines is a specific best practice intended to reduce the population of seismic lines	% (of seismic lines) / yr	0% / 0	10% / 5
Pipeline spatial overlap with roads	Increase spatial overlap between pipelines and roads to reduce the direct and indirect effects of these two linear features	%	0%	50%
SAGD well pad area (ha) SAGD wells/pad Wellsite regeneration lag	Increased well pad area to allow higher number of wells per pad Greater dependency on directional drilling (i.e., placing more wells on a single pad), will result in less direct and indirect habitat loss Reduce linear edge density associated with well pads. Note: Access roads are assumed to be permanent features in the Fort McKay ALCES model	Hectares # wells / pad Relative index	12 ha 18 wellpad lives for 40 yrs	15 ha 25 wellpad lives for 20 yrs
Surface mine reclamation lag	Increase reclamation rate trajectory of surface mine features (mines)	Relative index	30 yr (active mine life)	20 yr (active mine life)

[4]

[4] A more complete description of the BMP are provided in the Fort McKay Cumulative Effects Study (ALCES Group and IEG Group, 2013)

Determinants of Moose Population Dynamics

In contrast to the habitat models in ALCES, the population dynamics module in ALCES explicitly simulates the numerical performance of each age class (calves, juveniles, young adults, mature adults, old adults) and gender category (cows, bulls) on a defined landscape experiencing a defined set of natural disturbance regimes (fire, insects) and land use (energy, mining, forestry, transportation, residential). The general methodology for simulating wildlife populations in ALCES is provided in Appendix B. An illustration of the general level of gender and age class structure is shown in Figure 18 and the dynamics of natality and recruitment are shown in Figure 19. The number of individual moose within each age class and gender strata is based on relative rates of recruitment and mortality that occur within a one-year time step. Natality is from adult cows with a reduced natality rate applied to yearling females.

A key decision when conducting population dynamic modeling is to identify those types of natural (Figure 20) and anthropogenic (Figure 21) mortality that will be simulated.

The different sources of moose mortality explored within this study included:

- Natural predation (combined as a single value reflecting both wolves and black bear)
- Density-dependent mortality associated with populations approaching carrying capacity
- Harvest by aboriginal hunters
- Harvest by non-aboriginal hunters (for this study, the harvest of residents and non-residents were combined)
- Episodic die-offs from winter ticks (although this dynamic was simulated and presented in the report to demonstrate its effect, it was subsequently excluded from simulations exploring alternative harvest strategies)

Of the anthropogenic mortality sources, aboriginal hunting and non-aboriginal sport hunting were simulated as discrete mortality events. Because of lack of data, mortality relating to poaching, to gender misidentification (for example, a cow moose mistakenly shot and its carcass abandoned and then the hunter using his tag to harvest a bull) and wounding were not included. Because of these omissions, the anthropogenic mortality rates used in these simulations are likely to be conservative relative to actual mortality rates being experienced.

In this study, the dynamics of moose population size and sustainable harvest rates were explored for a suite of alternative scenarios using the population dynamics module of the ALCES Fort McKay landscape simulator.

Some of the key input assumptions relating to moose in these analyses include the following:

- Maximum food-limited moose density where predators are absent (1.01/km^2)
- Maximum food-limited moose density where predators are present and the landscape is non-industrial (.25/km^2)

- A density-dependent function was applied to reduce natality and increase mortality as moose population increase towards carrying capacity (K) as defined by forage availability or maximum density.
- Maximum moose density in regions supporting healthy predator populations (0.17-0.20/km^2)
- Average moose density in Alberta where industrial footprint exists and access management principles are not deployed (0.06/km^2)
- Average annual fecundity (1.2 calves/adult cow/yr)
- Average sustainable moose harvest rate (10% recommended) if harvest in not gender-selective
- Average liveweight of age classes:
    - Calves (0.17 tonne)
    - Yearling (0.365 tonne)
    - Young Adults (0.43 tonne)
    - Mature Adults (0.43 tonne)
    - Old Adults (0.43 tonne)
- Fraction of liveweight that is carcass (55%)

Based on moose habitat quality simulations completed in the Fort McKay cumulative effects assessment (2012), moose habitat area/quality and harvest were assessed separately for the protected and the industrial landscape. Moose hunting in the industrial landbase is considered less desirable to the community of Fort McKay because:

1. Moose populations, and sustainable offtake, are very low.
2. Access management principles are unlikely to be implemented in these extensive regions in the near future
3. The desirability of moose hunting on industrial landscapes is lower.

The ALCES model requires input assumptions about moose density and offtake that apply to different land management decisions being deployed on different management zoning.

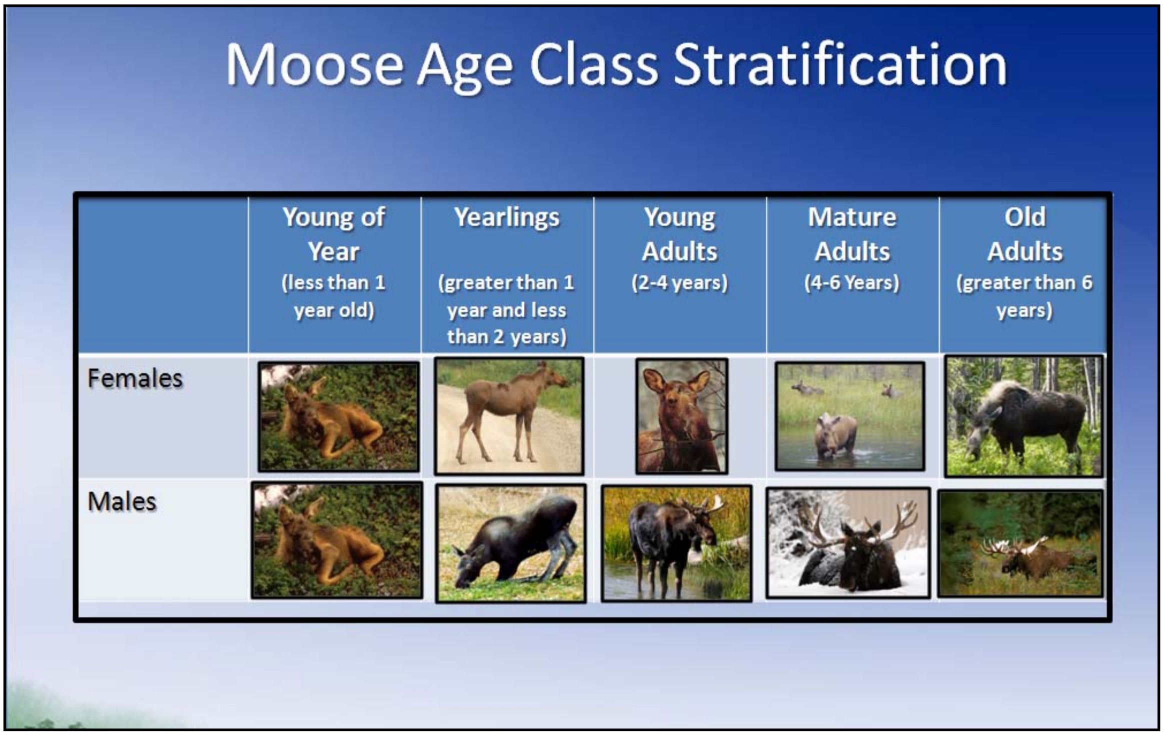


Figure 18. Age classes of moose simulated in this study.

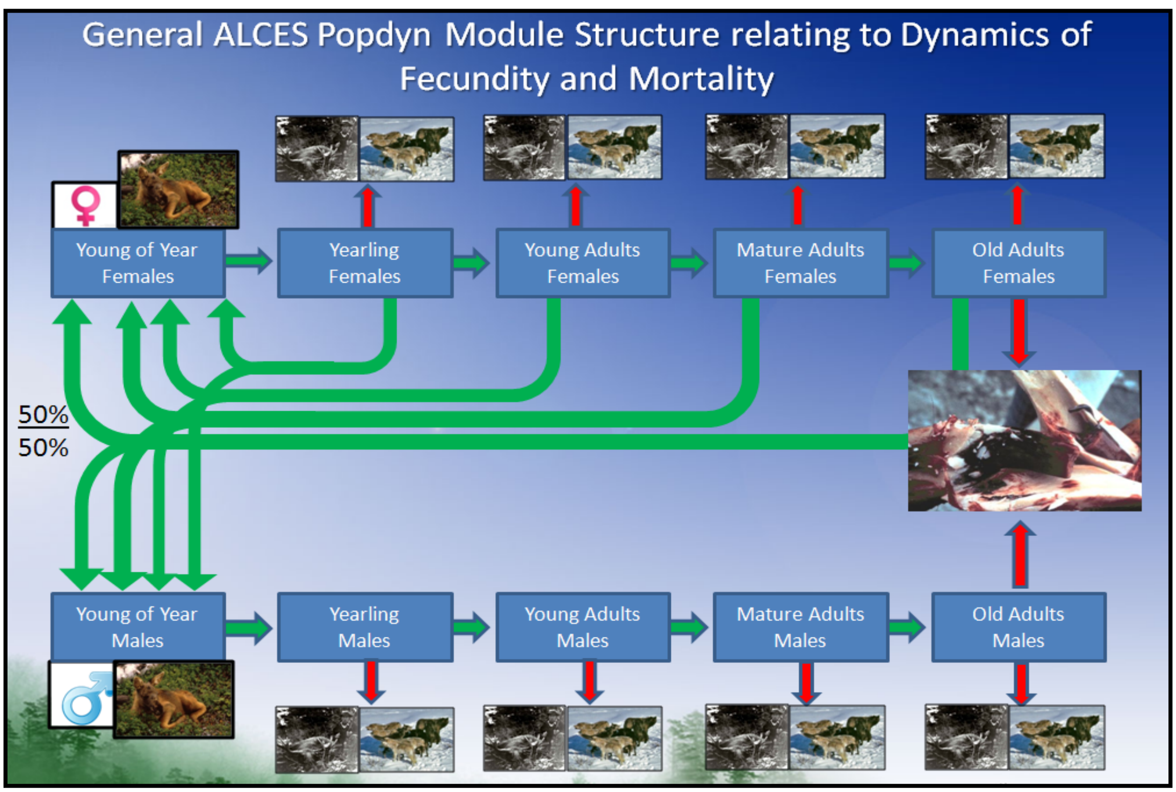


Figure 19. General structure of the population dynamics module within the Fort McKay ALCES landscape simulator.

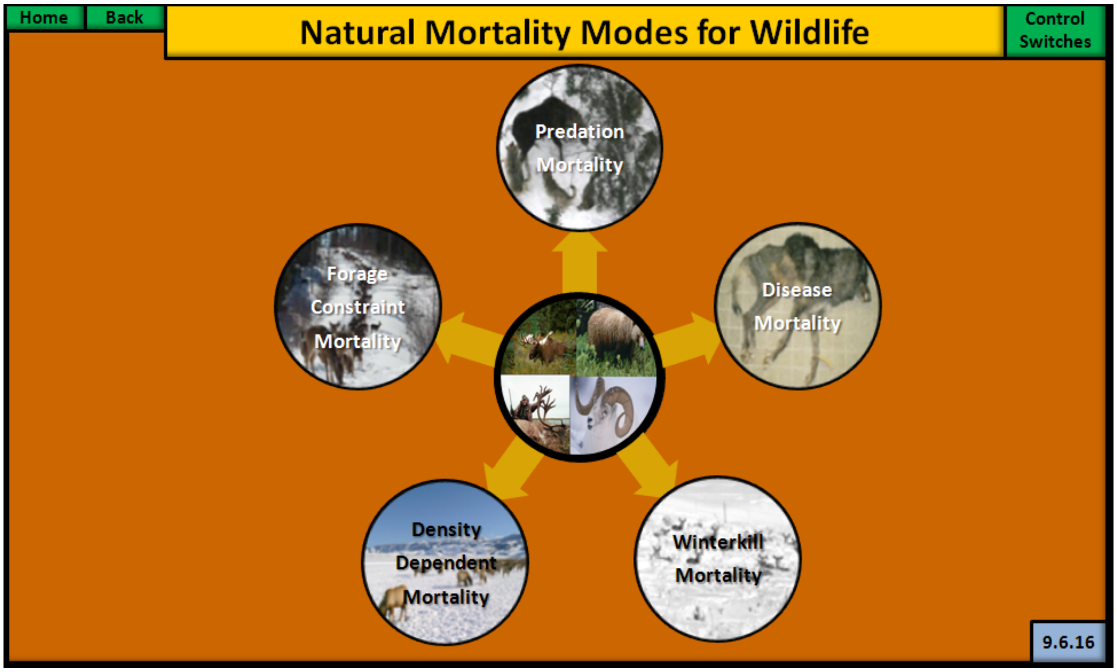


Figure 20. Examples of the diversity of natural processes that affect moose populations, including predation, disease, winterkill, density-dependent mortality and forage-constraint mortality.

Figure 21. Graphic illustrating the variety of stakeholder groups that wish to harvest moose in northern Alberta.

Table 11. Distribution of each study area within management zones and average moose density and sustainable harvest rates.

Landscape Types	Fraction of each Study Area in each Management Zone			Average Density (#/km^2)		Sustainable Harvest Rate (%/yr)	
Study Area	Study Area 1	Study Area 2	Study Area 3	Without Access Mgmt	With Access Mgmt	Without Predator Control	With Predator Control
Fraction that is Non-Industrial Reserve	1.000	0.00	0.00	0.200	0.250	0.100	0.200
Fraction that is "No-Go" Buffer (no industry!)	0.000	1.00	0.00	0.170	0.200	0.100	0.200
Fraction that is managed with Intensive Management (high level of BMPs)	0.000	0.000	1.00	0.100	0.170	0.100	0.200
Fraction that is Regular Industrial (current practices)	0.000	0.000	0.000	0.060	0.100	0.100	0.200

Determinants of Moose Harvest Demand

Moose are legally harvested in northeast Alberta by First Nation hunters, by Metis hunters, by non-aboriginal resident hunters, and by the outfitter industry. Poachers cause illegal harvest. Non-hunting mortality of moose caused by humans include collisions with vehicles.

It is understood that demand by hunters to harvest moose generally exceeds the sustainable harvest capacity of the regional moose population. For this reason, it is important for wildlife managers to carefully monitor population levels and allocate harvest effort at levels that can be sustained. Given that moose harvest levels are affected by both demand (number of eligible hunters) and accessibility of hunters to moose (number of linear features on which hunters can travel through moose habitat), it is likely that moose harvest rates will increase concomitantly with expanding linear edge network associated with the expanding in-situ bitumen and forest sectors.

The above assumptions inevitably lead to the conclusion that access-mediated increases in moose harvest are likely to encourage overharvest of moose, followed by a situation where moose populations are depressed and remain at lower densities.

Constitutional rights of Fort McKay indicate that aboriginal populations have priority access to harvest moose in-situations where total hunter demand exceeds sustainable harvest levels. As such, it is important to quantify moose harvest demand by the community of Fort McKay. It is the understanding of the Fort McKay community that they have the constitutional right to harvest moose at rates occurring at the time of the signing of the Treaty. Quantifying this dynamic requires reasonable estimates of the following two metrics:

- Size of the Fort McKay community
- Average annual per capita moose harvest

Sensitivity analyses involving uncertainty in both aboriginal population size and per-capita harvest rates suggest that annual moose harvest may have been as low as 259 and as high as 1,264 moose.

It is worth noting that the moose harvest associated with the medium estimate of human population (400) and high harvest rates (1.56 moose/person/year) would require a landscape of 3.16 M ha, which is only modestly lower than the area of the Fort McKay Study Area (3.2 M ha).

Table 12. Estimate of moose harvest by aboriginal people inside the study area using different assumptions of aboriginal populations and per capita harvest rates.

	Estimate of Pre-European Population of Aboriginal Population in Study Area[1]		
Estimate of Harvest Rate[2] (#/person/year)	Low (230)	Medium (400)	High (800)
Low (1.24)	259	496	992
Medium (1.4)	322	560	1,120
High (1.56)	359	632	1,264

[1] Estimate of human population variation provided by Ann Garibaldi.

[2] Estimate of per capita moose harvest based on interviews conducted by Tanner et al (2001) with elders in Fort McKay elder in the late 1970s.

Table 13. Estimate of landscape area (km^2) required to support populations of moose sufficient to harvest moose at different per capita rates and at different population levels.

	Population Levels of Aboriginal Population in Study Area [1]		
Harvest Rate[2] (moose/person/year)	**Low (230)** (Estimated Fort McKay population prior to Oilsand era)	Medium (400)	High (800) (Indicative of current Fort McKay Population)
Low (1.24)	14,260	24,800	49,600
Medium (1.40)	16,100	28,000	56,000
High (1.56)	18,170	31,600	63,200

[1] Key habitat coefficients are pre-industrial moose population density of 0.20 moose/km^2 and annual harvest rate of 10%.

Results

Trends in Moose at the Scale of the Traditional Territory of Fort McKay

How do constraints of Forage, Predators and First Nations affect Moose Population Density and Harvest by First Nations in the Pre-Industrial Landscape

Attempts to comprehend the numerical changes in moose populations must recognize and address the diversity of natural (Figure 20) and anthropogenic factors that influence both mortality and fecundity. Simulation of moose performance metrics (population size, density, natural mortality, and aboriginal harvest) using the Fort McKay ALCES population dynamics module indicate that moose populations and density will decline as combined mortality rates to moose increase. To illustrate this general trend, simulated moose densities of ~1.00-1.20 moose/km^2 would have been achieved in the Fort McKay Study Area if both natural and human predators were absent. This density is intended to approximate K (carrying capacity) of the landscape as constrained by forage availability or social constraints. Once predators (i.e., wolves, black bear) are introduced to the system, average annual mortality due to predation approaches 15% of the moose population, and moose densities respond by declining to ~0.40-0.55 moose/km^2. With the addition of a First Nation community of ~230 individuals harvesting 10% of the adult moose population annually, the population is reduced further to 0.18-0.22 moose/km^2. Assuming a constant Fort McKay population of 230 individuals in a pre-oilsand era, the average annual per capita harvest of moose would have varied between 1.3-1.7.

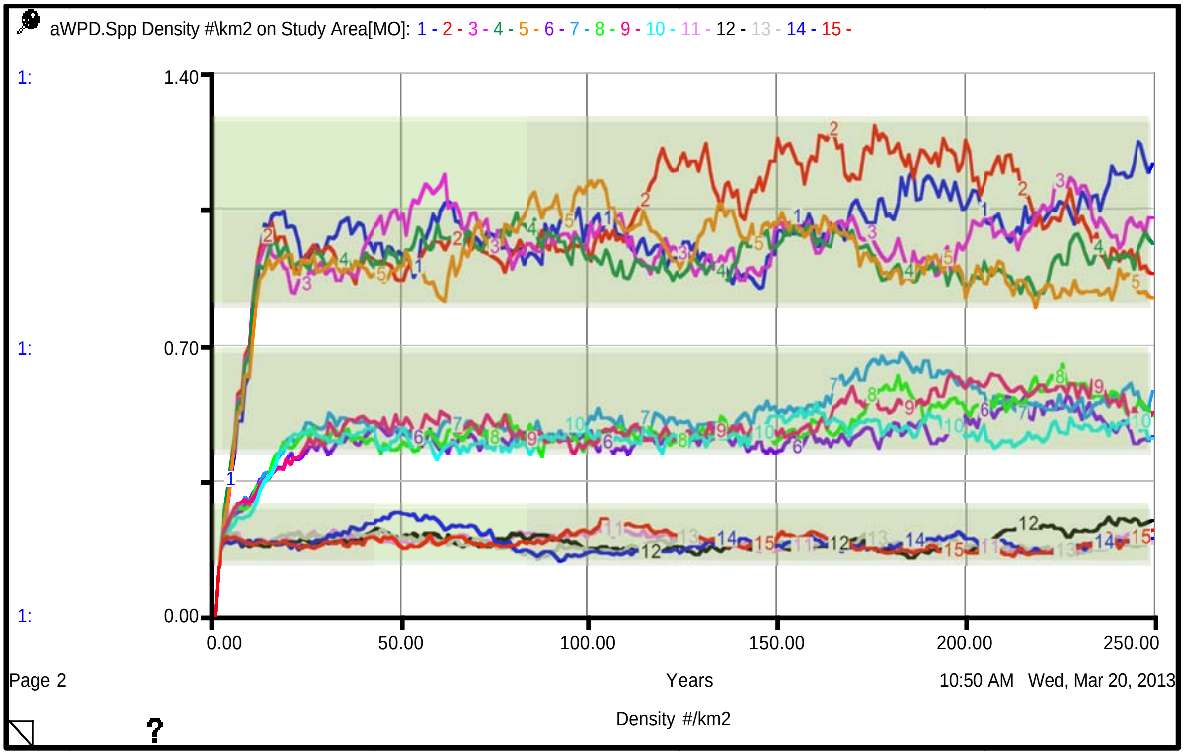


Figure 22. Simulated "Range of Natural Variability" moose population density (km/km^2) on Fort McKay study area based on 3 scenarios. Each scenario was explored using 5 monte carlo simulations, with each simulation lasting 250 years. The high density band (top) reflects simulations where both predators and aboriginal populations are excluded and only food limitation constraints apply. The middle band reflects a scenario involving a stable predator population causing an average annual mortality rate of 15% of the moose population. The low density band (bottom) includes both predators and a First Nation community of 230 people harvesting 10% of adult moose annually. Inter-annual variation is caused by changes in fire-induced forest demography and inter-annual variation in meteorological (snowpack) conditions.

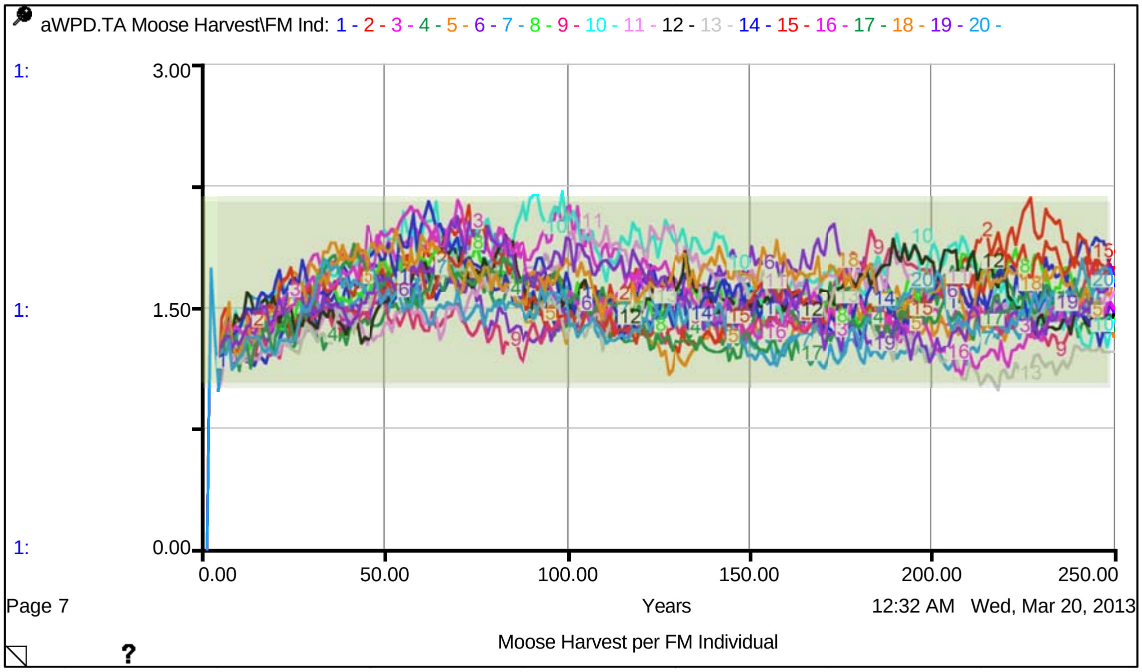


Figure 23. Simulated "range of natural variation" (based on 10 monte carlo runs) of inter-annual variation in per capita harvest rates of moose by the Fort McKay community. In this scenario, the size of the Fort McKay community was set to 230 individuals. Inter-annual variation also caused by changes in fire-induced forest demography and inter-annual variation in meteorological (snowpack) conditions.

Dynamics between Moose Harvest Rate and their Population and Density

Simulation of moose performance metrics (population size, density, natural mortality, and aboriginal harvest) indicate that an average moose density of ~.20/km^2 would occur if the combined (natural and anthropogenic) mortality is ~25%/year. Given predator harvest rates of ~15%/yr, a human-caused harvest rate of moose of 10% is sustainable and harvest above this rates leads to lower moose population, density, and longterm harvest rates (Figure 24). In contrast, a human harvest rate below 10%/yr leads to a higher moose population and density (Figure 24). Using an annual human-related moose harvest rate of 10%/yr (applied only to young adults (2-3 years old), mature adults (4-6 years), and old adults (greater than 6)) that is non-selective by gender (bulls and cows are harvested equally based on encounter rates), then moose populations in the FM study area would have been about ~0.20/km^2 and would have supported an annual offtake of ~1.2-1.7 moose/ individual (based on a aboriginal population averaging 230). This value is similar to that provided by Tanner et al. (2001) who referenced values of 1.1-1.7 moose/individual/year based on interviews with FM elders in the 1970s.

The highest sustainable harvest rate (expressed as annual per capita moose harvest rate) occurred at a rate of 8%/yr (Figure 25). This level of harvest translate to an annual harvest of ~200 metric tonne of moose liveweight (Figure 26), or 110 metric tonne of carcass weight (based on principle that carcass weight is 55% of liveweight). Assuming that FM elders were providing moose harvest rate estimates based on observations during their lifespan as hunters, it is likely that these rates may have been higher than those occurring in the pre-European era. Reasons for higher rates would have included the arrival of modern firearms with scopes, snowmobiles, trucks, and the establishment of a road network in the region.

The key summary message emerging from these specific simulations is that a harvest rate of 10% of adult moose/yr can be sustained by the moose population given relatively constant rate of predation of 15% and with no other significant causes of moose mortality. Higher harvest rates are likely to lead to declining moose populations and reduced harvest rates are likely to lead to higher moose populations. A harvest rate of 8% of the adult moose population will cause a simulated increase in moose populations and reflects that harvest rate that generates the higher annual offtake of moose from the population. All of the results described here are based on a non-selective harvest of gender. Both cows and bulls are harvested at rates equivalent to encounter rates.

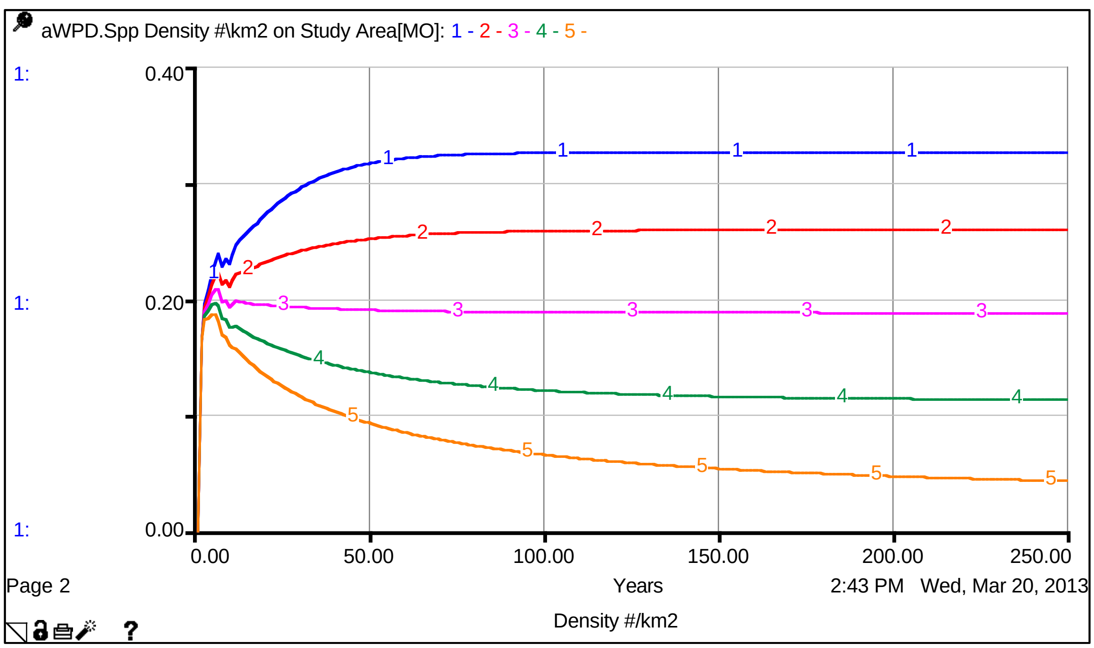


Figure 24. Relationship between increasing human-caused mortality rates of moose and moose density. In this scenario, harvest rates are restricted to adult moose and are applied equally to bulls and cows. Annual mortality rates are 6% (1), 8% (2), 10% (3), 12% (4) and 14% (5). Harvest rates are applied evenly to both adult cows and bulls.

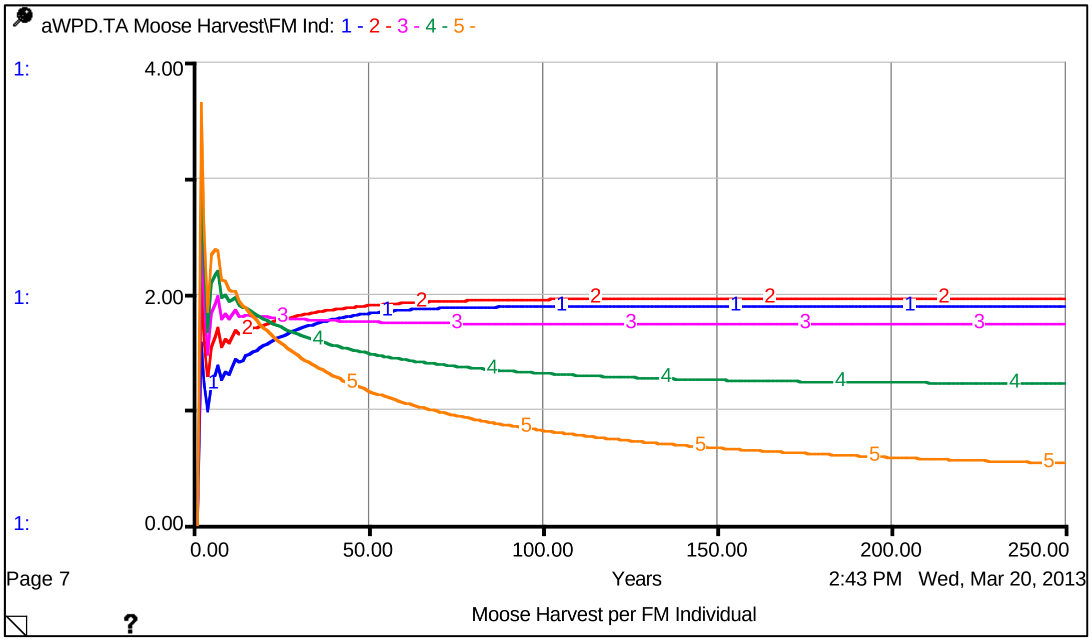


Figure 25. Relationship between annual harvest rate of adult moose (non-selective for gender) and sustainable harvest rates of moose on a per capita basis (moose killed per Fort McKay individual/yr (based on a community of 230 people). Annual harvest rates are 6% (1), 8% (2), 10% (3), 12% (4) and 14% (5). The harvest rate with the highest average harvest rate is 8%/yr.

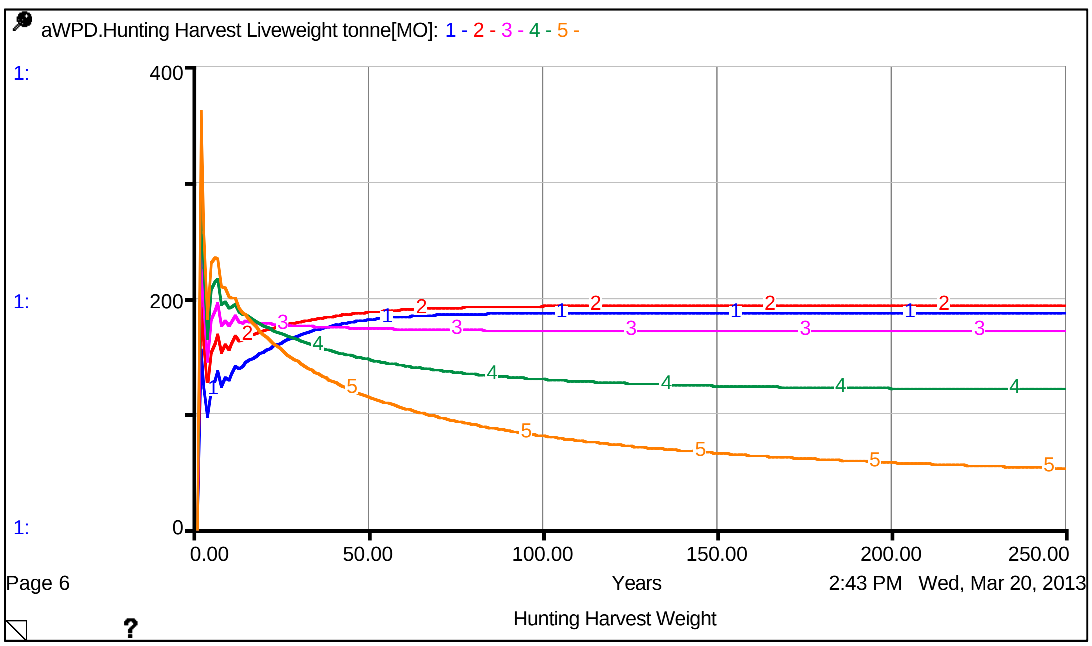


Figure 26. Changes in moose liveweight harvest (tonne) for different levels of harvest. Annual mortality rates are 6% (1), 8% (2), 10% (3), 12% (4) and 14% (5). Harvest rates are applied evenly to both adult cows and bulls.

Environmental Stochasticity and Moose Populations

Longterm data of moose populations generally suggest high inter-annual variation. Some of this variation is caused by sampling error and variation in sampling protocols (different sampling design, different aircraft, different sampling season) but some of this variation reflects actual temporal variation caused by changes in environmental conditions that reflect themselves in changes in natality, mortality, or both (Gasaway et al. 1986, Steinhorst and Samuel 1989). Examples of natural causes of background variation in moose populations include inter-annual variation in snowpack depth, forage availability, and predator density. Longer-term variation in habitat quality is caused by episodic fire regimes that affect forest age class structure (Figure 35, Figure 36). Moose densities may or may not be regulated by predators, reflecting the complexity (spatial and temporal) of the predator/prey communities in the region. An illustration of moderate-level temporal variation in pre-industrial moose population levels is shown in Figure 27 where moose mortality and fecundity rates are adjusted based on moose density and inter-annual variation in snowpack depth in the region.

The key message here is that moose populations are inherently variable and it can be challenging to detect longterm changes (increases or decreases) against the background variation caused by habitat quality, short-term meteorology (snowpack) and the dynamics of natural predators. For example, summaries of moose surveys in northeast Alberta by Gould (2012) suggest that moose densities may have declined by ~50 between 1972 and 2008 (Figure 9). The temporal decline suggested in may be quite accurate but demonstrating this pattern in a statistical sense is inherently problematic because of the very high variances caused by low sampling frequency, variable sampling methodologies, and the inherent “natural” variation in moose populations.

Another important source of inter-annual variation in moose numbers are those events, largely episodic, that cause a significant, though often temporary, reduction in moose numbers. An example of this dynamic in Alberta is moose mortality events caused by winter ticks outbreaks that can result in acute mortality rates of 25% or greater (Samuel, 2004; Samuel 2007). Assuming that moose populations in northeast Alberta can experience periodic die-offs of this magnitude, this dynamic emphasizes the importance of a diversity of country foods from an environment that varies in its productivity of different food types. Simulated temporal variation in moose density and harvest as caused by episodic tick infestations is illustrated in Figure 28 and Figure 29.

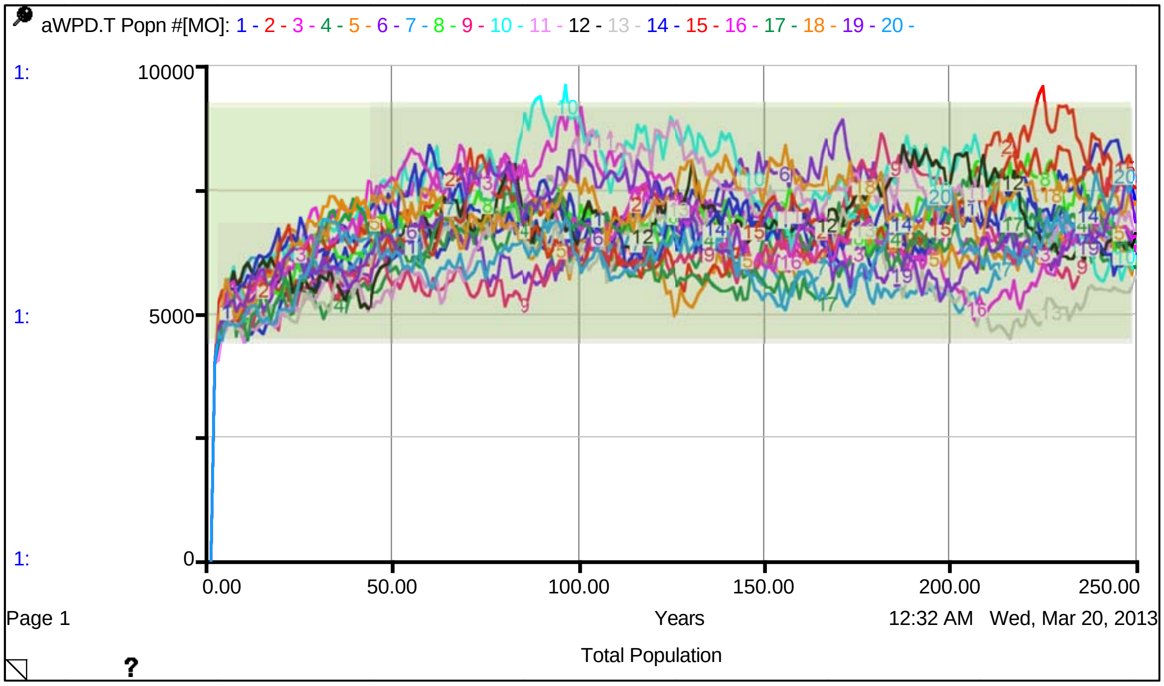


Figure 27. Simulated inter-annual variation in pre-industrial moose population levels in the Fort McKay study area. Variation reflects density-dependent body condition, temporal changes in forest age class structure and density-independent meteorological conditions (snowpack) that affects both natality and mortality.

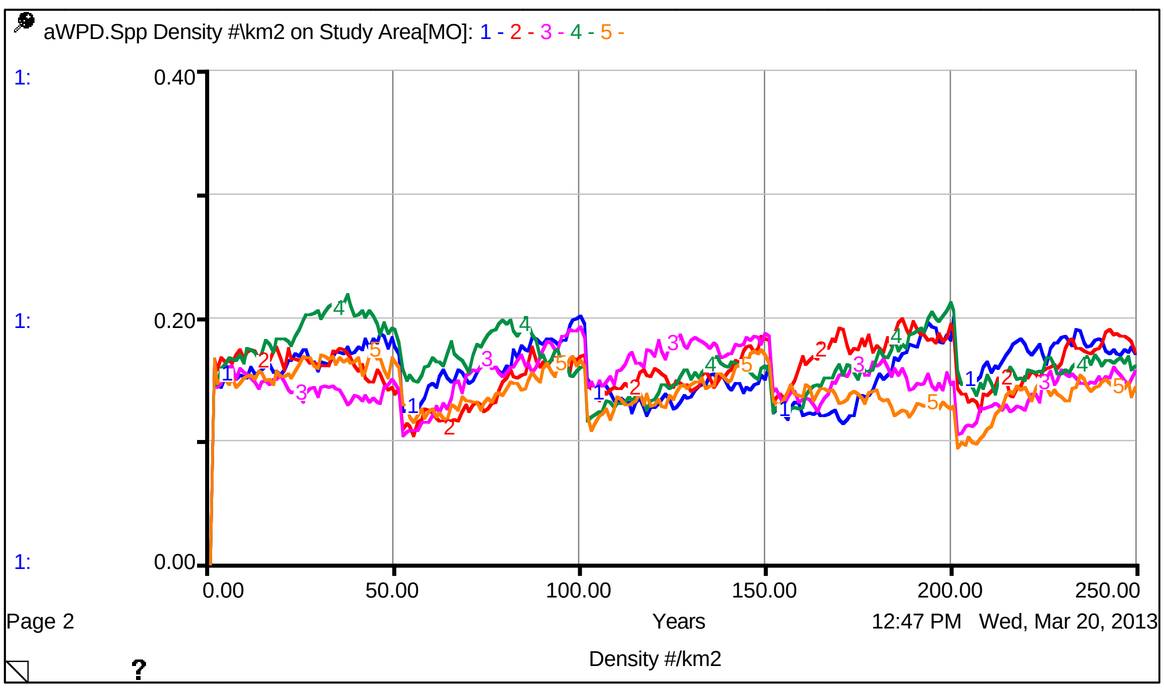


Figure 28. Simulated temporal variation in moose population density as caused by episodic outbreaks of moose winter ticks. Scenario attributed with 25% mortality events occurring once every 50 years.

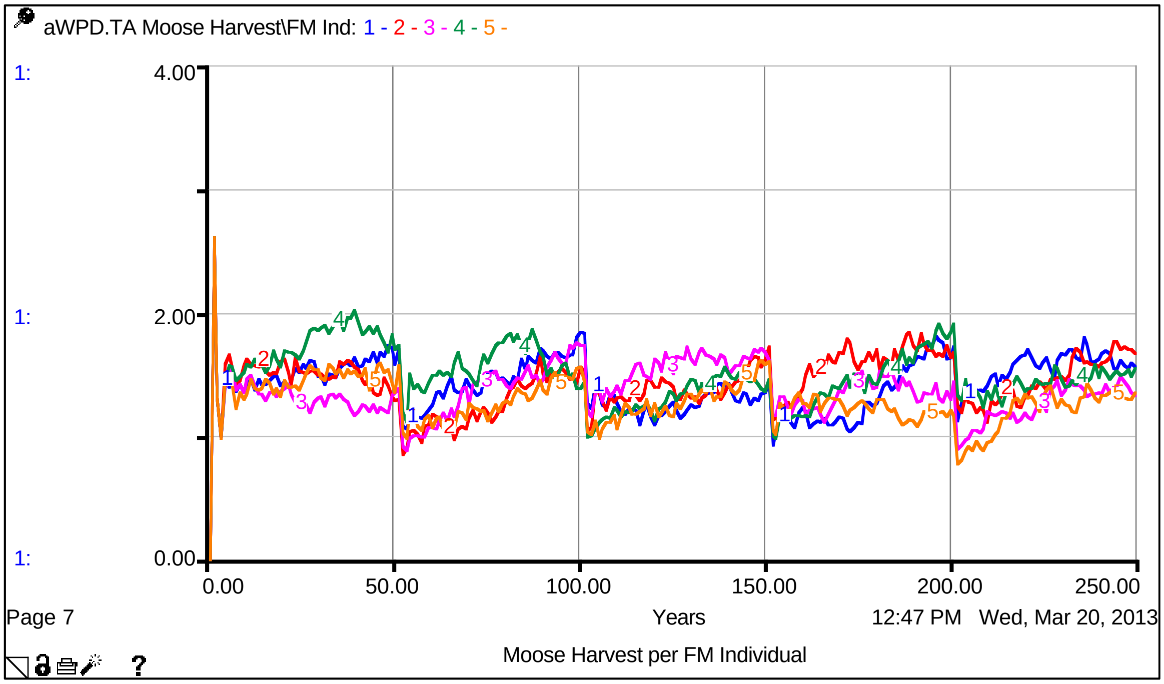


Figure 29. Simulated temporal variation in pre-industrial per-capita moose harvest rates (moose killed/Fort McKay individual/year) as caused by episodic outbreaks of moose winter ticks. Scenario attributed with 25% mortality events occurring once every 50 years.

Moose Population Dynamics and Sex-Selective Harvest

The ability of a moose population to withstand a given level of harvest is significantly affected by the sex ratio (cows/bulls) in the population. Since moose densities are constrained to some degree by forage availability and/or predation rate, there is an upper limit to the number of moose that a given amount of moose habitat can support. A key determinant of that dynamic is determined by the ratio of mortality to reproduction. Simply put, populations with higher reproductive rates can support higher rates of predation. As such, the ability of a moose population to withstand mortality rates (from either natural predators or humans) is heavily influenced by the ratio of cows to bulls, since only cows produce calves and a single bull can service multiple cows. In theory, and in practice, moose populations with higher ratios of cows/bull can support a higher level of annual harvest rate. This pattern is demonstrated in Figure 30 which illustrates the effects of changes in cow/bull ration on moose populations, density and offtake.

Using the Fort McKay ALCES simulator, the effects of selective harvest of bulls and cows on the Fort McKay study area were explored. These simulations demonstrated that bull-dominated harvest had minimal effect on moose populations and density but had significant effects on the sustainable moose harvest rate. As more bulls are harvested than are cows, the sex ratio begins to shift and the overall reproductive rate of the population increases as there is a greater fraction of the population comprised of calf-bearing cows. In this situation, a higher offtake rate can be sustained than in a moose population where bulls are as common as cows.

In contrast, increasing the rate of cow harvest had a strong and negative effect on moose population size, density, and sustainable offtake. Shifting the mortality incrementally from 6%/yr to 14%/yr resulted in moose populations dropping from 0.35 moose/km^2 to 0.05 moose/km^2 (Figure 33) and offtake rates from 550/yr to 100/yr (Figure 34) on the entire study area. These findings reconfirm what innumerable moose population studies have shown in the past – namely that maintenance of a healthy fraction of calf-bearing cows in your population is critical to maintaining population size and offtake rates (Xu and Boyce 2010).

There is a limit, however, in the ability of skewed sex ratios to support higher harvest rates, as at some point the sex ratio becomes so skewed that some of the cows remain barren and do not contribute calves. In our analyses, the sex ratio at which pregnancy rates begin to decline was set at a cow:bull ratio of 2:1. Research by Solberg et al. (2002) demonstrated that moose sex ratio greater than 2:1 can moderately reduce pregnancy rates of yearling, 2 and 3 year old cows.

Harvest strategies for moose need to be tied to management strategies. If the goal is to maximize the reproductive potential of the population, then a skewed sex ratio may be desirable. However, if the objective of the wildlife manager is to maximize the number, size (antlers) and age of bulls, then a harvest strategy that minimizes mortality to bulls will provide a preferred outcome.

As the key stakeholder with priority constitutional rights to moose harvest, the community of Fort McKay needs to become actively involved in setting objectives for moose habitat (quality, quantity), sustainable harvest rates, and allocation to different user groups. Given the diversity of user groups who wish to harvest moose in northeast Alberta (First Nations, resident hunters, non-resident hunters, poachers), decisions involving supply and demand of moose need to be made. Although the poaching community is an undesirable element in the moose harvest equation, it is still prudent for moose managers to empirically understand the magnitude of their moose offtake so that they can invest appropriate resources in minimizing their offtake and adverse effects on populations.

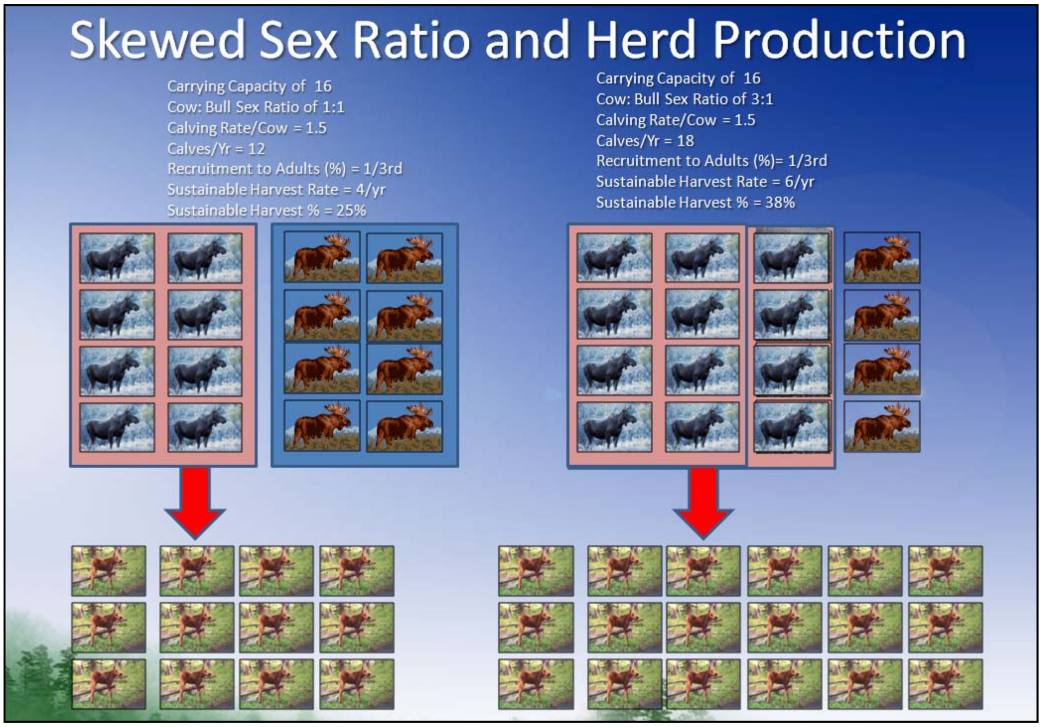


Figure 30. Graphic illustrating the differences in moose calf production caused by a moose harvest strategy that preferentially harvest bulls and skews the sex ratio in favour of cows.

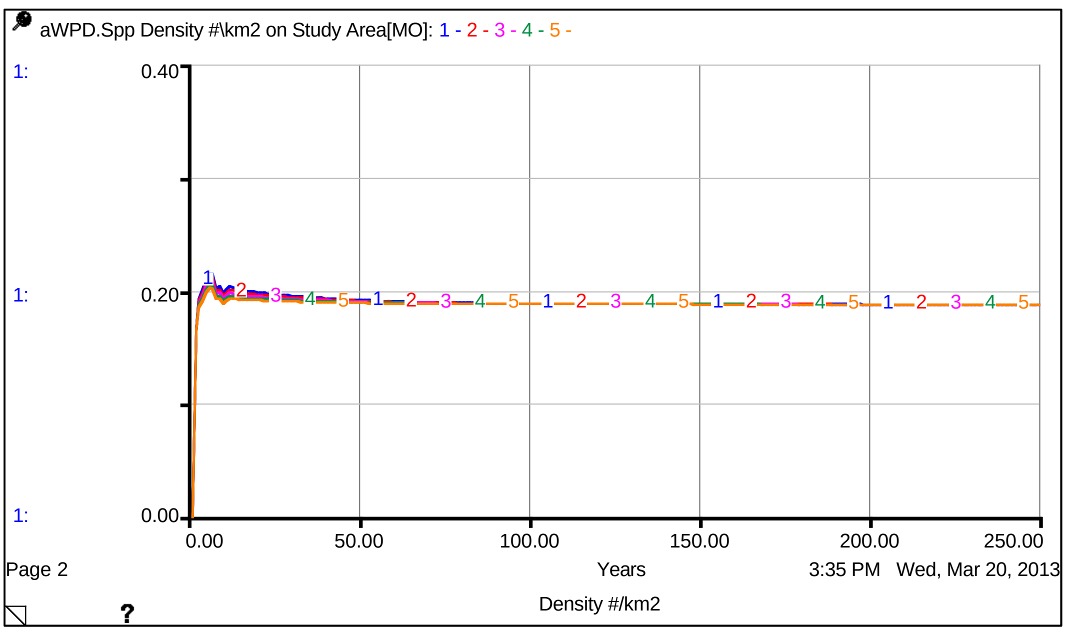


Figure 31. Simulated comparison of moose density in the pre-industrial era as affected by different bull harvest rates. Annual mortality rates for bulls are varied between 6% (1), 8% (2), 10% (3), 12% (4) and 14% (5). Harvest rates of adult cows remained at 10%/yr. Increased bull harvest rates did not alter moose density as skewed sex ratio creates higher reproductive performance. Environmental variation held constant for these simulations.

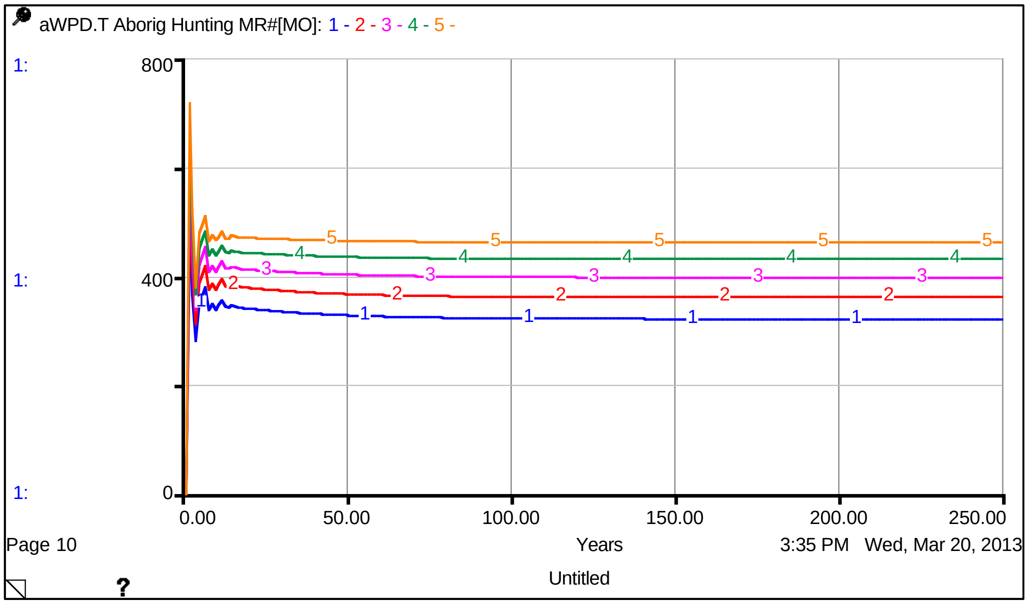


Figure 32. Simulated comparison of number of moose harvested by community of Fort McKay in pre-industrial era. Annual mortality rates for bulls are varied between 6% (1), 8% (2), 10% (3), 12% (4) and 14% (5). Harvest rates of adult cows remained at 10%/yr. Increased moose harvest rates at higher bull harvest rates reflect to shifts in sex ratio (cow/bull) that alter (increase) reproductive performance of the population. Environmental variation held constant for these simulations.

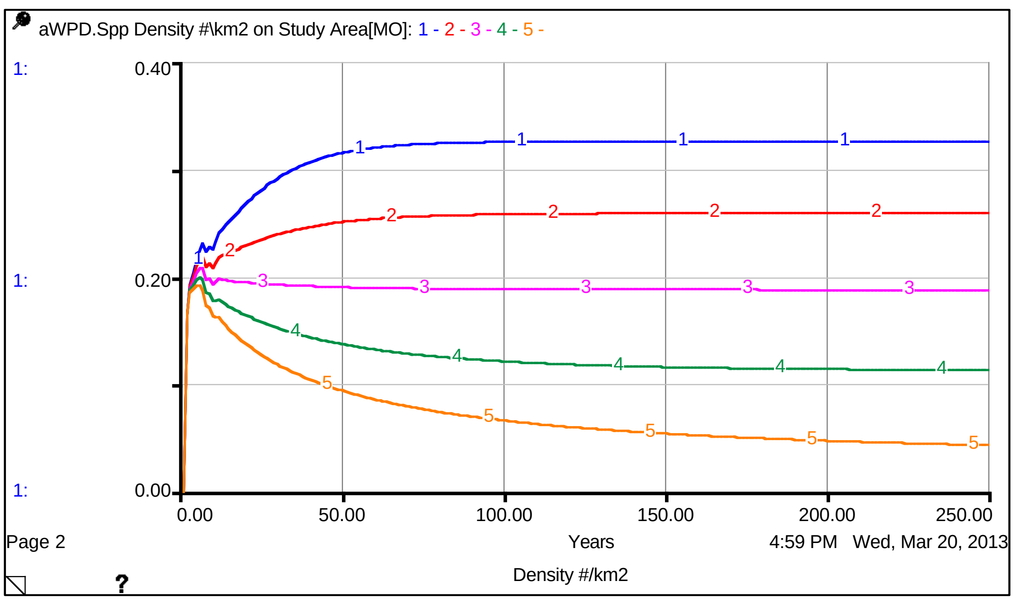


Figure 33. Simulated comparison of moose density in the pre-industrial era as affected by different cow harvest rates. Annual mortality rates for adult cows are varied between 6% (1), 8% (2), 10% (3), 12% (4) and 14% (5). Harvest rates of adult bulls remained at 10%/yr. Increased cow harvest rates decreased moose density as skewed sex ratio towards bulls reduces reproductive performance. Environmental variation held constant for these simulations.

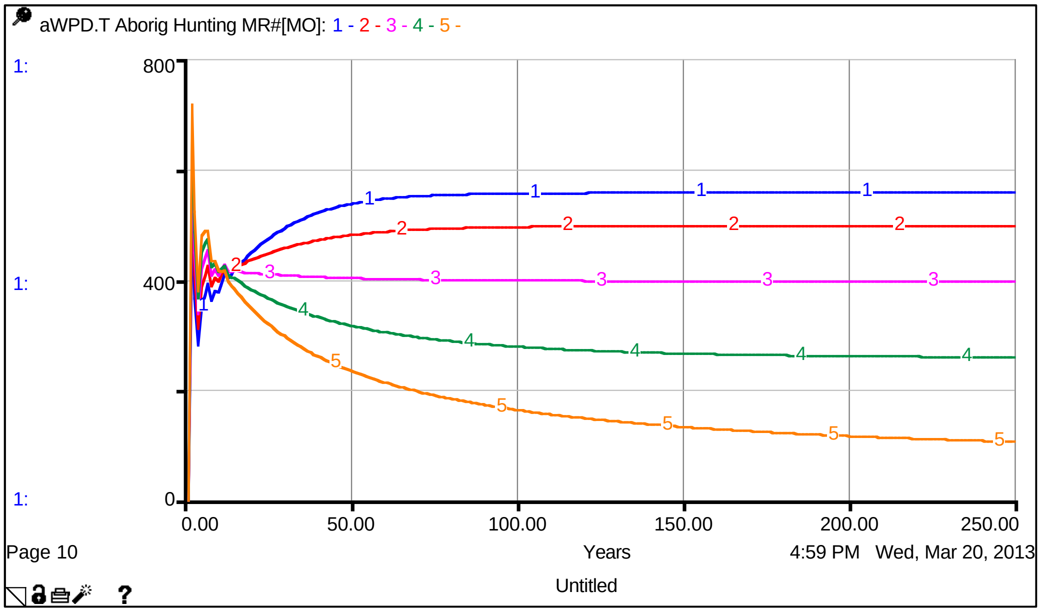


Figure 34. Simulated comparison of number of moose harvested by community of Fort McKay in pre-industrial era. Annual mortality rates for adult cows are varied between 6% (1), 8% (2), 10% (3), 12% (4) and 14% (5). Harvest rates of adult bulls remained at 10%/yr. Decreased moose harvest rates at higher cow harvest rates reflect to shifts in sex ratio (cow/bull) that reduces reproductive performance of the population. Environmental variation held constant for these simulations.

Landscape Size, Fire Regimes and Moose Dynamics

A key driver of moose habitat quality is forest age structure, as moose generally prefer younger forest seral stages because of higher levels of browse biomass (Schwartz, and Franzmann, 2007). Forest age class structure, in turn, is determined primarily by fire events occurring on non-industrial landscapes. In the boreal forest landscapes of the Fort McKay traditional territory, fire rates (0.0125/yr = average of 80 year fire cycle, as used in the CEMA and LARP analyses) are highly episodic (random draw from an lognormal function; Figure 35). Whereas small fire events are very frequent, they also contribute a very small proportion of the total area burned throughout the full fire cycle on the regional landscape. Large fire events, in contrast, occur sporadically but account for the vast majority of area burned. A general rule for the boreal forest is that 95% of the total area burned is caused by only 5% of the fire events.

Given that the majority of the forest area burned is caused by a few large fire events, small, discrete regions in the boreal forest are acutely influenced by fire events when they do occur. In the vast majority of years, small areas (for example, less than 5000 ha) experience no fire events at all. When fire events do occur, they are likely to affect all, or nearly all, of the small study area. As a result, an individual fire event is likely to reset the entire region to the youngest seral stage. In contrast, large regions of boreal forest are more likely to experience several fire events annually or during a short time period. The larger the region, the greater the probability of multiple fire events. In contrast to small areas, large regions experience more frequent fire events and a greater diversity of fire sizes.

Based on the above dynamics between study area size and fire events, smaller areas are likely to experience high levels of variation in forest age class structure. For example, when a small area is burned, the entire region will become the youngest seral stage. In contrast, small regions are also likely to experience multiple decades without a fire event and during these periods, the entire study area can become quite old. As such, the range of forest ages in small regions can vary from completely young to completely old.

Large regions of the boreal forest are highly unlikely to experience a fire event large enough to burn the entire region (Figure 35). They are also unlikely to experience multiple years of no fire events. As a result, large chunks of boreal forest are likely to have reduced variation in forest age than are smaller chunks of boreal forest (Figure 36).

So why is this dynamic important to moose management or the people of Fort McKay? The dynamic between the size of a boreal forest conservation area ("traditional use area") and forest age class structure has implications to moose management and harvest to the community of Fort McKay. If their moose hunting activities were to become restricted to small areas of non-industrial boreal forest landscape, such as the Buffalo and Moose Lake Reserves, then they are likely to witness extreme variation in moose habitat quality, moose populations, and moose harvest because of the high temporal variation in forest age class structure. By buffering the Buffalo and Moose Lake Reserves with a non-industrial buffer, this risk factor is mitigated to some meaningful degree. The larger the buffer around Buffalo and Moose Lake Reserves, the lower the level of forest age variation that will be experienced. From the standpoint of maintaining the appropriate diversity of forest ages centered on the Buffalo and Moose Lake Reserves, it is important that a non-industrial buffer be applied and protected.

The magnitude of the effect between study area size and variation in forest age class structure is illustrated below (Figure 35, Figure 36, Figure 37, Figure 38, Figure 39). The four scales of study area are:

1. Study Area 1: Buffalo and Moose Lake Reserves. Area of 14,700 ha
2. Study Area 2: 20 km “no-industry” buffer. Area of 255,700 ha
3. Study Area 3: 30 km “high intensity” industry buffer. Area of 747,400 ha
4. The full Fort McKay Cumulative Effects Study Region. Area of 3,200,000 ha.

As the largest study region at 3.2 M ha, the Fort McKay Cumulative Effects Study is a reasonable reference area against which to compare the other region. It is a reasonable description of the spatial and temporal variance would characterize a large boreal forest landscape. Temporal variation in fire area is shown in Figure 35, illustrating that fire occur in almost all years but it is the periodic large fire years that shape the overall forest age class structure (Figure 36).

These simulations illustrate how progressively smaller study areas have greater variation in forest demography. These variations in forest age class structure can prove difficult for maintaining adequate representation of forest seral stages through time for those species that rely on either very young or very old forest communities.

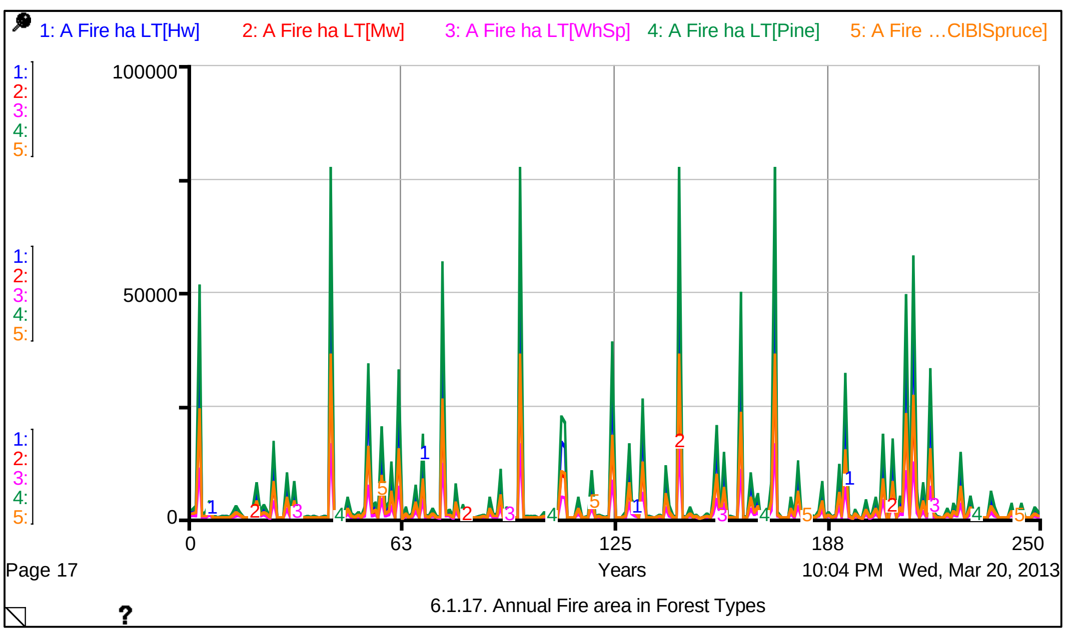


Figure 35. Simulated temporal variation in fire area with the Fort McKay study area. Fire simulated as a random draw from an exponential function with an average fire rate of 0.0125 (80 year fire cycle).

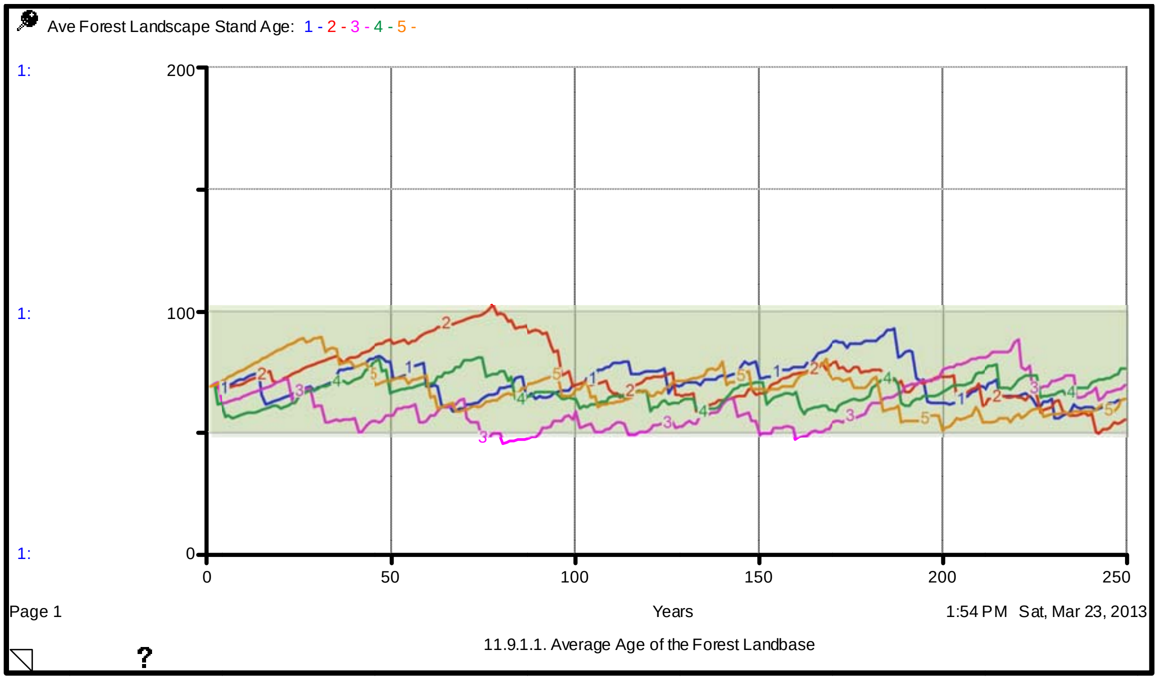


Figure 36. Simulated temporal variation in average forest age of the entire Fort McKay Study Area (3.2 M ha) based on a random fire regime based on an average annual fire rate of 0.0125 (80 year fire cycle).

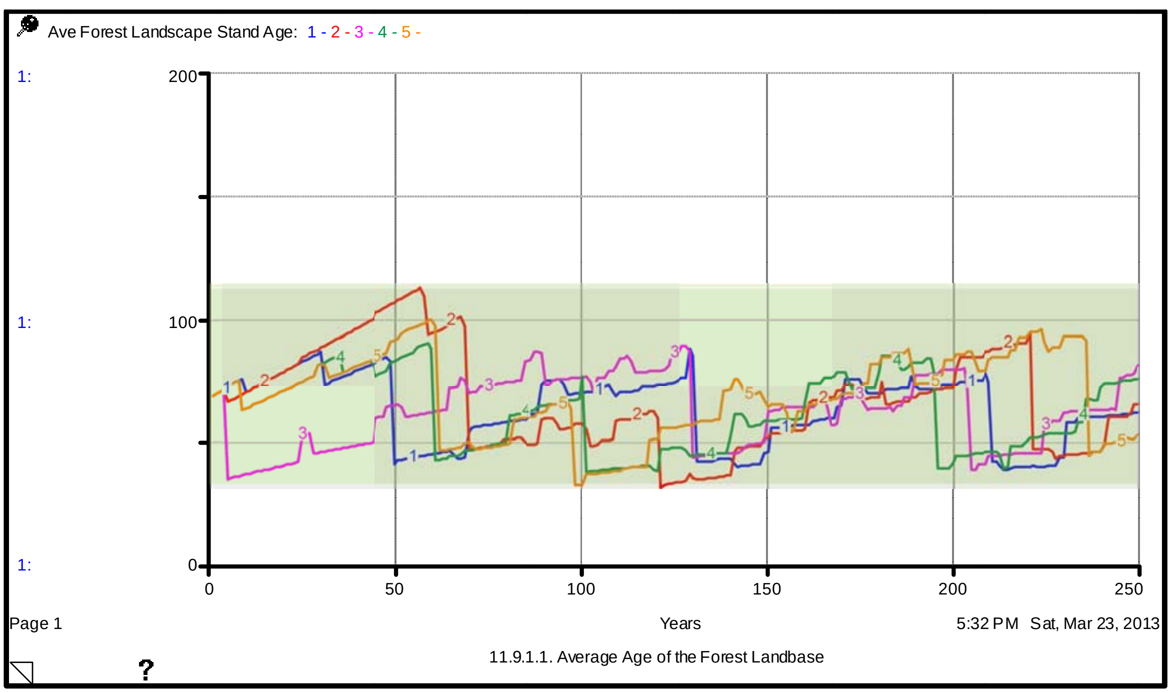


Figure 37. Simulated temporal variation in average forest age of Study Area 3 (7,474 km^2) based on a random fire regime based on an average annual fire rate of 0.0125 (80 year fire cycle).

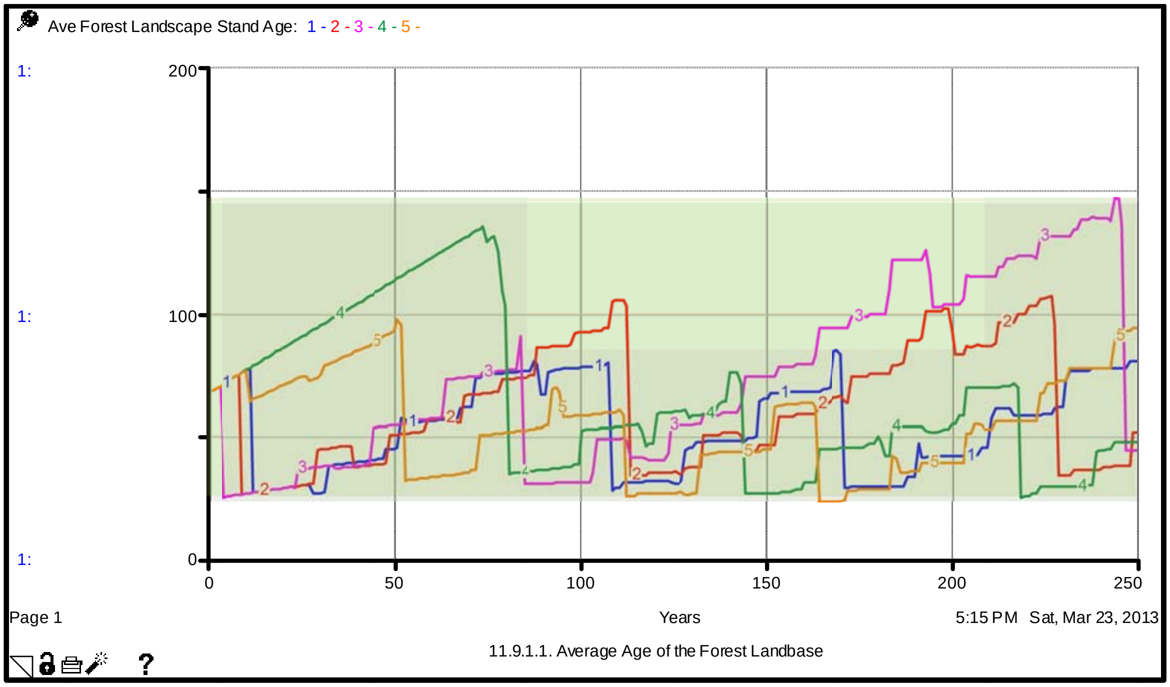


Figure 38. Simulated temporal variation in average forest age of Study Area 2 (2,557 km^2) based on a random fire regime based on an average annual fire rate of 0.0125 (80 year fire cycle).

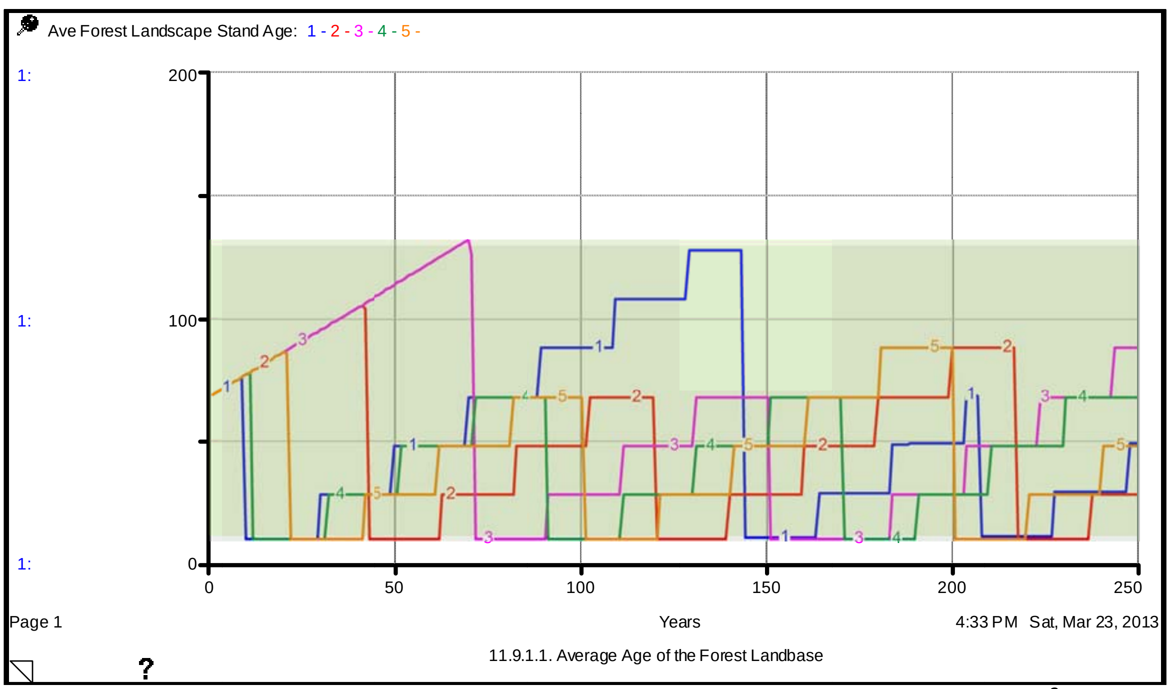


Figure 39. Simulated temporal variation in average forest age of Study Area 1 (147 km^2) based on a random fire regime based on an average annual fire rate of 0.0125 (80 year fire cycle).

Roads and Moose Collisions – The Hidden Mortality Factor

Mortality of both moose and humans involved in moose/vehicle collisions is well known in Alberta but has not been quantified until recently. Analyses by Boyce and Geven (unpublished, personal communication, 2013) indicate that ~880 moose vehicle collisions are "reported" annually during the past decade in the Province of Alberta. Based on an assumption that reporting of moose vehicle collisions is 50% (Mark Boyce, pers. comm.; based on assumption that large "semi" trucks are not damaged by moose collisions and hence are largely unreported), and that all collisions involving moose result in its ultimate death, one could assume that ~1,600-1,800 moose are killed by vehicles each year in Alberta. Based on an average annual "regulated" sport (resident and non-resident non-aboriginal hunters) harvest of ~9,000 moose/yr (ALCES Land Use Library; www.alces.ca) during the period 2000-2005, it can be estimated that that vehicular mortality of moose is ~19% (1,700/9,000) as high as the moose killed by the "regulated" harvest. If these assumptions are robust, then for every 5 moose killed by "permitted" hunters, one is killed by a vehicle.

Key landscape components to assessing vehicle-related mortality to moose include road density and vehicular travel rates (Seiler 2005, Danks and Porter 2010). During the past several decades, industrial roads leading to both wellsites and cutblocks have increased exponentially in the region. In addition, vehicle travel rates for industry have increased exponentially as has the opportunity for vehicle travel by the non-industrial motorist. The combination of expanding road network and high vehicle travel rates has lead to a much greater probability of moose mortality caused by vehicles. This vehicular mortality rate is likely to be additive (and not compensatory) to aboriginal moose harvest, non-aboriginal harvest, and predator harvest. It is the combined mortality rate that ultimately determines the abundance of moose. The above dynamics underscore the critical need for development and implementation of access management plans, within the context of cumulative effects of all land uses, in the boreal forest landscape of northeast Alberta.

Simulated Moose Populations and Harvest in the Buffers of the Buffalo and Moose Lakes Reserves

How do constraints of Forage, Predators and First Nations affect Moose Population Density and Harvest by First Nations in the Pre-Industrial Landscape

The results presented in this report outline the magnitude by which the Traditional Territory of Fort McKay has been transformed by the historical activity and footprints of the oilsand sector. The highest intensity of footprint and landscape transformation that has occurred to date is geographically centered at the community of Fort McKay and the surrounding oilsand surface mining activity. Whereas the extent of historical landscape transformation is profound, it is also true that it is relatively small in comparison to the level of landscape modification that is projected to occur during the next several decades caused by both surface mining, and to a larger degree, the direct and indirect footprint of the in-situ oilsand industry. Analyses presented in the Fort McKay Cumulative Effects Study (2013) describe the historical, current and future trends for the full suite of social, economic, and ecological variables within the Traditional Territory. The degrading performance of moose is of concern to the Fort McKay community.

In response to a deepening appreciation of the extent and magnitude of landscape transformation, the Fort McKay community is actively seeking a non-industrial (=”traditional use”) setting in which they can practice traditional activities, including the sustained harvest of moose. Of the various options explored, the region surrounding the Buffalo and Moose Lake Reserves holds greatest promise. It is reasonably close to Fort McKay, has a strong cultural history, is relatively pristine in landscape characteristics, and is underlain by relatively poor bitumen deposits.

In this section, the results of the ALCES population dynamics simulations are presented for each of moose populations, harvest, and per-capita harvest for each of Study Area 1 (Buffalo and Moose Lake Reserves), Study Area 2 (20 km no-industry buffer around Buffalo and Moose Lake Reserves), and Study Area 3 (20 km “intensive management” industrial buffer around Study Area 2). Recognizing that some level of moose harvest by Fort McKay will occur in other regions of the Traditional Territory, the performance of moose metrics in regions outside of Study Areas 1, 2 and 3 are also considered.

It is worth noting that it is challenging, form a modeling perspective, to separate the effects of access management from other forms of “best management practices” (BMP). Since access management principles generally restrict the movement of people along linear/curvilinear features (roads, seismic lines, trails, pipelines, transmission lines), any BMP or ILM strategy that reduces these futures will, in all likelihood, reduce the movement rate of people across the landscape. In contrast, the landscape can have an abundance of linear features, but resource managers can chose to implement rules that restrict our movement along these features. The ultimate effect may be the same in both scenarios – a fundamental reduction in the rate of movement (motorized, possibly non-motorized) across the landscape. This distinction is important to note, as both strategies have merit and should be considered as complimentary management practices that may assist resource managers in their goal of attaining performance of ecological indicators.

In the graphs below, the value pertaining to "business as usual" assumes that the in-situ industry adopts footprint metrics similar to those used by both the CEMA and LARP initiatives. Although BAU practices are still widely adopted by many companies in the insitu industry, there are many companies who practices are more progressive and leave proportionally less footprint on the landscape per unit of bitumen recovered. In reality, today's BMP are most likely to be tomorrow BAU practices. By the same argument, the BAU practices of today were the BMP practices of a decade ago. This industry is highly dynamic and is changing its practices as it responds to social, economic and ecological constraints.

In the graphs below, the other two values pertain to scenarios involving best management practices (BMP). Using the logic outlined above, access management is one form of BMP. In our scenarios, we conducted two BMP simulations, one with and one without access management. As such, the graphs illustrate the advantages of BMP relative to BAU, and also indicate the incremental value of imposing access management principles on a landscape already influenced by other forms of BMP.

It is also worth stressing that ecological indicators ultimately respond to the total amount of "load" (edge density, effluent, human density, hunting pressure, landscape transformation) placed on their populations. As such, it is remarkably easy to induce a significant deterioration in population size or distribution through the adoption of either BMP. One can literally "BMP-to-death" a system by imposing a land use trajectory that results in more and more footprint (and human activity) on a system while industrial sectors work hard to reduce "footprint intensity" of a given seismic line, wellpad, or access road. At the end of the day, it the total amount of footprint, emissions, landscape fragmentation, and associated human activity, that determines how well or how poorly our ecological indicators respond.

Results of the population dynamics simulations indicated, as expected, that population, harvest, and per capita harvest all increase with the size of the study area (Figure 42, Figure 43, Figure 44).

At the scale of Buffalo and Moose Lake Reserves (Study Area 1), an average population of 29-37 moose is supported, yielding an average annual harvest of 3-4 moose. The model also computed the hypothetical moose population (~9) should the Reserves ever experience industrial activity within their borders.

In the surrounding 20 km "no-Industry" buffer, moose populations were simulated to be 153 (if BAU in-situ were to be allowed), 435 (if no in-situ and no access management), and 511 (if no in-situ development and with access management). Readers might be wondering why access management provides benefits in a buffer intended to have "no-industry" development. The answer lies in the recognition that there is already some modest level of linear features (trails, seismic lines, footprint of in-situ industry) within the buffer.

In the 20 km “in-situ buffer with intensive management” that surrounds the 20 km “no-industry buffer”, moose populations were simulated to be 448 (if BAU in-situ were to be allowed), 747 (if no in-situ and no access management), and 1271 (if no in-situ development and with access management). The corresponding sustained harvest offtake was simulated at 45 (BAU), 75 (BMP and no access management), and 1,127 (BMP and access management) moose/yr from this industrial buffer.

If all three regions are combined (Buffalo and Moose Lake Reserves, 20 km “no-industry” buffer, and 20 km “in-situ” buffer), this larger area (~1 M ha) would support moose populations as low as 611 (if BAU principles are adopted) and as high as 1819 (if BMP practices and access management practices are deployed). The corresponding variation in average annual harvest rates (moose/year) is 61 (if BAU principles are adopted) and as high as 182 (if BMP practices and access management practices are deployed).

These results profile two key messages:

- Larger areas support larger moose populations on which a larger annual harvest can be achieved
- Best management practices in general, and combined with access management, can significantly increase moose populations and harvest rates.

In the context of the entire Fort McKay Study Area (~3.2 M ha), the combined buffers (Study Areas 1+2+3) amount to 10,178 km^2 or ~32% of the area. The landscape outside of the buffers will vary in composition and land use intensity based on the location of intensive industry (surface mining, in-situ mining, transportation, residential, etc.) and protected areas, but the vast majority will be in some form of intensive land use. In turn, the moose population in this region will vary in density and sustainable harvest levels based on the industry and harvest management practices that are applied. In these analyses, we are assuming that the in-situ industry outside the buffers is largely characterized by BAU practices and as such the industrial intensity of the landscape is higher and the moose population density is lower. Given an area-weighted average density of 0.08 moose/km^2 and an average annual harvest rate of 10%/yr, this region should support a population of ~1,746 moose and an annual harvest of 175 moose. There are two important factors when considering the overall utility of this region to provide moose harvest opportunities to the community of Fort McKay:

- This region is likely to experience high hunting pressure from the non-aboriginal moose hunting community
- This region may not be as desirable because of its higher industrial intensity and as such is less favorable as a setting to experience hunting in a wildland setting.

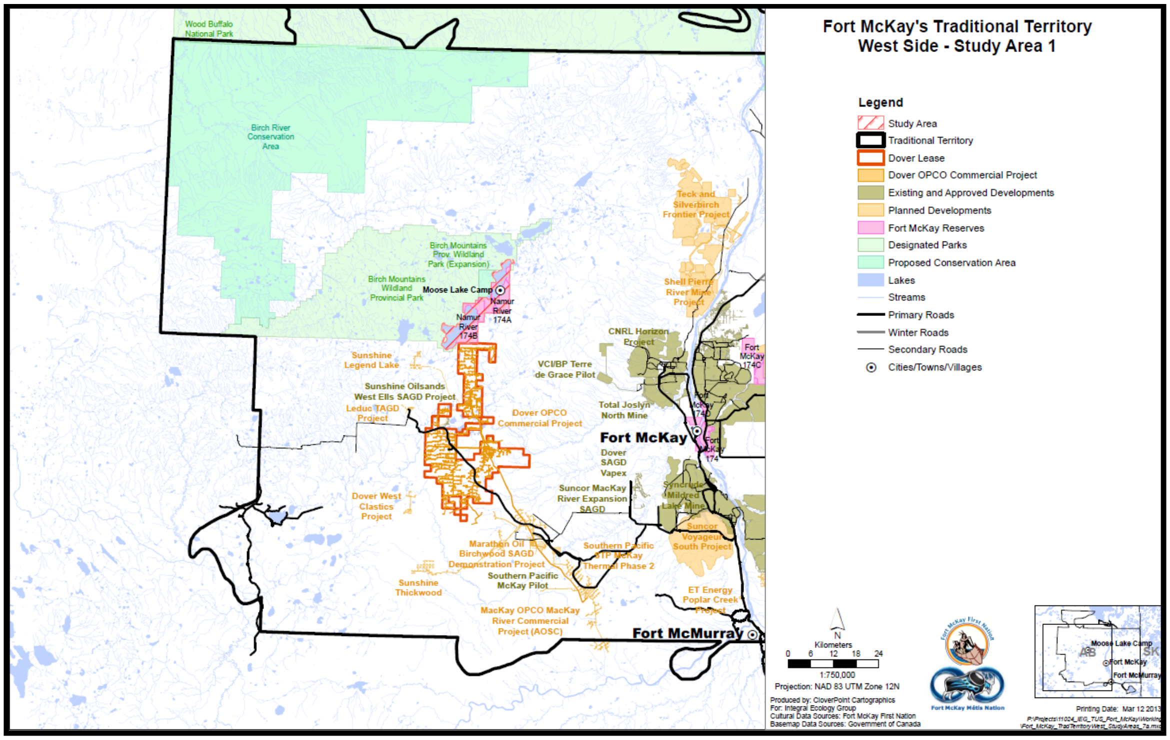


Figure 40. Map indicating location of Fort McKay, the current footprint of the surface mining sector, the location of the Fort McKay Reserves, and the proposed location of the Dover Corp. in-situ development adjacent to the southern border of the Buffalo and Moose Lake Reserves.

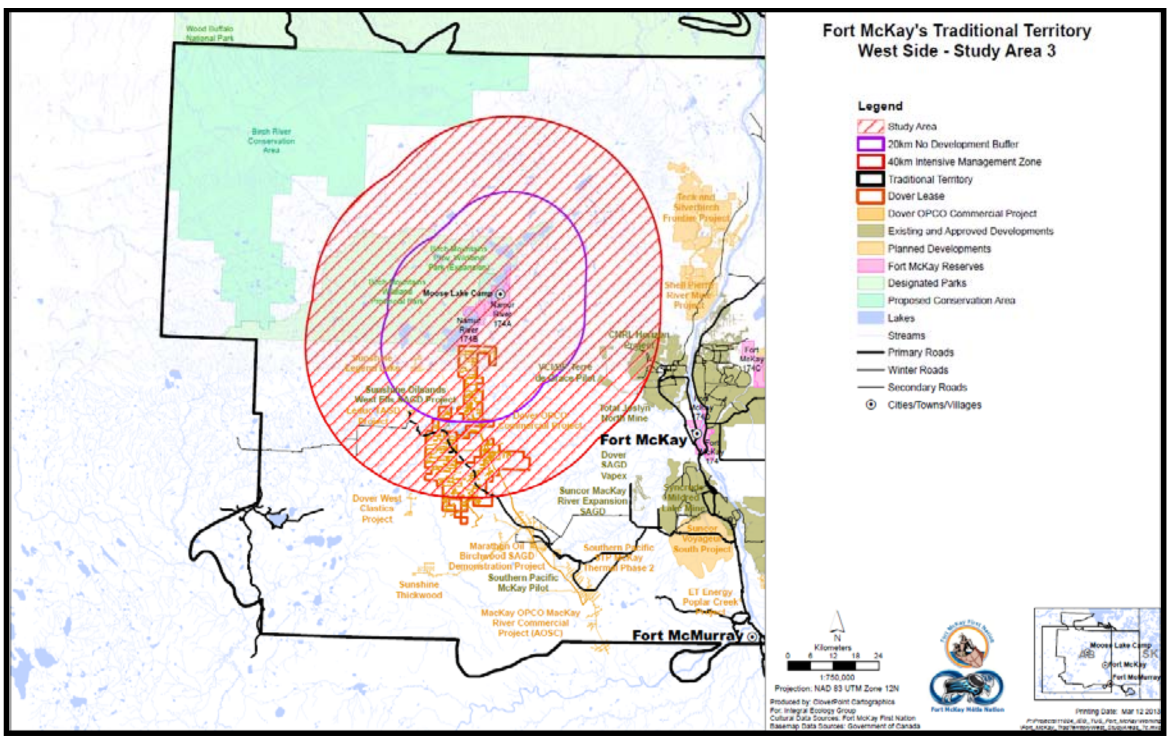


Figure 41. Map detailing the location of Study Area 1, 2, and 3 centered by the Buffalo and Moose Lake Reserves

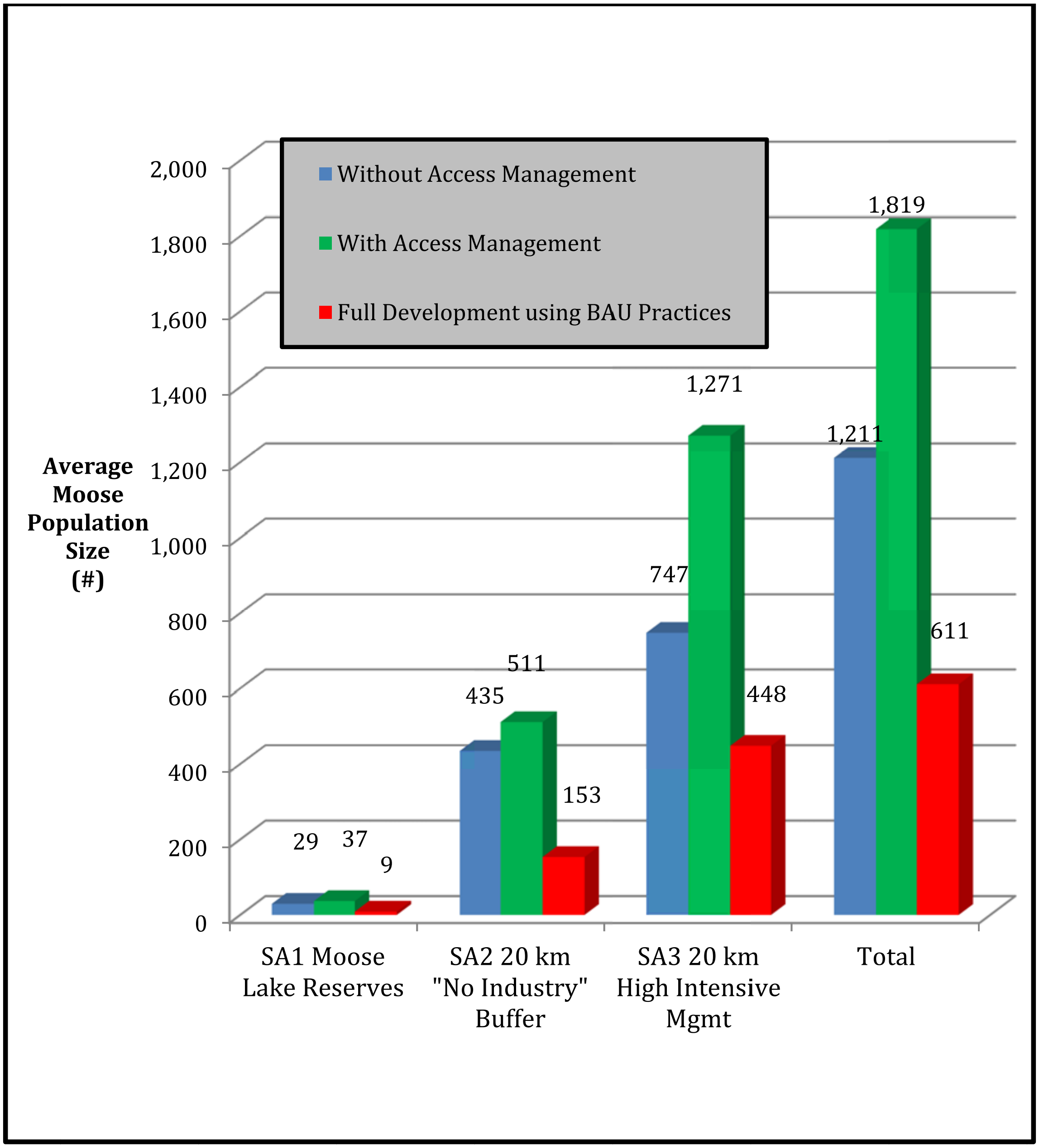


Figure 42. Average moose population based on 25 Monte Carlo simulations for the 3 different study areas, including the combined population of all three areas. The Full development scenario (red) reflects a scenario where the full study area is developed for in-situ development adopting business as usual principles.

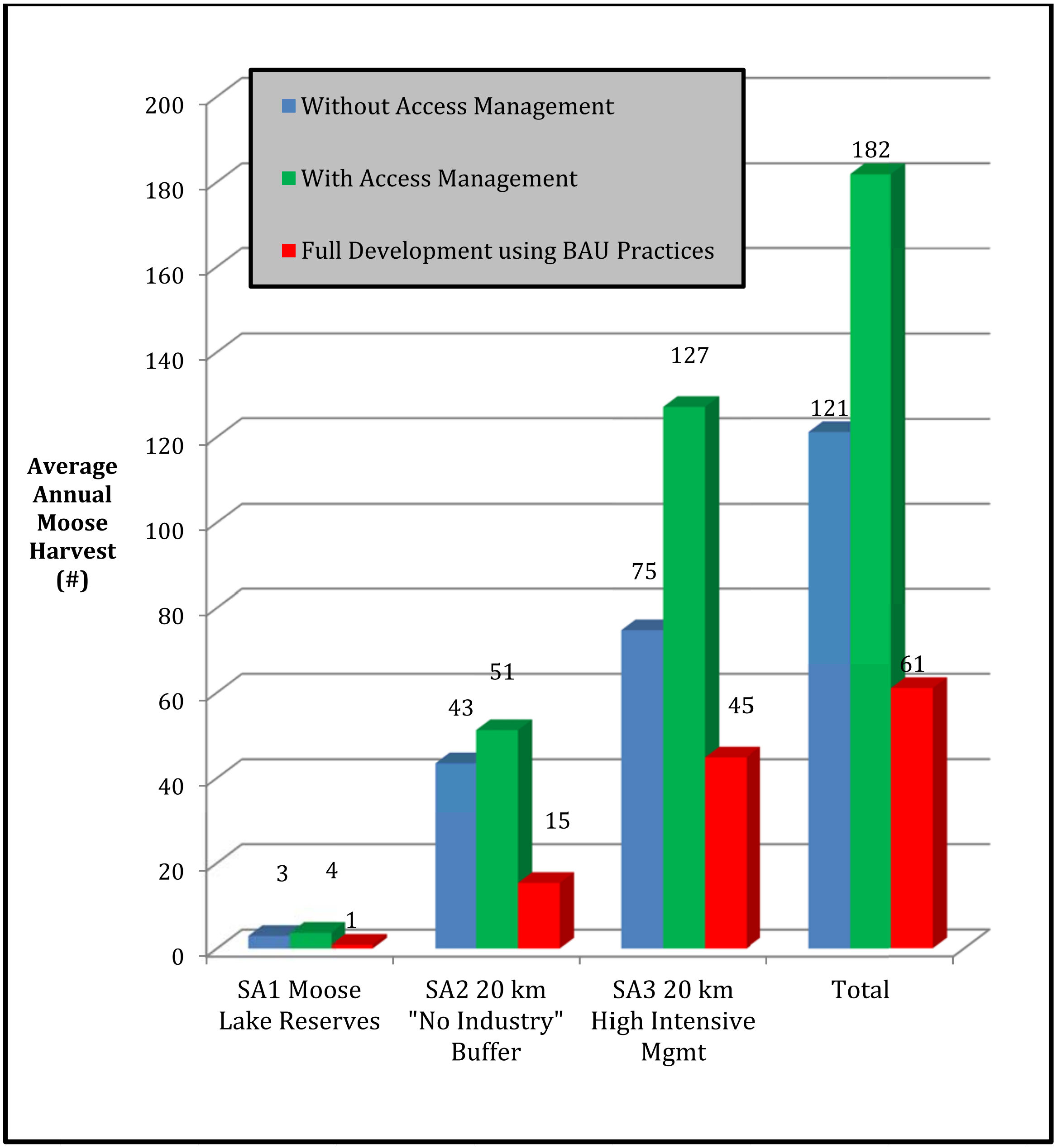


Figure 43. Average annual moose harvest based on 25 Monte Carlo simulations for the 3 different study areas, including the combined population of all three areas. The Full development scenario (red) reflects a scenario where the full study area is developed for in-situ development adopting business as usual principles.

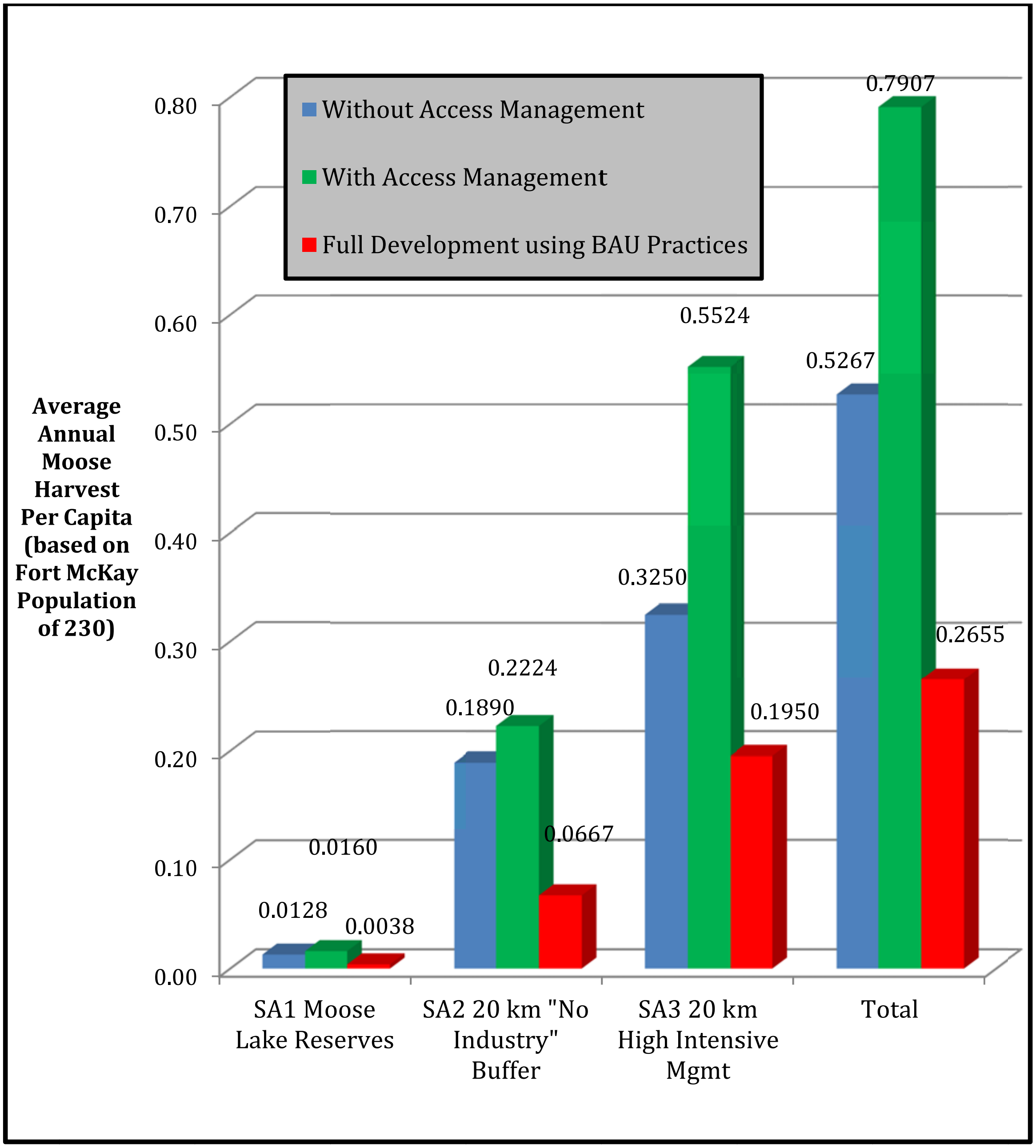


Figure 44. Average annual sustained moose harvest per capita of Fort McKay community (based on initial population of 230) based on 25 Monte Carlo simulations for the 3 different study areas, including the combined population of all three areas. The Full development scenario (red) reflects a scenario where the full study area is developed for in-situ development adopting business as usual principles.

Discussion and Challenge

Moose in Northeast Alberta - From Past to Present

Industrial-scale development of the oilsands brought major changes to northeast Alberta that extended well beyond landscape transformation. Concomitant with the arrival of the oilsand sector in the 1960s was a rapid increase in non-aboriginal and aboriginal population, road network, linear features (pipelines, seismic lines, access roads), vehicles (trucks, quads, snow-machines), and modern scoped rifles. The result of these combined factors was a rapid increase in the demand for moose (aboriginal, non-aboriginal) and the ability of moose hunters to move rapidly across the landscape to locate and harvest moose. The elevated harvest rates that attended these “demand” and “efficiency” increases exceeded the reproductive capacity of the moose population to an extent sufficient to cause a significant reduction in moose densities.

In response to observed declines in moose populations during the 1960’s, 1970s and 1980s, wildlife managers in Alberta responded by imposing a “draw” hunt for non-aboriginal sport hunters that was directed primarily to the harvest of bull moose. The intent was to limit the total sport harvest within sustainable limits and to create a sex ratio better suited to increasing reproductive rates. Although the adoption of more restrictive moose harvest regulations to “regulated” hunters will have value in arresting further declines in moose populations, the recovery of moose populations to densities similar to those experienced in the pre-oilsand era will require a larger and more strategic effort. This effort will need to involve the industrial land uses that alter moose habitat and create and maintain transportation networks and MUST include the aboriginal communities whose hunters have priority rights to harvest moose and whose actions also significantly influence moose populations and density.

From a population dynamics perspective, mortality to moose is generally additive (Gasaway et al. 1992, Van Ballenberghe and Ballard 1994, Murray et al. 2006). In the pre-oilsands era, moose mortality was caused primarily by natural processes (predation, disease, forage scarcity) and a low-density population of First Nation hunters. Almost certainly, there would have been some form of numerical dependency between the number of moose and the number of First Nations. Today, the non-aboriginal population in this region has grown to over 70,000 people, and the associated mortality from legal harvest, illegal harvest and vehicular mortality has also increased. The First Nation community has grown (from 230 to ~800 people) and there is no longer a direct feedback link between the moose population and the survivorship of First Nations communities. Whereas the community of Fort McKay enjoy and cherish the opportunity to hunt moose, they have access to alternative foods when moose meat is unavailable. When all of these causes of mortality are assessed in a cumulative sense, the total mortality is sufficient to induce a decline in the regional moose population. Although it is impossible to know exact values relating to moose populations, predator populations, and human-related offtake during the past five decades, all reasonable evidence suggest that the observed decline in moose populations relate to a combination of reduced habitat quantity caused by direct land use footprints, and the elevated moose mortality rates associated with the expanded human population.

Modeling Conclusions

From a strictly numerical perspective, moose management is not that difficult. More often than not, moose populations predictively conform to the principles of reproduction and mortality. Only cow moose can create new moose, and a diverse selection of mortality agents (predators, deep-snow winters, ticks, First Nations, non-aboriginal hunters, poachers, vehicle bumpers) kill moose. If combined mortality exceeds reproduction, moose populations go down. If reproduction and survivorship exceeds combined mortality, then moose populations go up. When these two opposing factors are about equal, then moose populations tend to remain generally stable with inter-annual variation in the range of 25%. The decisions made by resource managers on issues relating to linear features and access management will significantly influence this dynamic.

Our analyses also indicate the importance of gender biased mortality to population dynamics. Any mortality event that selectively kills cows will have a far greater depressing effect on population densities than those events that kill bulls. In contrast, any mortality strategy that selectively increases bull mortality will shift the sex ratio toward cows and will lead to a population with a higher reproductive potential and one that can withstand a higher rate of mortality from either predators or humans.

Sensitivity analyses of the pre-oilsand era using the ALCES population dynamics module suggests that natural mortality (predators, disease, ticks) rates were ~15%/yr and that an additional 10% mortality of adult moose was caused by First Nations for subsistence purposes. Based on Tanner et al. (2001) interviews of elders that suggested an average annual moose harvest per individual in the pre-oilsand era of 1.2-1.7, and a Fort McKay population of ~230, ~276-391 moose would have been harvested by the Fort McKay community each year throughout their traditional territory. Our analyses suggest that aboriginal harvest rates of moose of 10%/yr were sustainable and that absolute numbers of moose harvested likely fluctuated with moose population density.

The population dynamics simulations also suggest that if combined annual mortality (natural, anthropogenic) exceeds 25% of the population, then moose densities will begin to decline from the initial observed densities of ~0.15-0.20 moose/km^2 recorded in the pre-oilsand era. The higher the combined mortality rate, the faster the decline in moose populations. Many regions in northeast Alberta now report moose densities in the 0.05-0.10 moose/km^2 range, and these reduced populations are most likely the result of increased mortality rates associated with higher human populations, more expansive transportation networks, and greater densities of trucks and off-highway vehicles.

Addressing Old Challenges with a New Way Forward

The management of moose in northeast Alberta has evolved through the decades as government wildlife managers have responded to challenges caused by industrialized landscapes, growing human populations, improved hunting technology, and the inherent difficulties of trying to implement harvest management strategies with inadequate data on moose populations densities and harvest. A brief summary of some of the key changes in moose management strategies for northeast Alberta is included in Appendix D (Blair Rippin, personal communication).

Although the principles of wildlife and harvest management are based on biological sciences, effective implementation occurs within a broader socio-ecological system (Mangel et al. 1996, Levin et al. 1998). In regions where aboriginal communities are actively hunting wildlife and are a primary user with priority access to the resource, their harvest cannot be externalized from the management system. Rather, aboriginal harvest has to be explicitly incorporated as both an objective and a target that is monitored as a key component within an effective decision-making cycle.

The establishment of a moose management strategy for northeast Alberta that embraces the presence, rights, and knowledge of First Nations is long overdue. The advantages of moose co-management strategies involving First Nation communities are many and include social, ecological, and economic benefits. Development of a long-term management strategy will require a new collaborative vision from government and aboriginal communities with accompanying approaches and attitudes (Ostrum 2009, Cox et al. 2010) and a basis in adaptive co-management (Armitage et al. 2007,).

For example, there is much work to be done to assist First Nation communities to better understand contemporary principles of wildlife management and the suite of tools available to managers to monitor and manage harvested populations. A key focus of dialogue is harvest allocation, particularly in areas or times where demand exceeds supply. When a supply/demand constraint occurs, allocation priority to the resource should be transparent and explicitly built upon Treaty rights (Tollefson and Wipond 1998).

The analyses completed in this report, and those of others, point to the key importance of cow:bull sex ratio in determining both moose population size and sustainable harvest rate. It is reasonable to expect that concerns over allocation of scarce moose harvest opportunities could be mitigated to a significant degree through a co-management agreement that seeks to optimize population size, bull:cow ratios, and age class distribution.

It is unlikely that a successful moose harvest strategy can be deployed without implementation of some form of access management. The combination of large and rapidly increasing human population, vehicle population, and linear feature network all point to the elevated encounter rates with moose and the ease by which they can be harvested. In recent years, the Government of Alberta has openly discussed the strategic advantages of devising and deploying an access management plan in northeast

Alberta. Currently, access management is a topic being examined by the Cumulative Effects Management Association.

Experience in other areas suggests that effective and coordinated access management will be a critical component of successful moose management strategies. We highlight three examples.

- For example, in Newfoundland, where there are no large predators (i.e., wolves or bears), management of moose densities is achieved primarily through hunting. A key aspect to the efficacy and ability of hunters to harvest adequate numbers of moose is tied to access and road density. Ferguson et al. (1989) found moose management units that had most of their area greater than 2 km from roads were inaccessible to most resident hunters.
- In a comparison of resource selection patterns by moose in Algonquin Provincial Park (southeast Ontario) and an adjacent WMU, McLoughlin et al. (2011) found that moose clearly avoided roads more strongly in the WMU where hunting pressure was much higher, versus within the park, where only limited moose harvesting by aboriginal subsistence hunters was allowed.
- In a recent study in southeast Alaska, Shanley and Pyare (2011) found that dispersed vehicular activity on rural road networks significantly affected moose distribution. They determined a road-effect zone for male moose to be between 500 m and 1000 m, and >1000 m for female moose. They also showed a road avoidance pattern for moose, in which probability of moose occurrence by a road was higher below a threshold volume of approximately 0.25 km of vehicle travel/km^2/day.

Together, these studies suggest that managing human and vehicular activity provides a way of indirectly managing moose harvest rates, and a means of maintaining habitat effectiveness by reducing disturbance to moose. A key challenge for implementing access management is to reduce the ecological impacts of dispersed and extensive networks of roads and linear features as part of transportation and land-management planning, but to also consider and coordinate with access required to maintain traditional land use in an increasingly industrialized landscape.

The “traditional use” buffers surrounding Buffalo and Moose Lake Reserves, as proposed by the community of Fort McKay, is a rational approach to addressing the issue of sustaining moose populations and traditional moose harvest within a wildland setting embedded within the rapidly industrialized landscape of northeast Alberta.

Limitations and Important Considerations

Future Conditions

Projecting (simulating) future land uses, and their implications, can have high levels of uncertainty. The land-use scenarios examined for this study are based on specific assumptions about the rate, location and operating practices of various land-use activities. Government policy, global commodity prices, trends in energy supply and transportation infrastructure, and technological innovation all have significant effects on the intensity and location of future land-use activities. It is highly probable that the land-use assumptions upon which the scenario modelling is based will become less robust as the future simulation period unfolds.

While changing future conditions are a near certainty, examining plausible futures based on current assumptions allows stakeholders to better understand potential benefits and risks that attend defined alternative land management options. For the various governing bodies (Canada, Alberta, Fort McKay) that are relevant to this region, a decision-making framework is critical to developing and implementing sustainable land management strategies that can be re-evaluated as circumstances change. Similar to the precautionary principle, uncertainty about future land-use activities should not prevent informed decision-making today.

Impact Prediction and Significance

Projected wildlife (moose) status under different development assumptions is compared to simulated RNV to provide some information on the ecological risk associated with projected changes. This approach assumes that risk is minimal where indicator status is within the RNV, and increases as indicator status moves further away from 'natural' conditions. The risk management categories presented here were utilized for land-use planning by the Government of Alberta in northeast Alberta as part of the Alberta Land-use Management Framework. Because risk tolerance of resource managers and communities can vary, these risk rankings may not reflect “made-for-Fort McKay” socio-cultural perspectives. Such perspectives should be considered when discussing and evaluating potential land-use impacts, particularly in the context of establishing limits of acceptable change.

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Appendix A. Wildlife Habitat Module

This appendix outlines the general structure and input assumptions that are used in the ALCES landscape simulator that pertain to simulation of wildlife habitat. The reader is recommended to download the entire ALCES manual at www.alces.ca to understand the full extent of model structure and assumptions.

Introduction

The availability and quality of habitat for specific wildlife species is determined by tracking the areas and area-weighted values of different landscape types and footprint types, and by defining the response curve of different habitat attributes (for example, edge density, human density, water quality, stand age, forest structure, herbaceous vegetation, linear disturbance, etc.) to habitat quality.

The size and dynamics of wildlife populations are in turn influenced by habitat quality and quantity, and a suite of factors that influence natality and mortality.

In this module, the User has access to a tool kit containing several different approaches for tracking wildlife habitat and population dynamics:

- Habitat Suitability Index models (see Section 9.1)
- Age and Gender-Stratified Population Dynamics models (see Section 9.6)

Habitat Suitability Index Models

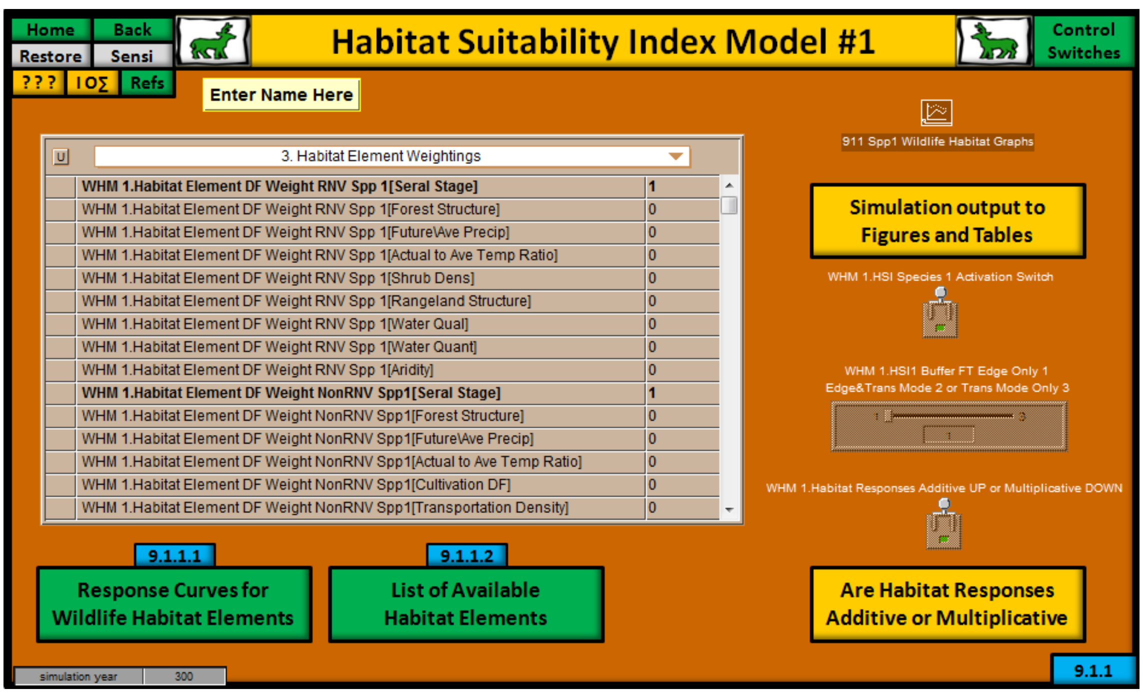

Figure 45. Habitat Suitability Index model for species 1

Introduction

The Wildlife Habitat Suitability Index module allows the User to explore changes in habitat availability and habitat quality of selected wildlife species in response to different trajectories of human land use practice and such natural disturbance regimes as fire, insects and meteorology.

There are five general data assumptions for the ALCES User to input:

- What are the relative habitat values of different landscape types and footprint types?
- What is the portion of each landscape type that can be occupied by a wildlife species?
- Which habitat elements are important to a given wildlife species, and what is the relative importance of each habitat attribute? This question needs to be answered separately for "RNV" and future simulations.
- What is the response curve between changes in levels of habitat elements and their value to wildlife habitat?
- Which anthropogenic linear features need to be buffered, what is the buffer width (in metres), and what is the buffer response curve?

Panel Instructions

Table 1. Habitat Value Index of Landscape and Footprint Type: In Table 1, the User identifies the relative habitat value of each LT and each FT for the species of concern. A value of “0” indicates that there is no habitat utility for that LT or FT and that no individuals would be observed in these strata. In contrast, a habitat value index of “1.0” indicates that a given LT or FT has maximum habitat utility, and the highest densities of that species would be observed. The User can consider the 0 to 1 index to be reflective of the long-term animal density that can be expected for each LT. A LT given a value of 0.5 would reflect a LT supporting a population density of ~50% of that of the best available habitat type.

Table 2. DF Geographic Use of Landscape and Footprint Types: The User enters the fraction of each LT that is "geographically available" (irrespective of habitat quality) for a wildlife species. In almost all studies, the suggested value is “1.00”, indicating that all of a given LT or FT is "available" for use. The values can range from “0” (no level of expected use) to “1.00” (100% level of expected use). The value should not be confused with habitat quality or density, but simply whether a population resides on a portion of a LT over a long time period. The User should reduce the level of use of a particular LT as habitat if there is evidence that a portion is unusable for reasons of climate, geography, or incompatible land use. Examples of non-use for a given LT could include latitudinal, longitudinal, or elevational limits to occupancy for a given species.

Table 3. Habitat Element Weightings: In Table 3, the User examines the finer scale detail of habitat quality as it relates to wildlife species. Within LTs, habitat elements that are relevant to wildlife species for RNV include forest age, forest structure, future/average precipitation, future/average temperature, shrub density, rangeland

structure, water quality, water quantity, and aridity. Habitat elements that are relevant to wildlife species for future simulations include forest age, forest structure, future/average precipitation, future/average temperature, shrub density, rangeland structure, water quality, water quantity, aridity, transportation density, anthropogenic edge, energy sector fraction of landscape, human density, and cattle density.

It is important for the User to distinguish between habitat elements for predisturbance (RNV) and those for industrial landscapes. In the RNV era, only natural disturbance events can influence habitat performance. In the industrial era, both natural and anthropogenic features can help explain habitat performance. ALCES computes a combined weighted approach to habitat element values for simulations involving backcasting.

Identification of habitat elements important to individual wildlife species can be approached by the User by considering the following question: "What fraction of the total density variance for a wildlife species can be "explained" by each of the habitat elements?" The total value identified by the User must sum to 1.00. For example, a value of "0.8" for stand age and "0.2" for anthropogenic edge means that biologists feel that stand age and anthropogenic edge are the major drivers of habitat quality and that stand age is 4 times as important as anthropogenic edge.

Table 4. Seral Stage Value 0 to 1 scale and **GIDs in Panel 9.x.1 Response Curves for Wildlife Habitat Elements**: Once the User has identified the relative "weightings" for habitat elements, it is then necessary to define the response surfaces. In Table 4, the User identifies the relative importance of forest seral stage to habitat quality. Each seral stage can vary between "0" (no value) to "1.00" (maximum habitat value). The response surfaces for habitat elements other than forest seral stage are entered in the panel called "Response Curves for Wildlife Habitat Elements" (Figure 46). In the GIDs of this panel, the User describes the relationship between differing levels of habitat elements (precipitation, temperature, anthropogenic edge, human density, shrub density, etc.) and the response of a wildlife species. For all response surfaces for wildlife, the Y axis can vary between "0" and "1.00".

Table 5. Which FT represent Edge for HSI Species?: The level of habitat available to wildlife species can be further altered by identifying non-use or partial-use buffers on such linear features as seismic lines, roads, wellsites, pipelines, cutblocks, etc. In Table 5, the User enters a value of "1" for those features that should be buffered and "0" for those that should not be buffered. The User can conveniently turn off all buffering with a single master switch located at the bottom of Table 5.

Table 6. FT Buffer m Width and Buffer Use % w and wo Access Mgmt: The User enters the buffer width distance (in metres) that ALCES needs to apply to both the edge of linear features and the perimeter of polygonal footprints. To inform ALCES as to the extent of use of buffers adjacent to land use footprints, the User informs ALCES in Table 6 as to the fraction of the buffer that is effectively used by wildlife species relative to similar habitat types that are beyond the buffer width. For example, if the relative

abundance of a wildlife species within a buffer is 45% of the abundance of that species in the same habitat type outside the buffer, the User should enter a value of “0.45”.

Recognizing that access management is a best practices option for mitigating the negative effects of footprint buffers on wildlife, ALCES allows the User to define "use" values within buffers separately for scenarios where access management is turned on and where it is turned off. In cases where edge density is very high, and the FT buffers have significant overlaps, the sum of area caused by overlaps may greatly exceed the total area within a given LT. In such cases, the decision to adopt "access management" best practices may not result in an empirical benefit to wildlife habitat area.

At the bottom of Table 6, the User needs to indicate whether buffers are only applied to footprint types (enter a value of “1”), to be applied to footprint types and transportation modes (enter a value of “2”), or only transportation modes (enter a value of “3”). If ALCES is required to place buffering on transient transportation modes (i.e., walking, quadding, boat trips, plane trips, off-highway vehicles, etc.), then enter the average buffer width (m) and lifespan (minutes) in Table 8.

Table 7. Habitat Value DF of Invasive Species LT: If the User chooses to activate the exotic invasive plant expansion switch found in Panel 7 (Plant Community & Carbon Dynamics), then ALCES will compute the fraction of each LT that contains exotic invasive plants. If the wildlife biologists consider exotic plants to possess a lower or higher LT habitat quality than similar LTs without exotic invasive plants, then these values can be entered in Table 7. A default value of “1.00” indicates that a LT with invasive plants has maximum habitat utility. A value of “0.75” would indicate that a LT with exotic invasive plants has a habitat utility value that is 25% lower than the maximum value for that LT.

Table 8. Transportation Mode Buffer Metrics: If ALCES is required to place buffering on transient transportation modes (i.e., walking, quadding, boat trips, plane trips, off-highway vehicles, etc.), the User should enter the average buffer width (in metres) and lifespan (in minutes) for each type of transient transportation mode.

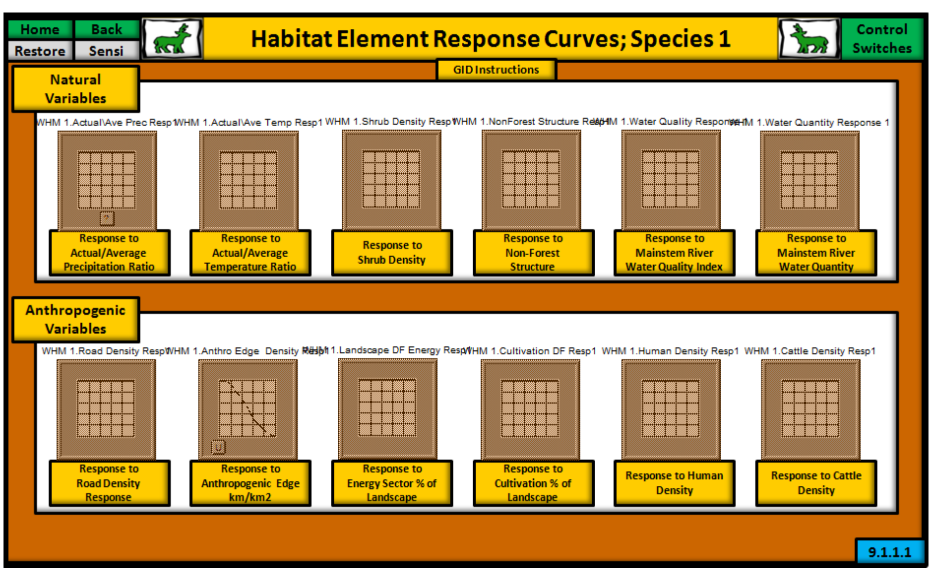

Figure 46. Panel 9.1.1.1 – Response curves for wildlife habitat elements for species 1

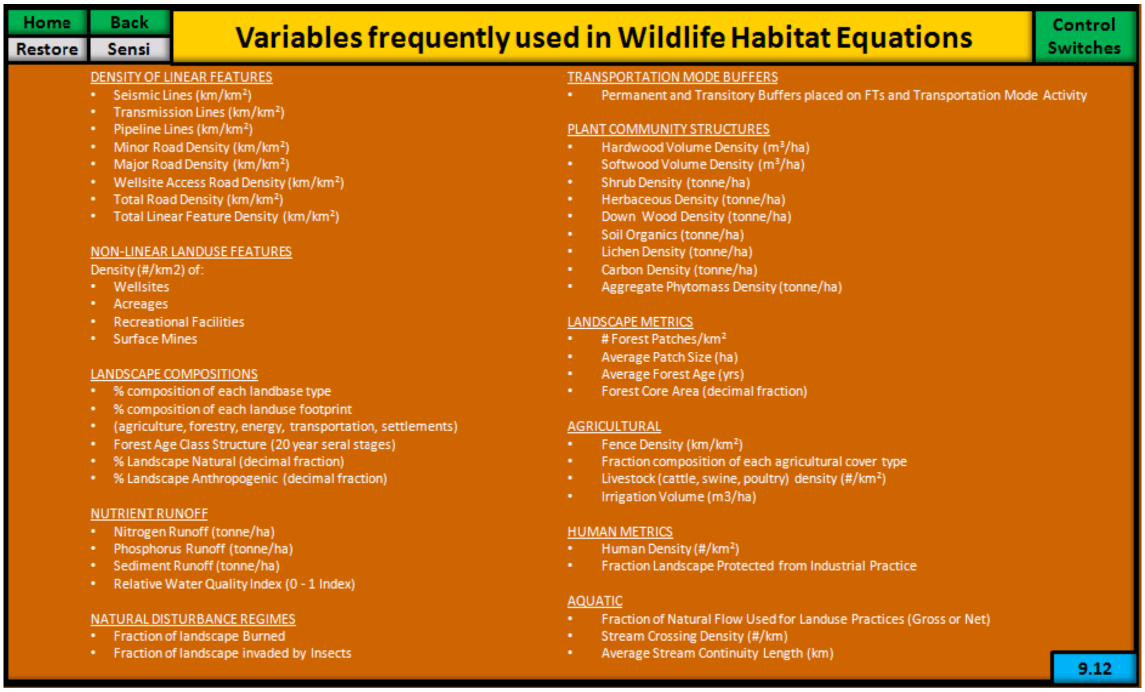

Figure 47. Variables frequently used in wildlife habitat equations

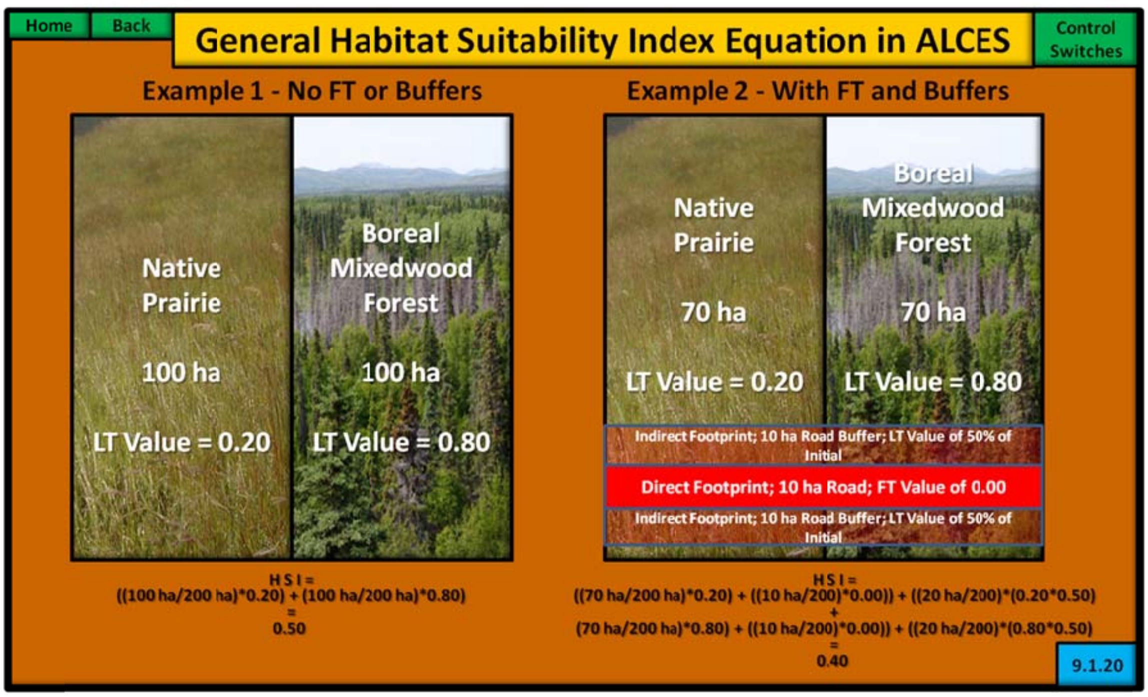

Figure 48. Panel 9.1.20 - General Habitat Suitability Index Equation in ALCES. For purposes of simplicity, this graphic does not contain relationships pertaining to: 1) fraction of LT used by species, 2) habitat quality influenced by habitat elements, or 3) effect of invasive species on habitat quality.

Appendix B. ALCES Population Dynamics Module

This appendix outlines the general structure and input assumptions that are used in the ALCES landscape simulator that pertain to simulation of wildlife population dynamics. Its goal is to assist the reader in better understanding the methodology adopted in this study. The reader is recommended to download the entire ALCES manual at www.alces.ca to understand the full extent of model structure and assumptions. The panel descriptions below refer to the general approaches to conducting population dynamics simulations in ALCES and any values in tables, graphic input devices or figures do not relate specifically to this study. There are also elements of the population dynamics module that were not used in these analyses.

Wildlife Populations Overview

Wildlife populations exhibit temporal variation in response to changing landscape metrics, and changes in natality and mortality factors. Accordingly, population size and dynamics can be shaped by any change in natural disturbance regimes (fire, insects, climate, climate change), land use (forestry, energy, mining, crops, livestock, residential patterns, etc.), or mortality rate (predation, sport, outfitting, aboriginal, poaching, disease control).

To assist the User in exploring the interface between landscapes, land uses and wildlife populations, the following features have been added to the Population Dynamics module in ALCES:

- Stratification by gender
- Stratification by age class
- Multiple mortality modes (commercial hunting, sport hunting, aboriginal hunting, poaching, density-dependent mortality, density-independent mortality, epidemic disease)
- Age class and gender specific mortality coefficients

A variety of outputs pertaining to populations are available including:

- Populating size (stratified by species, age and gender)
- Population biomass (stratified by species, age and gender)
- Populating harvest (stratified by harvest type and species, age and gender)
- Predator pit dynamics
- Revenue generated from harvest
- Simulated changes in trophy metrics

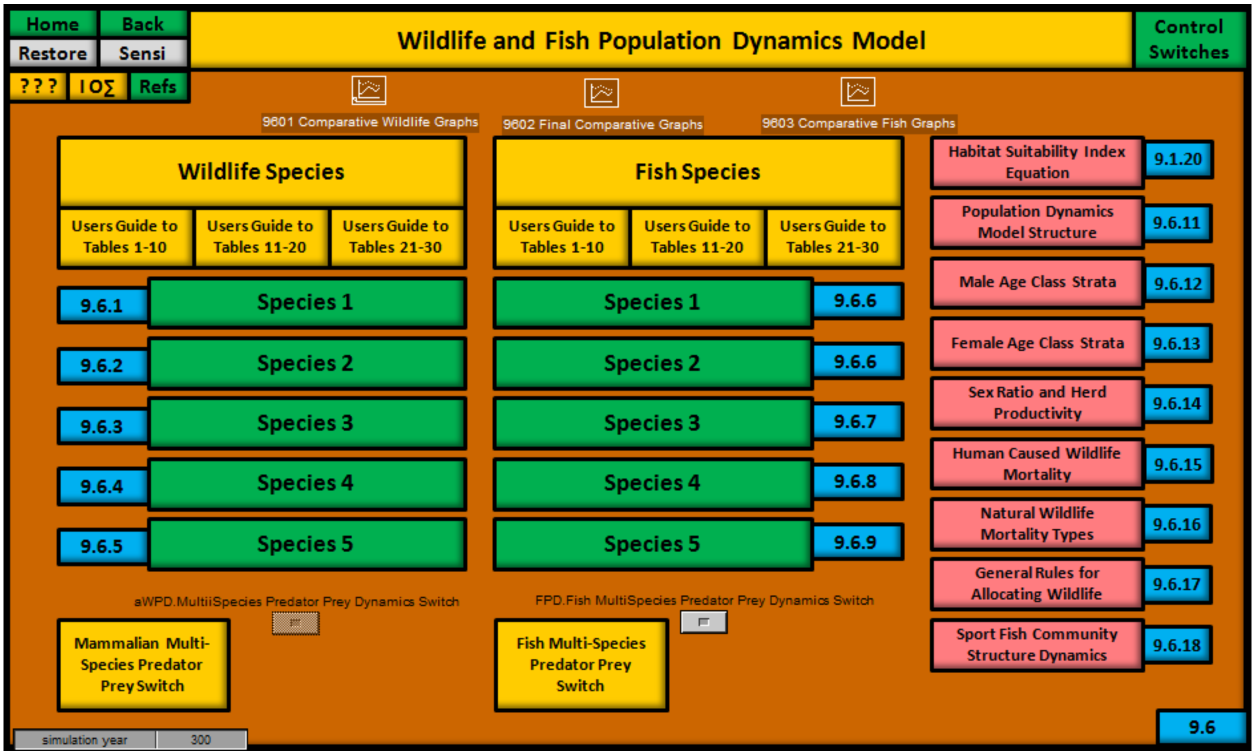

Figure 49. Panel 9.6 - Wildlife/Fish Population Dynamics Model

Introduction

The multi-species Population Dynamics module within ALCES enables the User to explore relationships between land use composition, management strategies, and predator-prey dynamics involving four or fewer species occupying a defined study area. Populations are stratified into gender classes (males, females) and age classes - young of year (YOY), yearlings (Yrlg), young adults (Yng Ads), mature adults (Mat Ads) and old adults (Old Ads).

For each species, the User provides input metrics to the Population Dynamics module relevant to:

- Reproductive rate (fecundity by age class)
- Immigration (rate and interval)
- Body mass (for each age and gender class for each species)
- Forage requirement as percent of body weight
- Landscape types contributing to habitat and the relative quality ranking of each LT
- Relative habitat quality ranking of seral stages for each forest type
- Prey species for defined predator species
- Relative vulnerability ranking of each prey species

Management actions available for the User to alter include:

- Sport harvest rate (stratified by gender and age class)
- Aboriginal harvest rate (stratified by gender and age class)

- Angling harvest rate (stratified by gender and age class)
- Depredation harvest rate and interval (stratified by gender and age class)
- Penning rate for cows and calves to enhance survivorship

A minimum viability population switch and metric can be activated, allowing the User to trigger metapopulation extinction rates once population sizes fall below a lower critical value.

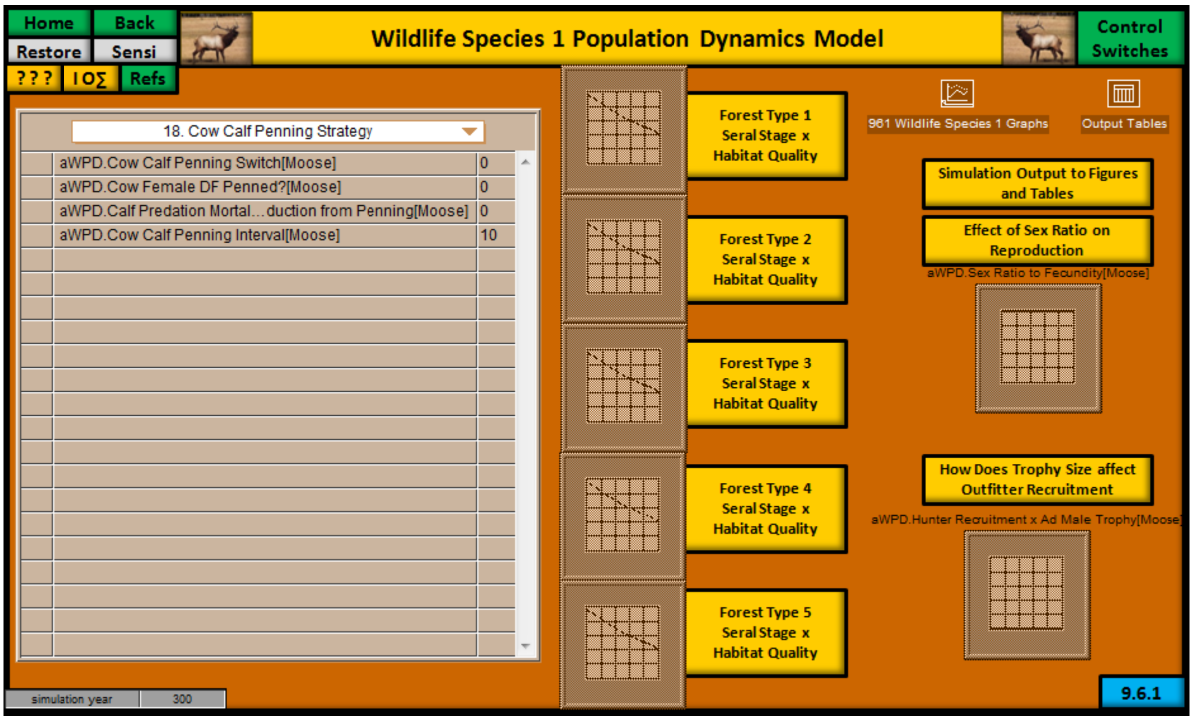

Figure 50. Panel 9.6.1 - Example of a Population Dynamics Model Panel

1. Species Entry Switches for Species and HerbivoryPredation
2. Initial Population Estimates Age and Gender
3. Body Metrics
4. Reproductive Metrics
5. Natural Mortality Rate
6. Maximum Social Defined Density Possible
7. Background Mortality Adjuster
8. Prey Susceptibility % for Year
9. Daily Forage Requirement % of Body Weight
10. Proportion of LT Forage Available for Herbivory
11. Which LT Represent Habitat for Species, Variance in Habitat
12. Relative Prey Vulnerability
13. Reproduction Constraint Strategy
14. Depredation Metrics
15. Sport Hunting Metrics
16. Aboriginal Hunting Metrics
17. Outfitter Hunting Metrics
18. Cow Calf Penning Strategy
19. Footprint Buffer Metrics
20. Prey to Predator Eligibility Matrix
21. Spp x Habitat Quality x Landscape Type
22. Immigration Metrics
23. Minimum Viable Population Metrics
24. Extra Table
25. Hunter Wounding Rate
26. Control Harvest Metrics
27. Poaching Harvest Metrics
28. Market Value $ per Animal Harvested
29. Is Natural Mortality Additive or Compensatory

Figure 51. List of input tables for Panel 9.6.1

Panel Instructions

Table 1. Species Entry Switches for Species and Herbivory Predation: Indicate whether the species is entered into the simulation and whether it represents a prey species.

Table 2. Initial Population Estimates Age and Gender: Enter the initial population size for different age and gender classes for the species.

Table 3. Body Metrics: Enter average body mass (in tonnes) for each age class, the proportion of the liveweight that would be harvested for meat, and the average trophy metric

Table 4. Reproductive Metrics: Enter average annual fecundity rate (newborns/female/yr) for each age class and the proportion of offspring that are females.

Table 5. Natural Mortality Rate: Chose to activate minimum and maximum food limitation mortality rates by turning on the "Natural Mortality Switches" for each age class and input appropriate values.

Table 6. Maximum Social Defined Density Possible: Enter the maximum density achievable given social constraints, irrespective of forage availability. Also, Met Induced Interannual Variance in Habitat Quality and New Random Met Variance 1 or Constant Variance 0.

Table 7. Background Mortality Adjuster: This is a sensitivity modifier that allows the User to easily adjust the natural mortality rate. The default value is "1.00", and the modifier is multiplied against the natural mortality rate in the model.

Table 8. Prey Susceptibility % for Year: Enter the portion of the year that a prey is susceptible to predation.

Table 9. Daily Forage Requirement (% of Body Weight): Enter the fraction of the live body weight of a species that is consumed as forage on an average daily basis. Also, define the average fraction of forage eaten or prey weight killed that is wasted.

Table 10. Proportion of LT Forage Available for Herbivory: In this table, enter the fraction of phytomass of each forage type that is available for consumption by herbivores on an annual basis.

Table 11. Which LT Represent Habitat for Species, Variance in Habitat: Enter a "0" for those LTs that DO NOT represent habitat for a given species, or a "1" for those LTs that DO represent habitat.

Table 12. Relative Prey Vulnerability: Define the relative susceptibility (continuous scale from 0 to 1) of different age classes to predation. A value of "1" represents the most susceptible prey option and a value of "0" represents an age class that is not susceptible to predation. At least one combination should be defined as a value of 1 so that other combinations can be scaled against it.

Table 13. Reproduction Constraint Strategy: The User needs to indicate whether the reproductive rate is constrained by food availability (enter a value of “1”), population density (enter a value of “2”), or both (enter a value of “3”).

Table 14. Depredation Metrics: The User decides whether to activate the depredation switch. If activated, the User enters the fraction of each age/gender class to receive depredation, and the interval (# of years) over which depredation events occur.

Table 15. Sport Hunting Metrics: The User decides whether to activate the sport hunting switch. If activated, the User enters the fraction (or number) of each age/gender class to be harvested annually and the interval (in years) over which sport harvest events occur.

Table 16. Aboriginal Hunting Metrics: The User decides whether to activate the aboriginal hunting switch. If activated, the User enters the fraction (or number) of each age/gender class to be harvested and the interval (in years) over which aboriginal harvest events occur.

Table 17. Outfitter Hunting Metrics: The User decides whether to activate the outfitter hunting switch. If activated, the User enters the fraction (or number) of each age/gender class to be harvested and the interval (in years) over which outfitter harvest events occur.

Table 18. Cow Calf Penning Strategy: The User decides whether to activate the "penning" switch. As a management strategy, penning is activated to reduce natural mortality rates on cows and calves. If activated, the User enters the fraction of cows and calves to be "penned", the anticipated proportion reduction in mortality through penning, and the interval (in years) between penning events.

Table 19. Footprint Buffer Metrics: The User decides whether to activate the footprint buffers using a switch at the bottom of the table. If the switch is activated (by entering a value of “1”), the User identifies the average buffer width (in metres) to be applied on FTs within each of the LTs. Also, enter the fractional use of LTs within buffers relative to identical LTs outside buffers. A value of "0" indicates no use, and "1" indicates that use of LTs within buffers is identical to LTs outside buffers.

Table 20. Prey to Predator Eligibility Matrix: The User identifies which wildlife species represents a predator of the species being modelled. A value of “0” indicates that the species is not a predator and a value of “1” indicates that a species is a predator. This table can be disregarded if the user does not intend to explore inter-specific trophic relationships.

Table 21. Spp x Habitat Quality x Landscape Type: The User identifies the habitat value (ranging from “0” to “1”) for each LT. A value of “1” reflects a LT supporting maximum densities, whereas a value of “0.5” would reflect a LT where population densities are typically half that of maximal LTs.

Table 22. Immigration Metrics: The User decides whether to activate the immigration switch. If activated, the User can identify the number of individuals that immigrate into the study area, and the interval over which immigration occurs.

Table 23: Minimum Viable Population Metrics: The User decides whether to activate the minimum viable population (MVP) equations and identify the MVP population level. If activated, ALCES will generate random extinction probabilities if the population is lower than the MVP population level.

Table 25. Hunter Wounding Rate: The User identifies the average annual wounding rate for each of the major human-related mortality types (sport hunting, aboriginal hunting, outfitter harvest). The wounding rate is entered as an additive fraction of the harvest from other mortality types. For example, a wounding rate of 0.05 indicates that wounding rate represents 5% of that occurring from sport harvest.

Table 26. Control Harvest Metrics: The User decides whether to activate the commercial hunting switch. If activated, the User enters the fraction (or number) of each age/gender class to be harvested annually and the interval (in years) over which commercial harvest events occur.

Table 27. Poaching Harvest Metrics: The User decides whether to activate the poaching harvest switch. If activated, the User enters the fraction (or number) of each age/gender class to be harvested annually and the interval (in years) over which poaching harvest events occur.

Table 28. Market Value $ per Animal Harvested: The User identifies the market value (in $/individual harvested) for each of the age and gender classes and for each of the mortality types.

Table 29. Is Natural Mortality Additive or Compensatory?: Outfitter Harvest Compensatory Switch 0 to 1 and Outfitter Harvest Compensatory Old Adult Natural Mortality DF

GIDs for Forest Seral Stage x Habitat Quality: In this set of 5 GIDs, the User defines the relationship between forest habitat utility function (ranging from “0” to “1”) and average forest age for each forest LT. **GID for Effect of Sex Ratio on Reproduction**: The User defines the relationship between the sex ratio (female:male) and a multiplying modifier that is used to influence reproduction. For example, a modifier of 0.5 would reduce fecundity rates by 50%.

GID for Effect of Trophy Size on Outfitter Recruitment: The User defines the relationship between the average trophy size of adult “living” males and the ability to recruit outfitted hunters.

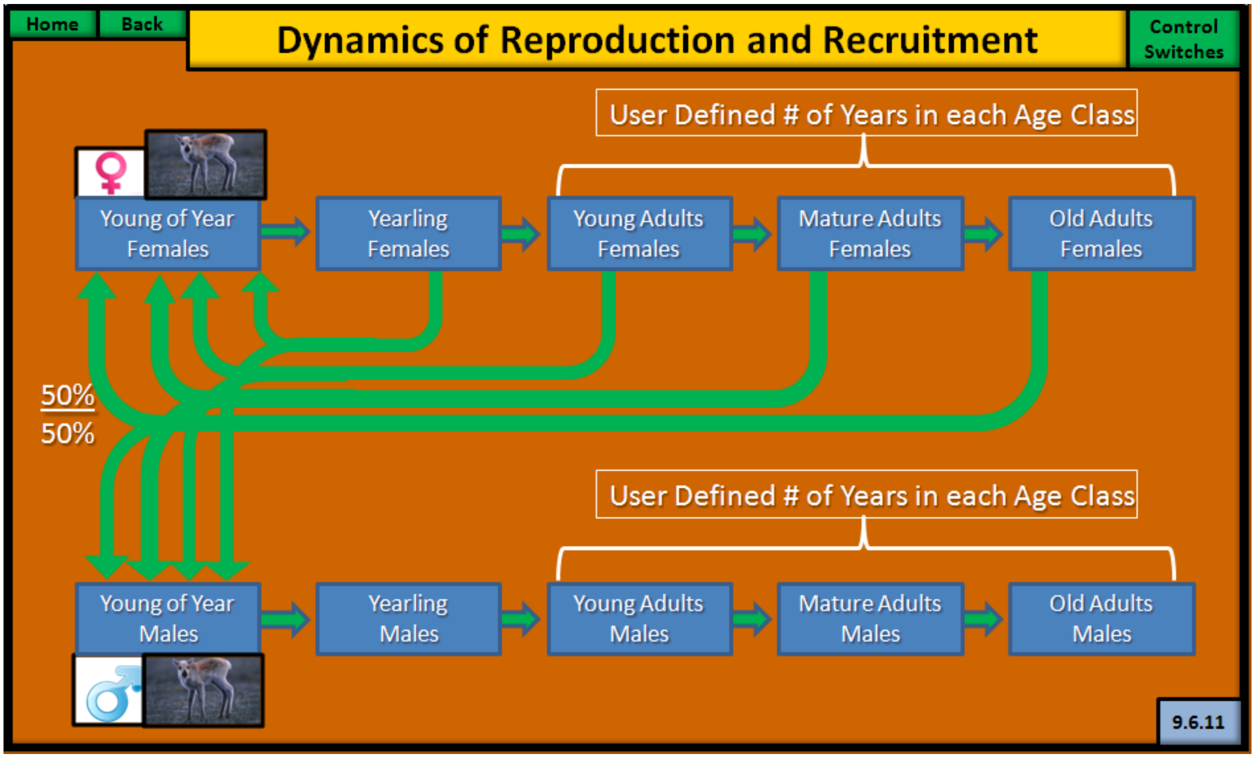

Figure 52. Panel 9.6.11 - Dynamics of Reproduction and Recruitment

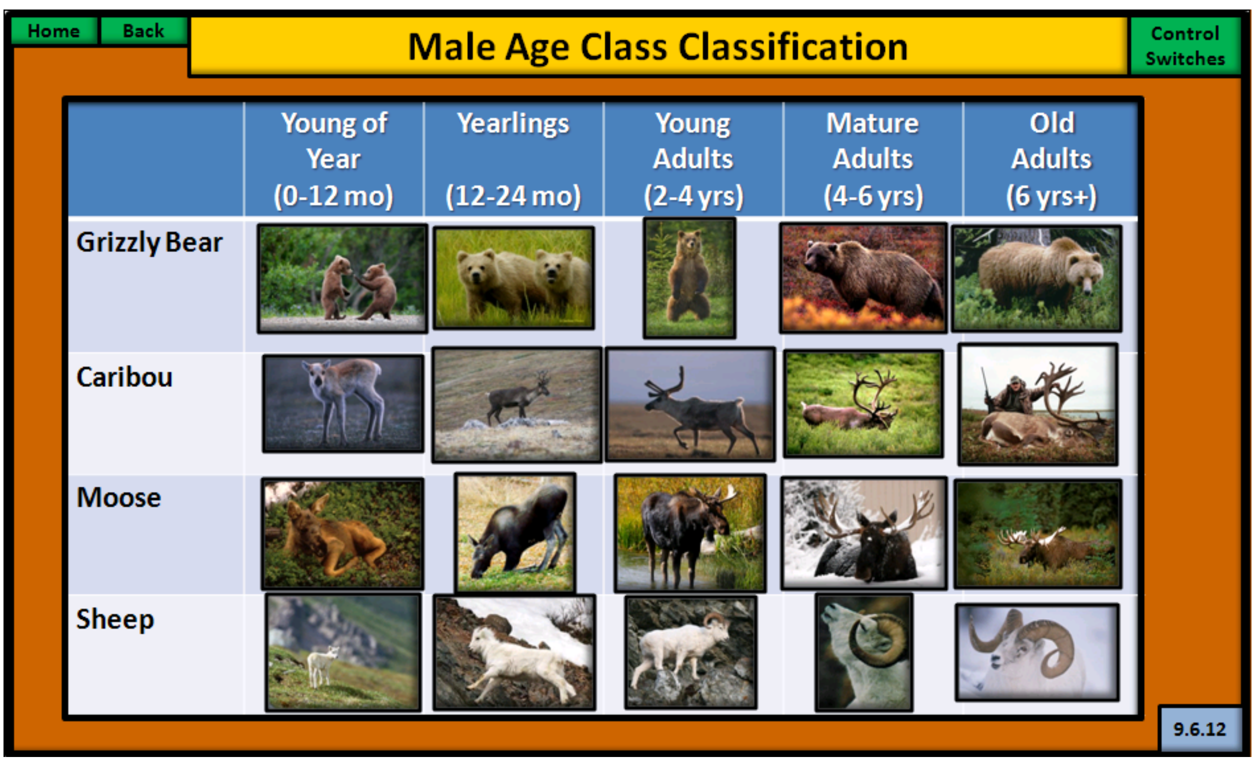

Figure 53. Panel 9.6.12 - Male Age Class Stratification

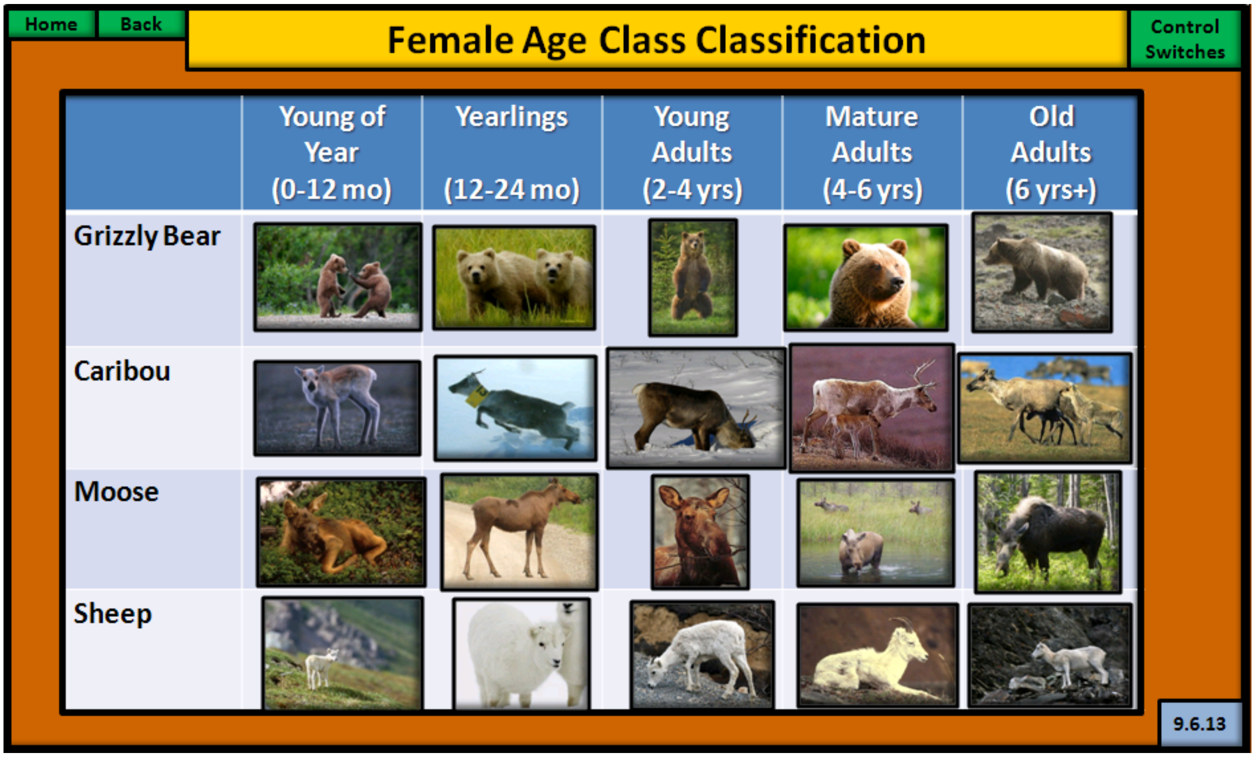

Figure 54. Panel 9.6.13 - Female Age Class Stratification

Figure 55. Panel 9.6.14 - Skewed Sex Ratio and Herd Production

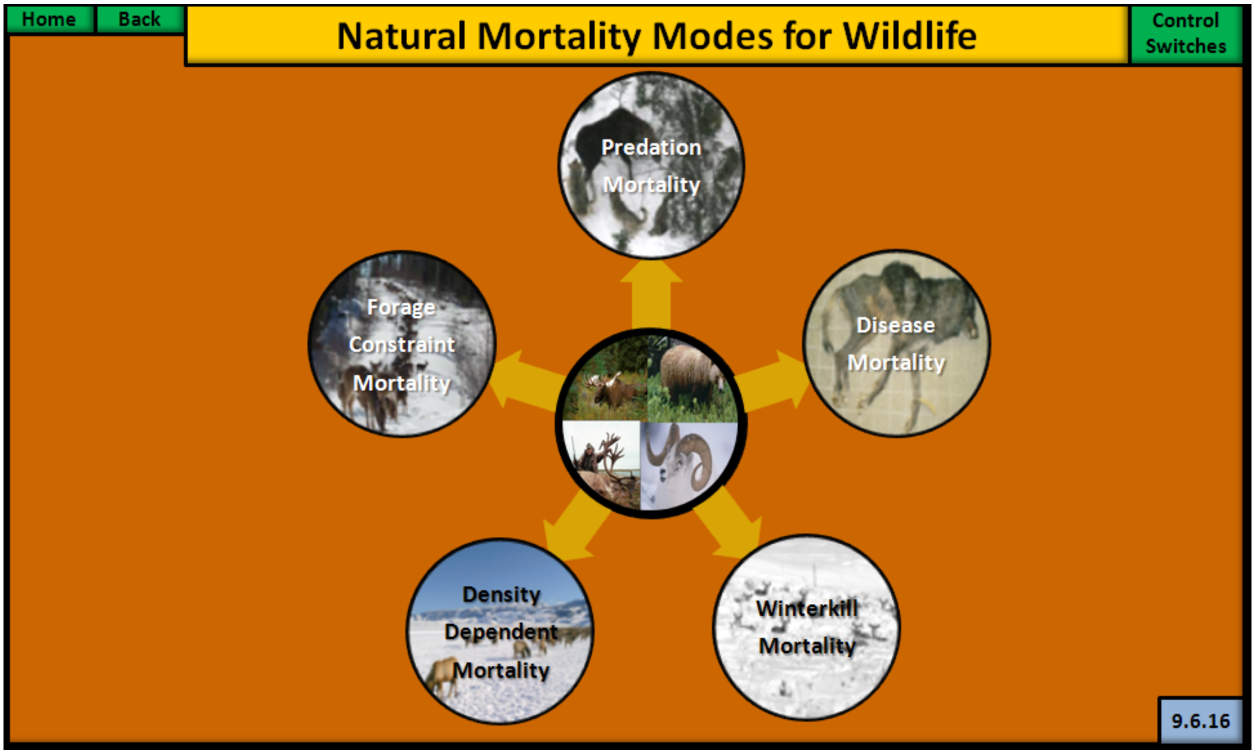

Figure 56. Panel 9.6.16 - Assorted Natural Mortality Modes

Figure 57. Panel 9.6.15 - Human-related Mortality Modes for Wildlife

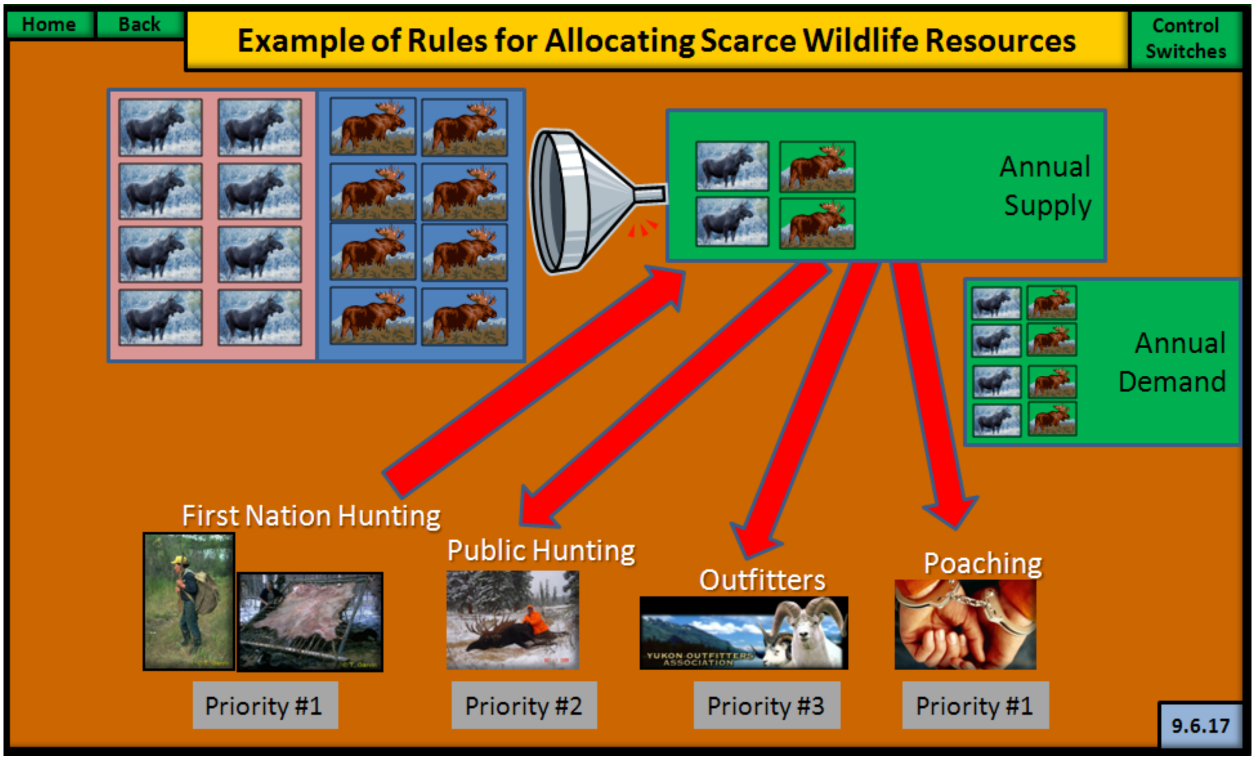

Figure 58. Example of Rules for Allocating Scarce Wildlife Resources

Appendix C. Summary of industrial projects (bitumen extraction) in the Moose Lake area buffer zones

Brief summary of the Dover Commercial Project (Phases 1-5):

- Disturbance footprint: 7,875 ha
- Project life: 65 years
- 250,000 bpd
- SAGD
- 3,000 SAGD well pairs, 525 well pads
- 2 Central Processing facilities
- No future planned expansions

There are three study areas for establishing “potential buffers” that were each geographically centered around the Fort McKay reserves (Namur River 174A and 174b) in the Moose Lake area. The three study areas were (Figure 13, Figure 14, Figure 15):

1. Namur River 174A and 174B reserves and Moose and Buffalo Lakes, without any adjoining buffer
2. #1 and 20 km “no go” industry buffer from the reserves boundary
3. #2 and 20 km “intensive management buffer”

Each of the 5 phases of the Dover project will have a production capability of 50 000 bpd (Dover 2010, Volume 1, p.1-7). We evaluated what portion of the proposed Dover project is located in the buffer zones, shown in Table 1.

Table 1. Details on the Dover project phases located in each of the buffer zones.

Study Area	Phase 1	Phase 2	Phase 3	Phase 4	Phase 5
1 **(reserves and lakes)**	Not impacted	Not impacted	Not impacted.	Not impacted.	Not impacted.
2 **(20 km "no-go" buffer)**	Phase 1 and one Phase 1 borrow pit are located within the buffer. Numerous phase 1 borrow pits are located outside of the study area. Dover North plant is within buffer.	Phase 2 is entirely w the buffer. Dover North Plant w buffer.	Not impacted.	Not impacted.	Not impacted.
3 **(20 km intensive management buffer)**	Numerous phase 1 borrow pits within the buffer	Not impacted.	Entirely within the buffer; Dover South Plant is within the buffer.	Entirely within the buffer; Dover South Plant is within the buffer.	Entirely within the buffer; Dover South Plant is within the buffer.

Notes:

1. This information is based on (Dover 2011, Dover Commercial Project, Project Update, Figure U1 2.0-1).

3. The majority of the project footprint is listed as "Production Support" or "Production Support Borrow Pit" (Dover 2011, Figure U1 2.0-1) and is not associated with any particular phase of the Dover project.

4. Each phase is 50,000 bpd.

5. Phase 1 and 2 are associated with the Dover North Plant and Phase 3-5 are associated with the Dover South Plant (Dover 2010, Volume 1, p.1-7).

***The Dover North Plant falls outside the buffers.

Other In-situ projects within the Buffalo and Moose Lake Buffer Zones

Other projects, in addition to the Dover Commercial Project, are located within the buffer zones. These projects are shown in Table 2.

Table 2. Location of currently approved projects in each Moose Lake buffer zone.

Project	20 km "No go zone"	20 km-40 km intensive management buffer
Dover Commercial	X (approx. 1/3)	X (approx. ½)
Leduc TAGD Pilot Project		X (all)
VCI/BP Terre de Grace		X (all)
CNRL Horizon	X	X (approx. 1/3)
Sunshine Legend Lake	X (majority)	X (small portion)
Sunshine Oilsands West Ells	X (small portion)	X (majority)
Total Joslyn North Mine		X (small portion)

Brief summaries of these projects are provided below:

Leduc TAGD Pilot project (Phase 1 and 2)

- Planned project - application has been submitted and is under review by ERCB & ESRD
- Disturbance footprint: 68 ha
- Project life: 20 years
- 6,000 bpd
- TAGD
- 85 horizontal wells, 22 observation wells, 2 TAGD well pads, 1 contingency well pad, 6 observation well pads
- 1 Central Processing facility
- No planned expansion

VCI/BP Terre de Grace (Initial and Future development)

- **Approved project - but construction has not started. VCI/BP indicates that development timing will confirmed over the next few years.**
- Disturbance footprint: 672 ha (401 ha initial development, 271 future development)
- Project life: 25 years
- 10,000 bpd
- SAGD
- 65 SAGD well pairs, 14 well pads
- 2 Central Processing facilities
- No expansions planned currently, however, BP/VCI are exploring future potential but have not announced specific expansion plans (Government of Alberta 2013).

CNRL Horizon (Phase 1)

- **Existing operating project**
- Disturbance footprint: 8,484.5 ha
- Project life: 41 years (including expansions)
- 110,000 bpd of synthetic crude
- Surface mine
- Expansions planned with ultimate capacity of 275,000 bpd (Government of Alberta 2013).

Sunshine Legend Lake

- **Planned project – application has been submitted and is under review by ERCB and ESRD.**
- Disturbance footprint: 240.3 ha
- Project life: 50 years

- 10, 000 bpd
- SAGD
- 184 SAGD well pairs, 23 well pads,
- 1 Central Processing Facility
- Access: planned access is via the Dover Road and then a 22 km high-grade gravel road off of the Dover Road. Sunshine it indicates that is plans for the road to be a multi-stakeholder road. Sunshine has not yet submitted an application for the 22 km road..
- Expansions planned with ultimate capacity of 50,000 bpd (Government of Alberta 2013).

Sunshine Oilsands West Ells (Phase 1 and 2)

- Approved and under construction.
- Disturbance footprint: 128.5 ha Phase 1, additional undisclosed disturbance are for Phase 2
- Project life: 25 years (End of production approximately 2037)
- 10, 000 bpd
- SAGD
- 73 SAGD well pairs, 9 well pads
- 1 Central Processing Facility
- Expansions planned with ultimate capacity of 100,000 bpd (Government of Alberta 2013).

Total Joslyn North Mine

- Approved and under construction
- Disturbance footprint: 6,980 ha
- Project life: 20 years mining plus reclamation
- 100,000 bpd
- surface mine
- No expansions currently planned (Government of Alberta 2013).

References

Dover Operating Company (OPCO). December 2010. Dover Commercial Project.

Dover Operating Company (OPCO). 2011. "Dover Commercial Project, Project Update and Supplemental Information Request Responses." AENV #001-268285; ERCB #1673682, Calgary.

Government of Alberta. 2013. Alberta Oil Sands Industry Quarterly Update Winter 2013. http://albertacanada.com/files/albertacanada/AOSID_QuarterlyUpdate_Winter2013.pdf.

Appendix D. General Chronology of Moose Management Strategies in the region.

Kindly provided by Blair Rippin, retired, who as Government of Alberta wildlife biologist, worked extensively on moose management issues in northeast Alberta for several decades.

Below are a few comments from Blair Rippin that assist the reader in understanding some of the changes to moose management regulations during the past decades.

- Up until the late 1960s, Game Licenses allowed hunters to harvest one of several big game species.
- Separate moose licenses were first required in 1968 with the introduction of the General Moose License for residents. From 1968 to 1999 a variety of special moose licenses were available to residents.
- From 1968-1971 and 1973-1977 residents could obtain a Big Game Zone 1 Moose License in addition to a General Moose License. In 1970 and 1971, a Moose-Elk-Deer (MED) license allowed resident hunters to harvest either a moose, an elk, a white-tailed deer or a mule deer.
- During 1985- 1989, the Northern Antlerless Moose (NAM) was available to residents, which allowed harvest of one antlerless moose during a three-day season in October. In 1985 to 1987, the NAM License applied to BGZs 1, 2, and 3; during 1988 to 1989, it applied only to BGZ1."
- Beginning in 1980, male and female moose authorizations (limited entry draw) were used to regulate the harvest in all moose ranges south of Calgary, and in fringe agricultural areas south and east of Edmonton.
- Authorizations were used extensively from 1980 to 1991.
- In 1985, the authorization system in northern and west-central regions was replaced by a short three-day female season (Northern Antlerless Moose license or NAM). However, the authorization system was reinstated in west-central Alberta (BGZs 2 & 3) in 1988. In 1991 a special license draw for residents was available to hunters who wanted to hunt antlered moose in west-central Alberta during the rut. From 1991 to 1995, the special license, which limited the hunter to harvest a moose of specified sex of age (calf or adult) in a specified WMU, gradually replaced the authorization and in 1996 it was completely phased out.