Status and management of moose (Alces alces) in Saskatchewan

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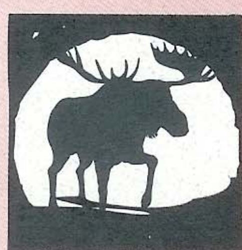

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Status and Management of Moose *(Alces alces)* in Saskatchewan

Fish and Wildlife Technical Report 00 - 1

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Executive Summary

The purpose of this report was to develop long-term population objectives and strategies which promote moose conservation, and to establish a biological basis for future moose population management using the best available science and information. This report attempts to place moose population management within the broader context of ecosystem management, maintenance of biological diversity, integrated and sustainable use of wildlife, and within SERM's corporate mandate, policy framework and legal obligations.

This report reviews existing moose population density and structure data, moose distribution, allocation, and population management in Saskatchewan. In Saskatchewan, 69% of moose occupy the mid-boreal upland and boreal transition ecoregions of the boreal plain ecozone, 29% of moose occupy ecoregions to the north of the boreal plain ecozone, and the remaining 2% consist of island moose populations in the prairie ecozone. Moose Management Units (MMU) were set up on the basis of population distribution with using Wildlife Management Zones (WMZ) which share similar ecological and geographic characteristics. Effort was made to place moose management within the context of provincial objectives of ecosystem management and maintenance of biological diversity by stressing the need to ensure that moose populations do not exceed natural levels of abundance in the habitats they occupy. Moose population management is challenged with ensuring conservation of moose where moose and their habitats are impacted by human activity.

Under current management, Saskatchewan moose populations are stable in most areas of their occurrence, but have declined in some areas. Current (1999/00 winter) populations in Saskatchewan are estimated to total 45,516 moose.   Long-term population objectives are presented for conservation of moose on an area-specific (MMU) basis, to attain a long-term provincial winter population objective of 50,265 $\pm$10%. These objectives are intended to conserve moose populations in their respective MMUs, at their long term average population density and structure. Range expansion and/or population increase should not be at the expense of other naturally occurring wildlife species. Systematically collected moose population density, herd structure (adult sex ratio/calf recruitment), and mortality (with respect to subsistence and licensed harvest, and predation) data are required. Population surveys, evaluation and research needs are identified. Monitoring programs must be improved to systematically quantify and evaluate progress towards long-term population objectives at the MMU level.

Recommendations are presented to guide development of an allocation strategy, and to encourage integrated and sustainable consumptive (subsistence, recreational, commercial) and non-consumptive uses of moose and the habitats they occupy. Management to obtain area-specific optimum moose populations over the long term will maximize consumptive and non-consumptive opportunities for Saskatchewan residents. Once conservation needs are met, subsistence and licensed hunting opportunities will depend on what is appropriate for sustainable consumptive use. Commercial opportunities in guiding-outfitting of moose for consumptive and non-consumptive users are available, and could increase once subsistence and licensed hunting demand is met.

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1.0 Introduction

The purpose of this report was to develop long-term population objectives and management strategies which promote conservation of moose, and to establish a biological basis for future moose population management using the best available science and information. This report provides a review of the scientific literature and research studies, summary and analysis of existing provincial moose population and allocation data, identification and distribution of moose populations on an area specific basis, and long-term population objectives for conservation of those populations on the basis of their ecological importance.

This report attempts to place moose population management within the broader context of provincial objectives of ecosystem management, maintenance of biological diversity, and integrated, sustainable use of wildlife. This was accomplished by:

- Focussing on long-term population management with the objective moose conservation without negatively affecting the ecological integrity and biological diversity of the habitats moose occupy (ie. conservation issues), while ensuring Treaty Indian subsistence rights (through direct Treaty Indian involvement in moose management), and optimizing recreational opportunities where possible.
- Improving the scientific knowledge of moose and their ecological requirements by reviewing the scientific literature, and population data for moose in Saskatchewan.
- Integrating scientific, traditional and social knowledge of moose with economics and social goals.
- Developing long term moose population objectives and management strategies within the ecological framework presented by Acton el al. (1998), and within SERM's policy framework, corporate mandate, and legal obligations.
- Using the best available scientific and traditional knowledge as a foundation for decision-making.

The problem confronting moose management within the broader context of ecosystem management and sustainable use of wildlife is how to balance the needs of managing moose within a broader level multi-resource management system with competing interests and tradeoffs.

1.1 General Description

1.1.1 Taxonomy

The name "moose" originates from one or more Aboriginal languages, which refer to "eater of twigs". Moose in Europe are referred to as European elk. Moose are members of the order Artiodactyla (cloven-hoofed ruminants) and family Cervidae (deer family). The paraxonic foot structure is diagnostic of the order (ie. the plane of symmetry passes between digits three and four). The third and fourth digits bare the animal's weight, the first digit is missing in living members, and the second and fifth digits (dew claws) are reduced in size (Vaughan 1985). Recognized characteristics of North American Cervidae include annually shed antlers (males only and female caribou), four chambered stomachs, and ruminant metabolism (Bryant and Maser 1982, Vaughan 1985). The genus *(Alces)* and species *(alces)* were described by Gray in 1921.

Four of the 7 recognized subspecies of moose occur in North America (Bubenik 1998). Only *A.a. andersoni* (northwestern moose) is native to Saskatchewan. Other North American subspecies include: *A.a. shirasi* (Shira's or Yellowstone moose), A.a. *americana* (eastern or taiga moose), *A.a. gigas* (Alaskan/Yukon or Tundra moose). The taxonomy of North American moose subspecies is not definitive, and some changes may occur (Bubenik 1998).

1.1.2 Physical Description

Moose are the largest member of Cervidae. Moose body size increases with latitude. Adult moose range in size from 1.95 - 2.25 m shoulder height, 2.06 - 2.79 m body length, and 315 - 635 kg in weight. Adult females are about 20% smaller than males (Banfield 1974, Whitaker 1996). Moose gain weight their entire life, although very little gain occurs after 4 years of age for females and 9 years of age for males (Schwartz 1998). Seasonal fluctuations in adult body weight are about 7% for females and 10-20% for males (Jordan et al. 1970, Verme 1971). Newborn calf weight varies from 11-16 kg (Whitaker 1996). Calves enter winter at about 33% of adult weight, and yearlings are 50% of adult weight. Moose calves gain weight (0.50 - 2.25 kg/day) faster than any other North American big game species.

Newborn calves are light red to reddish brown with shades varying from grey to black on the lower abdomen, chest and legs (Franzmann 1978, Whitaker 1996). Newborn pelage is replace by a darker coat with a similar pattern of shading after about 3 months. Adult winter pelage is characterized by long, dark brown hair, although colour may range from almost black to red-brown or grey- brown. This winter coat is replaced in spring by a new coat of short, fine, dark brown to black hair. Guard hairs grow out during the summer and may attain a length of 25 cm on the shoulder hump (Franzmann 1978). An undercoat of fine greyish wool develops in the fall to provide insulation for the winter months (Franzmann 1978).

External anatomy is characterized by high humped shoulders, long slender legs, an inconspicuous tail, pendulous muzzle, large dewlap (bell) under the chin, and large ears (Whitaker 1996). The function of the dewlap is not known. Vision is poorly developed but senses of smell and hearing are acute (Nowak 1999).

The stomach has four compartments consisting of a rumen, reticulum, omasum and abomasum (Renecker and Schwartz 1998), and the gall bladder is missing (Banfield 1974). Dentition is characterized by absence of upper incisors, lower central incisors larger than the outer ones, cisiform lower canines in the frontal row followed by a gap before the brachyodont premolar and molars (Banfield 1974, Vaughan 1985). The dental formula is $I^0/_3\ C^0/_1\ P^3/_3\ M^3/_3$ (X 2 sides) = 32.

Males grow a new set of large palmate antlers annually. Antler characteristics reflect age and nutritional condition. Antler growth (initiated in late May) is under the control of testicular and pituitary hormones, and is stimulated by pituitary response to increasing photoperiod (Schwartz 1992, Vaughan 1986). Growing antlers are covered by velvet consisting of fur-covered skin attenuated with nervous and vascular tissue. Antler growth is related to age, with older males initiating growth before younger bulls (Bubenik 1998, Hauge and Keith 1981, Schwartz 1992). Antler growth may last 60-160 days (140 days in prime males) (Bubenik 1998). Antlers on mature bulls can grow 1.9 cm/day, with main beams reaching 150 cm (North American record is 206 cm) in spread by August (Bubenik 1998, Whitaker 1986). Once the velvet is shed, androgen maintains the connection of dead antler bone to the frontal bones of the skull during fall. The shorter winter photoperiod results in lower androgen production and subsequent antler shed by mature males ($\geq$5 years of age) usually in December. Younger bulls (ages 2 - 4 years) do not carry fully developed antlers and may retain their antlers as late as March (Bubenik 1998).

1.1.3 Distribution

Moose evolved in Eurasia and entered America by way of the Bering land bridge at least 100,000 years ago during the Pleistocene (Mikko and Andersson 1995). Moose distribution is closely associated with the spruce/fir/pine dominated circumpolar boreal forest of the northern hemisphere, where fire and logging activities are major influences on vegetative communities (Karns 1998). Moose have been well established across the northern 2/3 of the Prairie Provinces for thousands of years, but their distribution has been very dynamic in recent years in many parts of their North American range (Karns 1998).

The present distribution of moose in Saskatchewan is presented in Figure 1. Primary ranges (Figure 1) consist of high quality suitable habitats that traditionally, or potentially, can support higher moose population densities. Secondary ranges (Figure 1) cannot support high moose population densities because of intensive agriculture (farming, livestock production, etc.), settlement, greater ambient temperature in the south, habitat fragmentation, lower quality habitat (food and/or cover limited), and/or increased access. Primary moose range occurs in the mid-boreal lowland, mid-boreal upland and boreal transition ecoregions of the boreal plain ecozone. It encompasses 27% of total moose range and contains approximately 69% of the provincial moose population (Figure 1). The ecoregions to the north of the boreal plain ecozone are less productive, encompass 66% of total moose range, and contain approximately 29% of the provincial moose population (Figure 1). The remaining 6% of moose range and 2% of the provincial moose population are located in islands of isolated habitat in the aspen parkland, moist mixed grassland, mixed grassland and Cypress upland ecoregions of the prairie ecozone (Figure 1).

1.2 Habitat Selection

There is no professional value in assuming that moose (or other early successional wildlife species) populations will benefit from current timber management simply because they have in the past (Keppie 1995). Within an “ecosystem management” context, wildlife management could theoretically influence timber management planning by quantitatively incorporating wildlife (including moose) habitat attributes

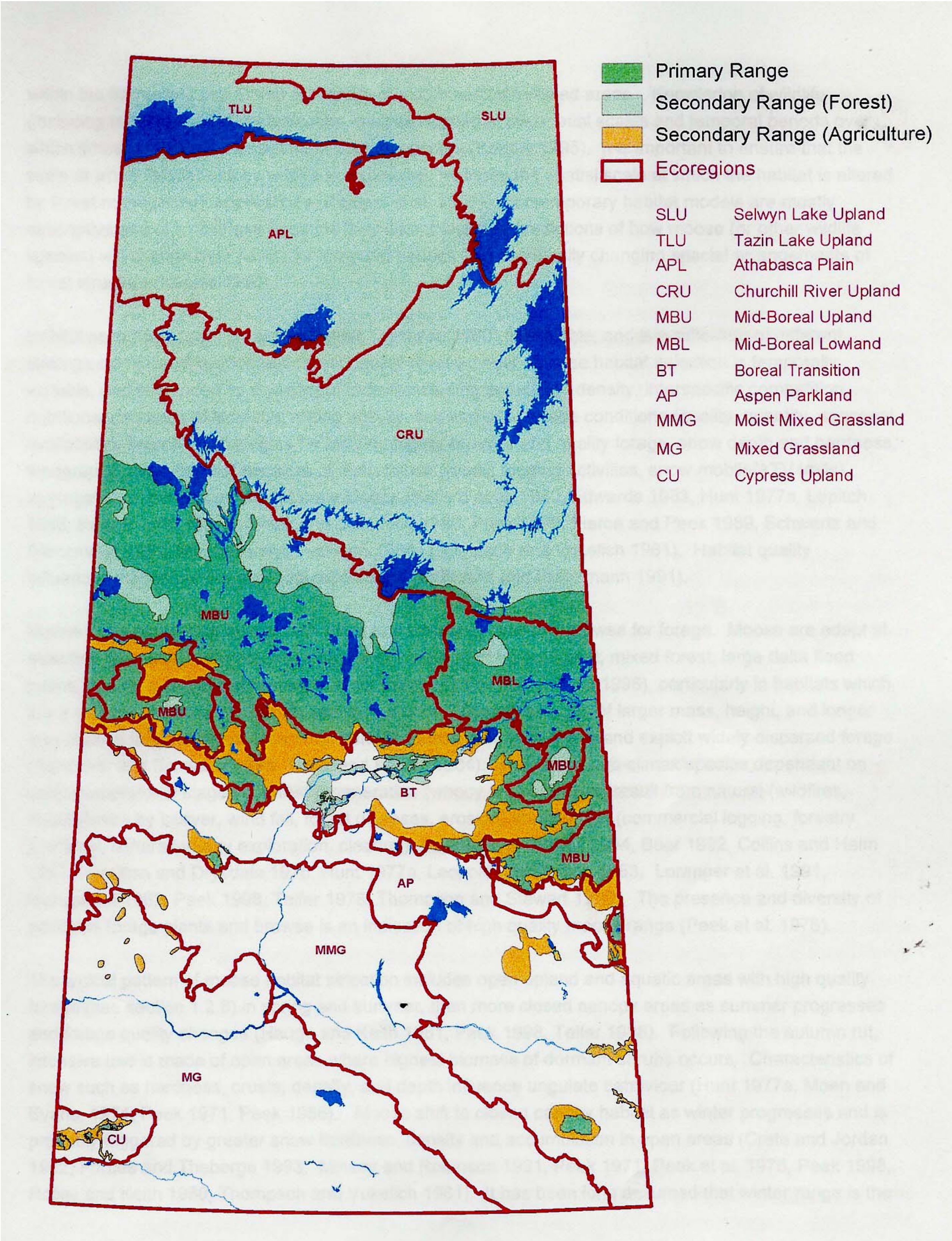

Figure 1. Current distribution of moose in Saskatchewan, 2000.

within the framework that timber is managed in commercial forested areas. Knowledge of wildlife (including moose) habitat use/selection must be applied at the spatial scales and temporal periods over which timber and forest management planning occurs (Keppie 1995). It is important to ensure that the scale at which habitat use by wildlife is measured, matches the spatial scale at which the habitat is altered by forest management applications (Rempel et al. 1997). Contemporary habitat models are mostly descriptive and of limited use because they do not facilitate predictions of how moose (or other wildlife species) will change over particular temporal periods and continually changing spatial arrangements of forest structure (Keppie 1995).

Habitat selection occurs on several levels (Johnson 1980), is variable, and is a reflection of different strategies employed by moose to meet habitat requirements. Moose habitat selection is temporally variable, and influenced by a variety of factors including population density, interspecific competition, nutritional demands of lactation, rutting activity, sex and age, forage conditions (quality, quantity, seasonal availability), searching strategies for locating higher quantity and quality forage, snow depth and hardness, topography, displacement because of disturbance (roads, logging activities, snow mobile/ATV trails), aggregation patterns, and predator avoidance (Ballard et al. 1980, Edwards 1983, Hunt 1977a, Lepitch 1986, Kelsall 1969, Mastenbrook and Cumming 1989, Peek 1998, Pierce and Peek 1989, Schwartz and Franzmann 1991, Stephens and Peterson 1984, Thompson and Vukelich 1981). Habitat quality influences moose density and population trend (Schwartz and Franzmann 1991).

Moose are a pioneering animal and adapt to a variety of available browse for forage. Moose are adept at selecting seasonally advantageous habitats consisting of boreal forest, mixed forest, large delta flood plains, tundra, sub-alpine shrub and stream valleys (Telfer 1984, Peek 1998), particularly in habitats which are a mixture of willow, spruce, fir, aspen and birch. The advantages of larger mass, height, and longer legs relative to other boreal browsers, permits moose to remain active and exploit widely dispersed forage (Renecker and Schwartz 1998, Telfer and Kelsall 1984). They are a sub-climax species dependant on early successional stages of forest regeneration (woody browse) which result from natural (wildfires, manipulation by beaver, wind fall, forest diseases, erosion) and artificial (commercial logging, forestry practices, mineral/energy exploration, clearing) disturbances (Attiwill 1994, Boer 1992, Collins and Helm 1997, Hamilton and Drysdale 1975, Hunt 1977a, Leopold and Darling 1953, Loranger et al. 1991, Maliepaard 1962, Peek 1998, Telfer 1978, Thompson and Stewart 1998). The presence and diversity of palatable forage plants and browse is an indication of high quality moose range (Peek et al. 1976).

The typical pattern of moose habitat selection includes open upland and aquatic areas with high quality forage (see section 1.2.8) in spring and summer, then more closed canopy areas as summer progresses and forage quality changes (Hauge and Keith 1981, Peek 1998, Telfer 1988). Following the autumn rut, intensive use is made of open areas where highest biomass of dormant shrubs occurs. Characteristics of snow such as hardness, crusts, density, and depth influence ungulate behaviour (Hunt 1977a, Moen and Evans, 1971, Peek 1971, Peek 1986). Moose shift to closed canopy habitat as winter progresses and is probably triggered by greater snow hardness, density and accumulation in open areas (Crete and Jordan 1982, Forbes and Theberge 1993, Minzey and Robinson 1991, Peek 1971, Peek et al. 1976, Peek 1998, Rolley and Keith 1980, Thompson and Vukelich 1981). It has been long assumed that winter range is the most critical to ungulates (Schwartz et al. 1988). Physical condition of animals can be influenced through habitat enhancement of summer and winter ranges (Schwartz et al. 1988).

1.2.1 Snow

Standing chest heights, body mass, and hoof loads vary by age, sex, and species, and indicate the ability of each to cope with varied depths and density of snow packs (Kelsall 1971), as well as influence foraging strategies and energetics (Cederlund et al. 1991). Moose movements begin to be impeded by snow depths of 60-70 cm, with significant limitations at 90-100 cm (Brusnyk and Gilbert 1983, Coady 1974, Kelsall 1969, Kelsall and Prescott 1971, Racy and Racy 1991, Renecker and Schwartz 1998, Telfer 1970, Thompson and Vukelich 1981).

1.2.2 Temperature

How moose spend their time is strongly influenced by the thermal environment (Renecker and Hudson 1992a, Renecker and Schwartz 1998). Ambient temperatures above 5°C in winter and 14°C in summer can be stressful and discomforting for moose (Renecker and Hudson 1986, Renecker and Hudson 1989). Moose will suppress feeding activity during winter when temperatures become warm (Renecker and Schwartz 1998). Moose calves must produce additional heat when temperatures drop below -30°C (Schwartz and Renecker 1998).

1.2.3 Water

Riparian habitat, wet meadows, lakes and wetlands provide water, high quality forage, insect relief, and/or thermoregulation from spring through autumn (Peek 1998, Peek et al. 1976). Where fire suppression and artificial disturbances are lacking or minimal, thereby reducing frequency and extent of forest rejuvenation, the influence of rivers and streams on forest vegetation and wildlife habitats are of increased importance to early successional wildlife (Collins and Helm 1997, Kelsall et al. 1977, Koehler and Brittell 1990, Peek et al. 1976). Flood plains and early succession low-lying uplands are important to moose in mature forest ecosystems (Collins and Helm 1997).

1.2.4 Cover

Cover requirements for moose are poorly understood. Cover is used by moose for resting, travelling, and hiding, but requirements vary in relation to feeding habitat, snow cover, wind, temperature, and reproduction. Moist lowland habitat is important during the fall rut. Following the rut, moose prefer open habitats with high quality and quantities of forage. As snow accumulates over winter, moose shift into closed canopy stands where snow depth is less (Allen et al. 1991, Crete and Jordan 1982, Eastman 1974, Hundertmark et al. 1990, Peek 1971, Peek et al. 1976, Phillips et al. 1973, Pierce and Peek 1984, Rolley 1982, Rolley and Keith 1980, Stevens 1970, Telfer 1970, Thompson and Vukelich 1981).

Moose winter cover preference is for shelter rather than for browse (Phillips et al. 1973). Moose avoid using the centres of large clear-cuts and burns, but will make use of residual timber along the edges, and will primarily forage in clear-cuts and burns within 100 m from the edge of cover (Allen et al. 1991, Bangs et al. 1985, Neu et al. 1974). Trees and topography provide thermal and hiding cover, movement corridors, and browse. Moose prefer disturbed areas offering a wide variety of interspersed stand types and age classes, which provide both mature confers for thermal and hiding cover and open disturbed areas for foraging (Hamilton and Drysdale 1975).

Optimal thermal and hiding cover is provided by tall dense forest stands of conifers, or mixed-wood and deciduous stands with a well developed understory (McNicol and Gilbert 1978, Minzey and Robinson 1991). Wintering habitat in multi-layered conifer-dominated boreal forest of southern Quebec was characterised as 40-80% closed canopy with heights of 9 - 18 m, interspersed with young stands of rich browse (Proulx 1983). Allen et al.(1991) characterised high quality winter habitat as stands of mixed species composition that contain a multi-layered canopy of balsam fir and/or spruce associated with aspen and paper birch.

Thermal cover is important for maintaining an energy balance between fixed body temperature demand and extremes in ambient temperature (Collins and Helm 1997, Renecker and Hudson 1992a, Schwab and Pitt 1991, Telfer 1988). Moose cannot tolerate hot climates that exceed 27°C for long periods without shade and access to lakes and rivers (Kelsall and Telfer 1974).

Prior to parturition, cows seek secluded areas, frequently using islands and peninsulas (Leptich 1986). Cows with calves select denser cover (hiding cover) with substantial amounts of forage and are more secretive than other age groups (Peek 1998, Thompson and Vukelich 1981). This is likely a predator avoidance strategy to increase the probability of calf survival (Miquelle et al. 1992).

1.2.5 Cut-overs

Commercial timber harvesting produces widespread changes in successional plant communities, and is an important variable affecting the abundance and distribution of moose and other cervids (Monthey 1984). Moose density has been shown to increase following habitat disturbance by logging (Forbes and Theberge 1993), but this depends on juxtaposition of moose available to colonize, and on severity of the habitat disturbance (Rempel et al. 1997). Historical forest cutting practices (since the 1960s) and large scale forest fires, in the boreal plain ecozone of Saskatchewan, have had a strong influence on enhancing population growth and distribution of moose because of substantial production of high quality and quantity of browse. Logging, if accomplished in time, place, and with sensitivity to conform with moose habitat needs, can create the plant community diversity that is afforded by wildfire (Keppie 1995, Peek 1998).

Clear-cuts are beneficial, provided sufficient cover is maintained by leaving an interspersion of uncut areas (Hundertmark et al. 1990), or 100-200 m wide corridors of uncut timber (Mastenbrook and Cummings 1989) to produce more edge within the clear-cut for browsing and thermal/escape cover (Peterson and Peterson 1992). Clear-cuts established with irregular boundaries that blend with contours and landscape features would benefit moose (Peterson and Peterson 1992). The value of clear-cuts as moose foraging areas decreases with increased snow depth (Hundertmark et al. 1990, Monthey 1984, Thompson and Euler 1987).

Moose prefer smaller clear-cuts (≤65 ha) to larger ones (MacLennan 1975, McNichol 1976, Telfer 1974). Clear-cuts larger that this would not likely be used by moose until the stand has grown sufficiently (10-15 years) to provide shelter. In Saskatchewan, softwood clear-cuts were traditionally limited to 40 ha and hardwood clear-cuts are limited to 120 ha (Peterson and Peterson 1992). Browse production was higher in aspen cut-overs than in spruce cut-overs, with peak browse production generally occurring in 5-10 yr old aspen cut-overs (Hunt 1977b). Regrowth of adequate winter shelter in spruce-dominated forests began only 20-25 years after logging (Stelfox 1981). Use of clear-cuts is greatest within 100 m of the edge of coniferous cover (Hamilton and Drysdale 1975, MacLennan 1975, McNichol 1976). Some jurisdictions (including Saskatchewan) use an operational guidelines approach to integrating wildlife requirements with habitat modification (logging) to regulate cut block size and configuration to achieve desired landscape patterns (Thompson and Stewart 1998). This approach does not guarantee long-term retention of sufficient habitat to maintain the affected wildlife populations. Other jurisdictions adjust operational cutting plans to obtain specific habitat objectives.

Moose populations in Saskatchewan are limited by access created primarily by the proliferation of logging roads. Consequently, stand -type management using a regressive logging pattern (ie. in a particular area, harvest furthest away stands first and work back to the nearest, with reforestation as logging progresses) would result in larger cut-over size but minimize long term access. This would benefit the conservation of moose provided some blocks of habitat are retained within the cut-over to provide thermal and hiding cover for moose. A feather-cut logging pattern would also benefit both moose and elk by providing an interspersion of naturally regenerating forage and thermal/hiding cover.

Shoreline reserves around lakes and along streams can function as important wintering habitat provided they offer sufficient thermal cover and adjacent to browse along the edge of the thermal cover (Brusnyk and Gilbert 1983). When snow cover restricts moose movement in cut-overs, uses of edge by moose in reserve stands facilitate browsing adjacent to dense coniferous canopy (Brusynyk and Gilbert 1983).

Silvicultural practices impact the suitability of habitat for wildlife (Racey and Racey 1991, Schwab et al. 1987). The value of conifer plantations following clear-cutting is a function of conifer species, tree density and height, and their subsequent ability to intercept snow and provide thermal cover for ungulates. Most conifer species at 6 m height and 1.8 - 2 m spacing probably provide sufficient snow interception (Racey and Racey 1991) and adequate winter cover for moose provided sufficient quality forage is available proximate to the cover. The spatial arrangement of forage has a strong effect on time spent foraging and the energy expended for locomotion (Risenhoover 1986). Proximity of cover to adequate browse determines habitat quality.

1.2.6 Fires

Fires create high quality forage sources that are best used by populations capable of rapidly colonizing post-fire habitats (Peek 1998). Moose density has been shown to increase following habitat disturbance by fire (Peek 1974, Rempel et al. 1997, Schwartz and Franzmann 1989, Schwartz and Franzmann 1991), but this depends on juxtaposition of moose available to colonize, and on severity of the habitat disturbance (Gasaway et al. 1989, Loranger et al. 1991, Rempel et al. 1997). Optimum successional stages used by moose in boreal forest were 11 - 30 years post-burn (Kelsall et al.1977, Schwartz and Franzman 1989). Research indicates individual prescribed burns to improve moose habitat should be no larger than 20 ha in dense cover and should be less in open forest areas, but this also depends on the amount of natural openings (Gordon 1976). Prescribed burning should be done in spring as soon as the area will carry a fire (Peterson and Peterson 1992).

In the Weyerhaeuser FMLA, the fire cycle before 1900 was 30 - 50 years. The policy of fire suppression begun in the 1940s has protracted the fire cycle to 205 years, with the majority of fires being ≤10 ha (<0.3% of FMLA area burned) and <2% of fires >1000 ha in area (responsible for 93% of area burned in the FMLA). As a consequence of fire suppression policy, the average age of forest stands in the FMLA is greater now than it would have been prior to the 1900s.

1.2.7 Roads

Control of human access and disturbance is often the most practical and important ungulate management tool available. Accessibility is a function of the degree of development and retention of road and trail networks as a result of community development, industry (logging, oil and gas exploration and development, mining, hydro-electric development, trapping), and recreation (hunting, skidooing, wildlife viewing). Controlling road access is more important than manipulating cover and feeding areas for ungulate management and habitat enhancement in the boreal plain ecozone. Most of the roads and trails in the boreal plain ecozone are a result of logging operations. Roads adversely affect wildlife by fragmenting and destroying habitat, interrupting wildlife travel corridors, increasing access and vulnerability to harvest, increasing predator (wolf) access to prey, displacement of wildlife and reduction of potential habitat use as a consequence of road avoidance and noise disturbance, littering, and vehicle-animal collisions. This has significant management implications and emphasizes the need to work with forest companies to control road density and access following logging operations.

Logging concentrates moose into remnant forest stands, while logging roads provide access that increases the speed and effectiveness of search by wolves (Bergerud 1981) and humans (Rempel et al. 1997). Bare road surfaces have no browse value for moose, but browsing activity is often concentrated along road edges due to ease of access (Hamilton and Drysdale 1975). Moose density did not increase in habitat that was modified by clear cutting and where increased hunter access occurred (Rempel et al. 1997). Phillips et al. (1973) found that roads and trails appeared to serve as home range boundaries. Road location is particularly important if it occurs in heavily used riparian habitat. Cover value for ungulates can be increased, and incidence of road hunting decreased by limiting straight stretches of forestry roads to < 0.4 km in length/km² of habitat.

Harvesting strategies that limit road construction and duration of use, coupled with concurrent cut-over reforestation would greatly reduce wildlife access concerns.

1.2.8 Forage/Nutrition

Moose have an energy maximizing feeding strategy whereby they attempt to feed as much as possible within the constraints of thermal stability and rumen capacity (Belovsky 1978, Belovsky and Jordan 1978). Moose are generalist browsers (Peek 1974b, Renecker and Hudson 1986b, Renecker and Schwartz 1998, Saether and Andersen 1990) when forage quality and quantity are high, but as quality declines moose become more selective by maximizing nutrient capture (Renecker and Hudson 1992a). Nutritional requirements of moose vary seasonally, and by sex and age of the animal. Forage quantity and quality varies seasonally and are influenced by distribution, topography, weather, snow cover, successional stage and disturbances (Peek et al. 1976). Food habits may be the result of several levels of selection based on available habitat and seasonal availability, abundance, and quality of preferred forage (Saether and Andersen 1990). Therefore, a basic understanding of moose nutrition is necessary to make appropriate and timely decisions affecting habitat in moose range (Schwartz and Renecker 1998), and to understand the interspecific, intraspecific and environmental dynamics of moose (Peek 1974b). Mechanisms involved in selecting forage and feeding have important implications for habitat management (Thompson and Stewart 1998).

Aspen is a very important browse species. Aspen bark can be a very important food in early spring and becomes highly digestible during the spring nutrient flush, particularly among female moose when movements are restricted by limited mobility of their calves (Chapin 1980, DesMeules 1968, Miquelle and Van Ballenberghe 1989, Renecker and Hudson 1985). Foliage (leaves of deciduous trees and shrubs, forbs and aquatic plants) is the major dietary item following leaf flush (Renecker and Hudson 1992a, Trottier et al. 1983). Winter diets consist of woody browse. Saskatoon (*Amelanchier alnifolia*), willow (*Salix* spp.), red-osier dogwood (*Cornus stolonifera*), beaked hazelnut (*Cornus cornuta*), choke cherry (*Prunus virginiana*), pincherry (*Prunus pensylvanica*), white birch (*Betula* spp.), aspen *(Populus tremuloides*) and balsam poplar *(Populus balsamifera)* are the most common fall and winter browse species used (Knowlton 1960, Kowal 1977, Stevens 1970, Stewart 1977, Trottier et al. 1983).

Protein (nitrogen) intake is essential for growth of fibre-digesting bacteria (Hobbs et al. 1983), which are necessary for the digestion of carbohydrates and fats. Digestible protein and digestible energy are important to moose fitness (Schwartz and Renecker 1998, Wallmo et al. 1977). Plants growing in shade tend to have a higher protein and water content and are more palatable than the same species growing in sunlight (Hjeljord et al. 1990). Aquatic plants provide a high protein content as well as a source of concentrated sodium needed by moose to compensate for a sodium deficit incurred during winter, and because of high potassium uptake from green vegetation during spring and summer (Jordan 1987, Jordan et al. 1973, Schwartz et al. 1987). Moose seek habitats during spring and summer where their high protein requirements can be rapidly met (Belovsky 1978) for milk production and antler growth requirements. Crude protein and nutritional quality decreases with increasing age of browse, and is greater in summer than winter (Peek 1971, Risenhoover 1989, Schwartz and Renecker 1998). Therefore, when food becomes scarce and/or of poor quality, moose are restricted by the high fibre content of the forage and the need to ruminate (Renecker and Hudson 1989b). The minimum daily protein requirement for winter maintenance in adult moose is 5 - 7% (Schwartz and Renecker 1998), and a 12.7% crude protein content resulted in mean body weights of captive moose greater than that for wild moose (Schwartz et al. 1985).

Cervid browse produced in mature forests provides greater nutritional value (tannin levels were lower and crude protein levels were higher) compared to clear-cuts, therefore, retention of old growth forest within the habitat mosaic of managed forests provides better year-round forage habitat (Happe et al. 1990). Moose produce specific salivary proteins to combine with, and precipitate tannins in their principal foods of willow, aspen and birch (Hagerman and Robbins 1992). However, winter forage quality rapidly deteriorates through forest succession, necessitating the need for early successional stages in the habitat mosaic for high quality winter foraging areas. Early successional stages resulting from clear-cuts and fires provide large amounts of forage and are preferred feeding areas in all seasons except fall and early winter (Hunt 1977a, Peterson and Peterson 1992, Saether and Andersen 1990, Singer 1979). Moose density declines after browse grows out of reach, which is about 2.4 m high (Peterson and Peterson 1992). Telfer and Cairns (1978) reported that moose will break saplings (mainly <5 cm dbh) to access browse that would otherwise be beyond reach.

Copper (Cu) is an essential trace element required by moose. Copper deficiencies result in decreased tensile strength of hair, and faulty hoof keratinization resulting in hoof abnormalities (Schwartz and Renecker 1998). Manganese (Mn) deficiencies result in impaired estrus and conception, weakness and impaired growth, and ataxia of neonate calves. Iron (Fe) deficiencies are associated with anemia, weight loss, listlessness and gastritis in domestic livestock. Moose in Saskatchewan are not known or suspected to be subject to any specific elemental toxicity or deficiency (Stewart and Flynn 1978).

Daily resting and feeding are dictated largely by the cycles of rumen filling and emptying (Renecker and Schwartz 1998). Ruminants exhibiting low digestive efficiency have relatively greater dietary selectivity (Collins and Urness 1983). Ungulate food intake is limited by food passage rate because of the time required for rumination (Joyal and Ricard 1986, Norberg 1977, Pyke et al. 1977, Renecker and Hudson 1992b, Saether and Andersen 1990, Schoener 1971). Both quantity and quality of food influence time-energy budgets, habitat selection and the pattern of food exploitation by moose (Belovsky 1978, Saether and Andersen 1990, White 1983). A moose must accumulate enough energy (fat reserves) from a high quality summer diet to maintain itself through the winter (Schwartz et al. 1988, Stewart et al. 1977, Van Ballenberghe and Miquelle 1990). The annual cycle of metabolic rate in moose coincides with cycles in forage quality, food intake and body weight (Regelin et al. 1985, Schwartz et al. 1984). The lowest metabolic rate in late winter coincides with the lowest level of activity, lowest body weight and lowest food intake at a time when forage quality is at its lowest (Bevins et al. 1990, Reglin et al. 1985). Smaller bodied ungulates are thought to require greater concentrations of digestible energy in their diets than larger animals (Hobbs et al. 1983) because of larger surface to volume ratios. Moose eat approximately 2.6 - 3.5% of their body weight/day in dry matter during summer, and 0.5 - 1.3% during winter months (Schwartz et al. 1984, Renecker and Hudson 1986a). Intake of digestible energy to meet maintenance requirements is 148 -179 Kcal/kg $BW^{0.75}$/day for free ranging moose (Renecker and Hudson 1985, Schwartz et al. 1988, Schwartz and Renecker 1998).

1.3 Population and Community Ecology

1.3.1 Annual Movements

Hauge and Keith (1981) documented most range shifts in northeast Alberta to vary from an average of 6 to 20 km, and were attributed to movements between summer and winter ranges. Phillips et al. (1973) documented migrational shifts of 14 - 34 km in Minnesota. Hauge and Keith (1981) also noted considerable individual variation in the timing of the range shifts. Moose movements are more extensive during the rut (Hauge and Keith 1981). Nowak (1999) states that moose migrations reportedly cover up to 179 km in North America, and 300 km in northeastern Europe. In Saskatchewan, snow depth influences movement.

1.3.2 Home Range/Territory

Home range size, location, and use is influenced by many factors including forage conditions (quantity, quality, density, phenology in seral stages of succession), ambient temperature, cover, abundance of insects, difficulty of travel, activities related to breeding and parturition, forage density and phenology, social relationships and population density, and logging or other human disturbances (Hauge and Keith 1981, Phillips et al. 1973). Home range size is inversely related to productivity of foraging habitat. Studies of annual home range size in North America revealed that the size was variable, but averaged 15-25 km^2 (Hauge and Keith 1981, Leptich, 1986, Leptich and Gilbert 1989, Lynch and Morgantini 1984, Mytton and Keith 1981, Phillips et al. 1973, Taylor and Ballard 1979). Cederlund and Okarma (1988) reported summer home ranges to be twice the size of winter home ranges. Moose exhibit strong attachment to home ranges that are traditionally used annually in seasonal environments (Bailey and Franzman 1983, Cederlund and Okarma 1988, Van Ballenberghe and Peek 1971). Annual home ranges overlap with those of other females (Cederlund and Okarma 1988).

1.3.3 Dispersal

Because of their large body size, moose require substantial amounts of forage. Dispersal and density of moose are therefore related to forage abundance and quality, and conspecific competition for food (Renecker and Schwartz 1998). Peek (1998) hypothesized that yearling moose dispersal is a function of attraction to a combination of food and cover in new areas resembling natal home range from which they strayed, or were driven by social pressure or predation.

The common occurrence of fire in boreal forests promotes dispersal of sub-adult moose into newly created habitats (Peek 1998). Long-distance dispersal movements are most common with 1.5 - 2.5 yr old moose (Mytton and Keith 1981). The fidelity females demonstrate towards their home ranges minimizes their role in colonizing new areas through dispersal (Cederlund and Okarma 1988, Cederlund et al. 1987, Gasaway et al. 1980).

1.3.4 Reproduction/Life History

Mating behaviour is well documented (see Bubenik 1998). Breeding strategies vary geographically with open tundra moose forming harems and taiga moose forming breeding pairs (Lent 1974, Schwartz 1992). Moose are seasonally polyestrous, with the peak of the rut occurring within one estrous period in late September (Edwards and Ritcey 1958), or early October (Schwartz 1992, Schwartz and Hundertmark 1993). The first cycle usually occurs in early September, and the days between estrous cycles do not increase with each subsequent cycle. If not bred, cows experience as many as 6 additional estrous cycles during the rut (Schwartz 1992). Edwards and Ritcey (1958) and Schwartz (1992) concluded that 85 - 89% of all reproductively mature females conceived within a 10-day period in their second estrous, with 5% bred before peak rut and 6% impregnated after peak rut.

Conception dates for Saskatchewan moose ranged from Sep. 22 to Oct. 23, with 74% of mature cows (n = 69) bred by October 3 (Killaby et al. 1990). The average date of breeding in Manitoba was September 29, with 93% of cows bred by Oct. 12 (Crichton 1992). Each estrous cycle lasts 22-28 days (mean = 24.2 days), with the cycle being slightly shorter for first time breeding females (23.7 days) than females bred in previous years (24.5 days), and with most females receptive for 15 - 26 hours (Nowak 1999, Schwartz 1992, Schwartz and Hundertmark 1993). The final cycle usually occurs in late November, although it may occur as late as March (Schwartz and Hundertmark 1993). Cessation of the estrous cycle is probably triggered by increasing day-length (Schwartz 1998).

Most cow moose ovulate at 16 or 28 months of age (Schwartz 1992), but this may be delayed in populations on poor range (Albright and Keith 1987), and is variable between populations and years (Boer (1992). Generally, yearling cows are not bred. Females continue to breed until about 18 years of age (Nowak 1999). Their maximum reproductive potential is from 4 - 12 years of age, and maximum output is from 4 - 7 years (Nowak 1999, Saether and Haagenrud 1983, Schwartz and Hundertmark 1993).

Boer (1992) reviewed fecundity of North American moose and found that adult pregnancy rates averaged 84.2% and were relatively constant over a broad geographic range, population densities and winter severities. Prime cows (ie. those most likely to produce twins) breed earlier (Schwartz 1998). Schwartz and Hundertmark (1993) found that first time breeding cows generally produced a single calf (1.07 calves/female) and experienced breeders produced more twins (1.60 calves/cow) and had greater body mass ($\geq$379 kg).

Most cows likely produce a calf (calves) each year, although calf production is lower on poor quality range (Schwartz 1992), or poorer forage (Schwartz et al. 1985) and as a result, moose may not produce offspring in consecutive years (Albright and Keith 1987). Mech et al. (1987) found that the cumulative effects of snow depth summed over 3 consecutive years may influence calf:cow ratios and twinning rates in moose. Crichton (1992) found that there were 66% more female calves conceived before peak rut, and 55% more male calves conceived after peak rut. Schwartz and Hundertmark (1993) found the overall sex ratio of newborn calves was 1:1.05 in favour of females.

A protracted breeding season resulting from a skewed adult sex ratio (few breeding males in the population) can result in shifts in fetal sex ratio favouring males. Shifts in fetal sex ratio favouring males over females can significantly reduce population growth rates for moose (Boer 1992, Reuterwall 1981). Calf gender is not related to maternal body mass, although pregnancy and twinning rates are a function of nutrition. Fecundity is a sensitive indicator of population status with respect to habitat quality (Boer 1992).

Bull moose are capable of breeding as yearlings, but are usually excluded from active breeding by more mature dominant males (Schwartz et al. 1982). Testosterone levels peak in September and rapidly decline following the rut. Prime bulls (ages 5 -12 years) are sexually active before sub-matures ($\leq$4 years of age) and therefore have a greater chance of mating with cows in first estrous (Bubenik 1998). Antler size and display (supplemented by olfactory cues) indicate bull rank and influences cow moose choice of mate (Bubenik 1998).

Gestation lasts an average of 231 days with a range of 216 - 240 days (Cederlund 1987, Nowak 1999, Schwartz 1992, Schwartz and Hundertmark 1993). Cows move to a calving site several days or weeks prior to calving. Islands are frequently chosen. Parturition is short, lasting 15 - 30 minutes (Bogomolova et al. 1992, Bubenik 1998). Calves are born in late May/early June and weigh 11 - 16 kg. Usually a single calf is born although twins are not uncommon and triples have been reported (Hosley and Glaser 1952, Nowak 1999). Twinning rates are positively related to habitat quality, nutrition and climate (Franzmann and Schwartz 1985, Schwartz 1992). Cows remain within 50 m of their offspring for 5-7 days postpartum (Bogomolova et al. 1992), while the calf gains its coordination. Milk intake peaks in June (1.5 - 2.0 l/day) and gradually declines over the next couple of months (Schwartz 1998). By late August, calf diet is primarily solid foods. Average weight gains range from 1.3 - 1.6%/day for the first 150 - 165 days.

1.3.5 Mortality

Maximum known longevity in captivity is 27 years (Peterson 1974). Life expectancy of bulls, in hunted populations is 12 - 15 years, and for cows is 15 - 20 years. The proportion of adults reaching old age is low because of hunting and other mortality factors affecting each age class. Lower life expectancy of bulls is a consequence of poor winter forage conditions, poorer body condition (particularly for prime bulls which have expended excessive energy during the rut), greater food requirements relative to females, and greater exploitation (hunter selection for bulls). Large males incur greater energy costs than small males and females primarily due to their larger size, lower fat reserves, and depletion of fat during the breeding season. Consequently, large males face a greater risk of starvation due to a greater energy deficit, particularly in protracted winters with large snow accumulations (Miquelle et al. 1992). Natural mortality from malnutrition and old age is not common because most moose populations are hunted in Saskatchewan. The mortality rate of females declines with age because females surviving to subsequent age classes have increased experience and occupy habitat sites where risk of death is lower (Boer 1988).

Mortality by hunting and predation is mostly additive (ie. in addition to natural mortality) when moose are near or below maximum sustained yield levels because a larger proportion of moose in the population are killed that likely would have lived to reproduce. Mortality becomes increasingly compensatory (ie. taking the place of natural mortality) as populations approach the carrying capacity and moose are killed that likely would have died from other causes before reproducing (Gasaway et al. 1992).

The probability of mortality increases with road and hunter densities, and is lower in areas with highly broken or dissected terrain.

1.3.5.1 Natural Predators

There are a variety of natural predators in North American moose range. Major predators of moose in Saskatchewan (and North America) are humans, timber wolves (*Canis lupus*), and bears (*Ursus* spp) (Franzmann et al. 1980, Kunkel and Pletscher 1999, VanBallenberghe 1983, Ward and Larsen 1995). Bear and wolf predation have a greater impact on moose population growth rate at low versus high moose densities, particularly if alternative prey (deer, elk, caribou) are also at a low density (Van Ballenberghe 1987, Ballard 1992, Gasaway et al. 1992, Messier 1994). Combined predation by wolves and bears can maintain moose populations within a low-density dynamic equilibrium that is well below the level that could be supported by the carrying capacity of the habitat, where moose are the primary prey (Gasaway et al. 1992). Calf survival is lowest during the first month of life, and is greater in subsequent months (Hauge and Keith 1981). Overall adult survival rate ranges between 0.6 and 0.9/year, depending on the combination of losses that result from hunting, predation, disease, parasites and weather conditions (Gasaway et al. 1983, Hauge and Keith 1981). Predator removal at low moose densities will likely improve calf survival, but may not increase moose populations (Boutin 1992) because often populations are limited by factors other than predators. Predator management is needed to maintain moose density in most cases where moose, wolves and bears are sympatric, and moose are the primary prey (Gasaway et al. 1992).

Adult moose can use deep open water to avoid wolf predation, but the safety of water vanishes with freeze-up and deep snow (Allen and Mech 1963). Increased predation on woodland caribou has been linked to moose densities that support high-density wolf populations (Bergrud and Ballard 1988). The wolf-caused mortality rate for moose in areas without wintering deer was found to be greater than in areas with wintering deer (Kunkel and Pletsher 1999). Little is known about how alternative prey affects cervid-wolf systems (Messier 1994). Alternative prey may reduce mortality of the primary prey via diversion to an alternative prey species, or may exacerbate the effects of the predator on the primary prey by stimulating higher predator numbers.

Stewart et al. (1985) reported a significant increase in moose calf survival in study areas where black bear densities were actively reduced, versus adjacent areas where the bear density was not manipulated. Franzmann et al. (1980) reported similar results in Alaska. Schwartz and Franzmann (1991) found that the vigour of black bear populations was directly related to neonatal predation of moose calves, but black bear predation rates of neonatal moose are independent of moose density (Boutin 1992, Franzmann and Schwartz 1986). Moose calves represent a source of protein and energy to bears during spring when other foods are insufficient to meet maintenance requirements (Schwartz and Franzmann 1991). Most moose calf predation by bears occurs from birth to about 30 days of age (Schwartz and Franzmann 1991), and this could amount to as much as 50% of the calves produced (Boutin 1999).

Coyotes, cougars, lynx, bobcats, wolverine, and golden eagles also contribute to moose calf mortality, but their impacts are considered to be inconsequential.

1.3.5.2 Diseases and Parasites

Diseases and parasites of moose have been reviewed by Barrett (1972), Lankester and Samuel (1998) and Sask. Agric. and Food (1990) and are summarized in Table 1. Since moose do not usually congregate in substantial numbers in restricted localities, density dependent diseases are probably less important in moose than in certain other ungulate species (Anderson 1975).

The occurrence of *P. tenuis* in moose populations is related to the presence, numbers, behaviour and distribution of white-tailed deer in relation to overlap with moose range and prevalence of the parasite in them (Anderson 1975). The presence of *P. tenuis* predisposes yearling and young adult moose to wolf predation (Peek et al. 1976).

Table 1. Diagnosed or potential diseases and parasites of moose in Saskatchewan.

Disease	Pathogen	Symptoms	Diagnosed cases in Saskatchewan
VIRAL			
Epizootic haemorrhagic disease (Bluetongue)	Virus	non-fatal, mild fever	no
Malignant Catarrhal Fever	Herpesvirus	fatal, affects gastrointestinal and upper respiratory tracts	no
Pseudorabies	Herpesvirus	non-fatal	no
Rabies	Virus	fatal, affects central nervous system	no
PROTOZOAN			
Anthrax	*Bacillus anthracis*	fatal systemic disease	no
Bovine Brucellosis	*Brucella abortus*	fatal, impacts reproductive system	no
Bovine Tuberculosis	*Mycobacterium bovis*	may be fatal, affects respiratory system	no
Johne□s disease	*Mycobacterium paratuberculosis*	chronic disease of lower digestive tract	no
Leptospirosis	*Leptospira* spp.	fevers, impacts reproductive system	no
NEMATODES			
Elaeophorosis	*Elaeophora schneideri*	fatal, blocks arterial system	no
Lungworm	*Dictyocaulus viviparis*	non-fatal, bronchitis	no
Stomach worms	various species	can be fatal for young, abdominal parasites	yes
Meningeal brain worm	*Parelaphostrongylus tenuis*	fatal neurological disease	yes
TREMATODES			
Liver fluke	*Fascioloides magna*	generally non-fatal, cysts in liver	yes
CESTODES			
Tapeworm	various species	non-fatal, infects alimentary tract	yes
ARTHOPODS / ECOPARACITES			
Moose Tick	*Dermacentor albipictus*	fatal if heavy tick load	yes
Myiasis, botflies	*Cephenemyla* spp.	non-fatal skin infestation	yes

1.3.6 Competition

Competition of moose with other ruminants for food and space is a function of the inter-relationships of range overlap, diet similarity, consumption rates and amounts, forage availability, relative size, species distribution patterns, timing and social interactions.

Large concentrations of elk in national parks are suspected in causing winter food shortages and subsequent declines in moose and mule deer populations during the 1920s (Flook 1970). Moose-elk competition for browse (particularly for willow) could be locally significant when both species coexist and concentrate on winter range (Nelson 1982). Moose are less restricted by snow cover relative to elk, and may have a competitive advantage in deep snow (>61 cm) conditions. Competition between elk and moose for food and space is minimal under most range conditions (Nelson 1982). Keith (1977) reported that elk did not have significant dietary overlap with moose. He did not observe any interspecific aggression and suggested that range separation among deer species was a consequence of individual ecological requirements rather than overt avoidance of areas used by other cervids.

Competition for moose forage is mostly from white-tailed deer on sympatric ranges, however, cattle, sheep and mule deer are also competitors to a lesser extent (Kowal1982).

1.3.7 Population Structure

Since the normal breeding period for moose is short, it is important to maintain a proper adult sex ratio to ensure timely mating of all breeding females (Schwartz 1998). Higher natural mortality rates of males in association with an intense harvest of bulls can significantly skew the adult sex ratio of a moose population. Moose tend to form pairs during the breeding season. Widely distributed populations at a low density likely require a higher proportion of breeding bulls (higher adult sex ratio) to ensure adequate reproduction. When the adult sex ratio is highly skewed in favour of females, the result is fewer females get bred, or variation about the mean conception date, resulting in late-born calves with low chance of surviving winter (Aitken and Child 1992, Bailey and Bangs 1980, Child and Aitken 1989, Schwartz 1998, Schwartz and Hundertmark 1993).

1.3.8 Ecological Role/Significance

Wildlife and wildlife habitat play a vital role in the ecological and biological processes that are essential to life and socioeconomic well-being. The health of wildlife populations is an excellent indication of the health of the environment. Biological diversity of the natural environment is the foundation of a sound economy (agriculture, science and medicine; Savard et al. 1994).

Moose have attained special management status because they are a game animal in most of their range, subject to limited sport and subsistence hunting (Nowak 1999). Moose are important to humans not only for hunting, but also for viewing, as well as the role they play in cultural and spiritual activities of First Nations peoples. In Russia, moose have been domesticated for the production of meat and milk, as well as for use as a farm draft animal (Nowak 1999).

The spatial and ecological requirements of moose encompass those of many other boreal forest species. Moose can have a major impact on wildlife habitats, are an important component of ecosystem dynamics, and play an integral role in large-mammal, predator-prey systems because they are an essential source of food for large carnivores (wolves and bears), and scavengers (ravens, wolverines).

Moose populations occupy areas where humans have an interest (forestry, mining, oil and gas exploration, agriculture, recreation). Consequently, population management is challenged with ensuring equitable treatment for moose where their habitats are to be impacted by human activity.

2.0 Status and Management

2.1 Moose Management Units (MMU)

Moose Management Units (MMUs) in Saskatchewan (Table 2) consist of parts of one or more Wildlife Management Zones (WMZ) (Figure 2) which share similar geographic and ecological characteristics. It is recognized that some exchange of moose naturally occurs among various MMUs, but this likely has a negligible effect on local moose density.

Table 2. Moose Management Units.

Moose Management Unit	Area Description
Cypress Hills	WMZ 6 and 7
Kindersley	WMZ 25 - 27
Moose Mountain	WMZ 33
Eastern QuAppelle	WMZ 35
Duck Mountain	WMZ 37
Parkerview/Good Spirit	WMZ 39
Barrier Valley	WMZ 40, 42
MacDowall Forest	WMZ 51, 52
Fort a la Corne	WMZ 43 and 50
Sonningdale	WMZ 45
Porcupine Hills	WMZ 48, 56 and 57
Pasquia Hills	WMZ 49, 58 and 59
Cumberland Delta	WMZ 60, 61 and 62
Candle Lake-Cub Hills	WMZ 63, 64, and 65
Sled-PANP	PANP and WMZ 66
Bronson Forest	WMZ 47, 68S and 68N
Divide Forest	WMZ 53, 55, and 67
Thickwood Hills	WMZ 54
Meadow Lake-PAWR	WMZ 69 and PAWR
Creighton	WMZ 70
Churchill	WMZ 71, 72, and 73
Boreal Shield	WMZ 74, 75, and 76

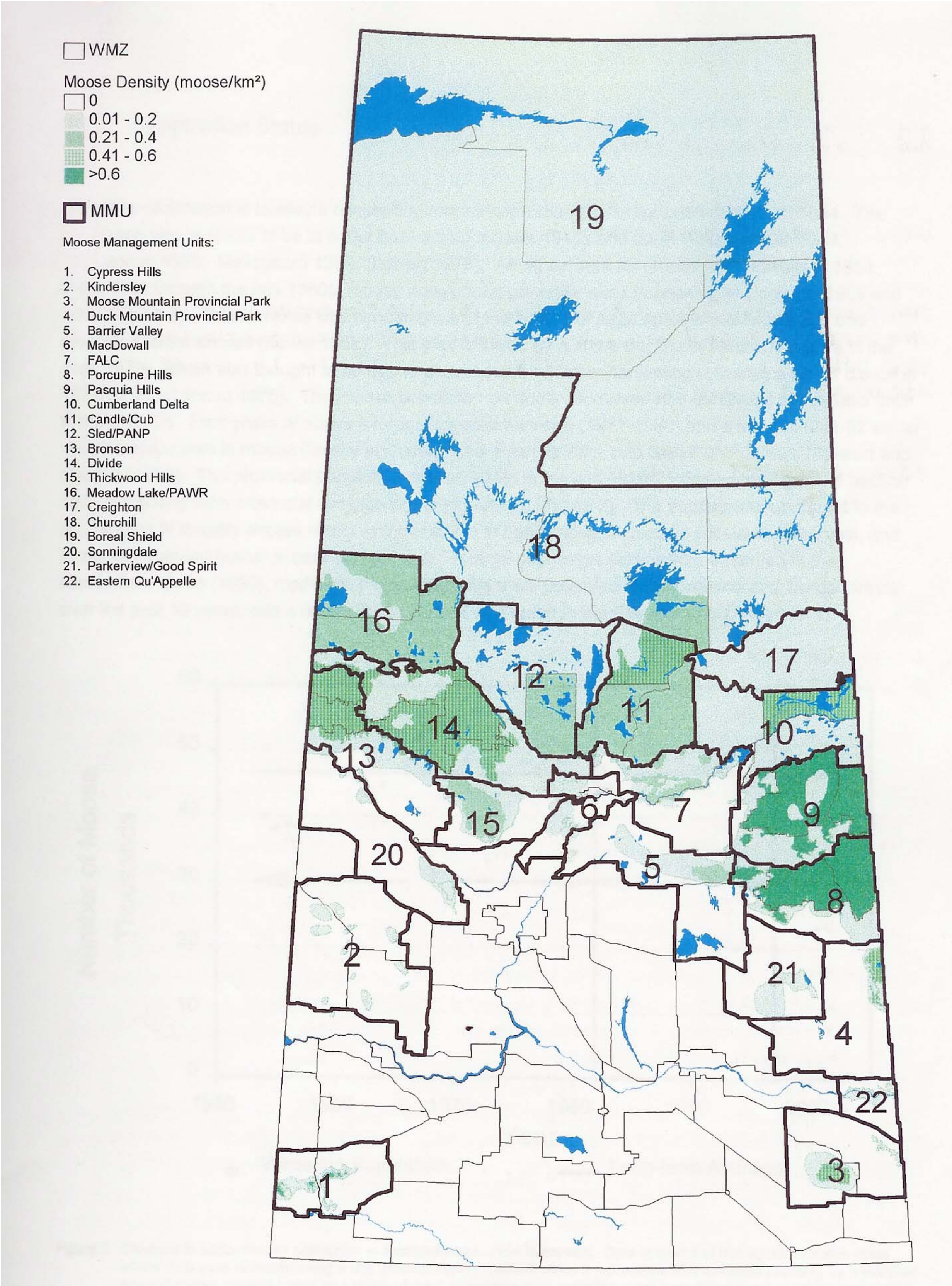

Figure 2. Moose distribution in relation to WMZ's and MMU's.

2.2 Population Status

Very little information is available concerning moose populations in Saskatchewan prior to 1954. The population was reported to be at a low level during the late 1940s and early 1950s (Hatter 1949, MacLennan 1975, Maliepaard 1962, Stewart 1978). Aerial surveys for moose were started in 1954. From 1954 through the late 1960s, moose populations generally were increasing to a peak in 1968 and 1969 (Figure 3). This increase was concurrent with the advent of large-scale forest harvesting and increased forest access (Kowal 1989). This was followed by a sharp decline in moose numbers in the early 1970s, which was thought to be due to a combination of over-harvesting following a winter die-off in 1971/72 (MacLennan 1975). The moose population gradually recovered and continued to increase until the late 1970s. Four years of above average licensed harvests (1977-1980) and a severe 1981/82 winter resulted in declines in moose density in Cumberland, Pasquia Hills, and Sled/PANP MMUs (Stewart and Gauthier 1988). The provincial population peaked again in the late 1980s, followed by a gradual decline back to the long-term provincial average winter population (Figure 3). The decline was attributed to the proliferation of forestry access roads, which resulted in habitat loss, increased subsistence harvest, and increased licensed hunter access and harvest. A large population decline was observed in the Cumberland Delta (1990), moderate gradual declines were observed in the Bronson and Divide forests over the past 10 years, and a recent minor decline was noted in the Pasquia Hills (Appendix 1).

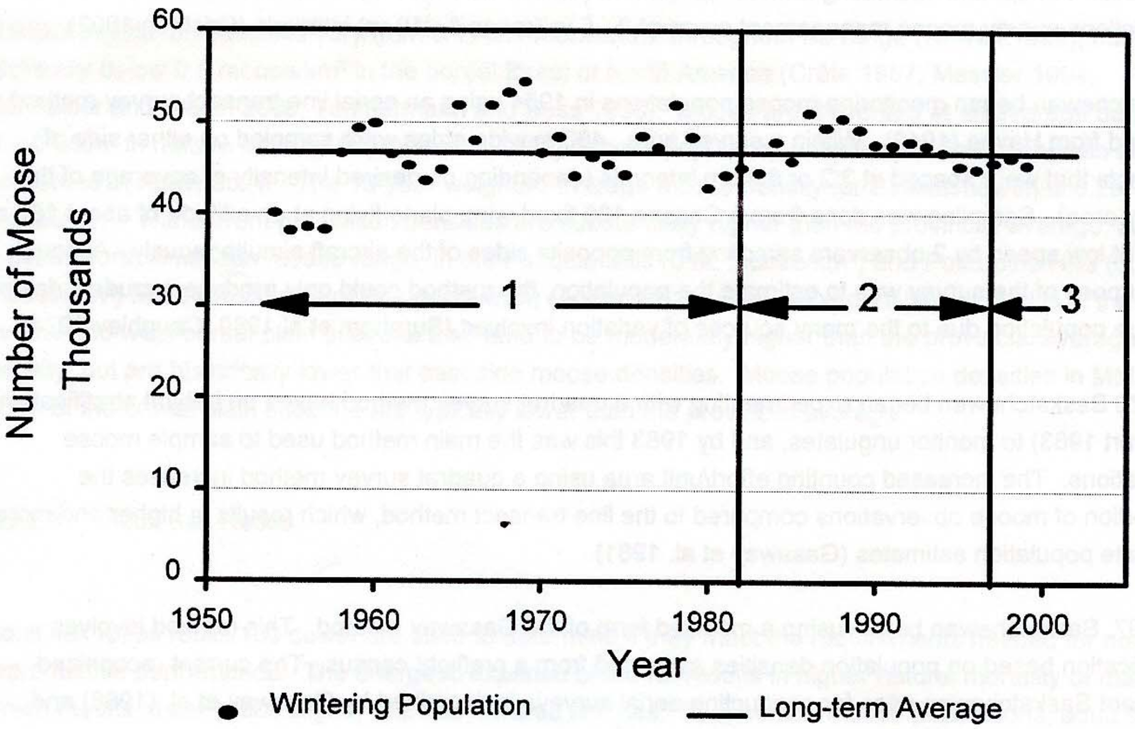

Figure 3. Changes in winter moose population in Saskatchewan, 1954 to present. Data in area 1 of this figure indicates years where data were collected using a line transect survey method. Area 2 represents data collected primarily by a stratified quadrat survey method based on habitat. Area 3 represents data collected using a modified Gasaway survey method.

Density estimates of wintering moose populations are limited for many MMUs (see Appendix 1). Winter moose population estimates for each MMU were derived from aerial survey results by applying density estimates (Appendix 1) to the area of primary and secondary moose range within each MMU. A constant of 0.05 moose/km^2 was used for secondary range (Figure 1) for WMZs where survey data were not available. This value was used because it reflected the average density of moose in adjacent survey areas in Saskatchewan where survey data was available, including estimates from adjacent provinces and territories. Interpolation was accomplished by assuming that winter moose population size changed linearly between survey years within individual MMUs. Annual MMU winter moose population estimates were then summed to derive an annual provincial winter moose population estimate (Figure 3).

The fluctuations in annual winter moose population size appear to be cyclic (Figure 3). Stewart and Gauthier (1988) hypothesized that Saskatchewan moose populations follow a distinct 9-11 year synchronous cycle in density, but they were unable to find direct correlations with variables that may affect moose density.

2.2.1 Moose Survey Design

Aerial surveys are used in obtaining measures of relative population size and distribution, assessing population trends, and estimating annual recruitment (Timmermann 1993). Most North American jurisdictions survey moose management areas at 2 - 5 yr (range 1 - 10 yr) intervals (Crichton 1992).

Saskatchewan began monitoring moose populations in 1954 using an aerial line transect survey method adapted from Hayne (1949). Within a survey area, 400 m wide strips were sampled on either side of transects that were spaced at 3.2 or 6.4 km intervals (depending on desired intensity of coverage of the survey area). Sampling was done from a Cessna 180 fixed-wing plane flying at an altitude of about 180 m flying at low speed by 2 observers sampling from opposite sides of the aircraft simultaneously. Although the purpose of the survey was to estimate the population, the method could only produce a crude index of the true population due to the many sources of variation involved (Burnham et al 1980, Caughley 1974).

In 1979 Saskatchewan began experimenting with a quadrat survey method based on habitat stratification (Stewart 1983) to monitor ungulates, and by 1983 this was the main method used to sample moose populations. The increased counting effort/unit area using a quadrat survey method increases the proportion of moose observations compared to the line transect method, which results in higher and more accurate population estimates (Gasaway et al. 1981).

In 1997, Saskatchewan began using a modified form of the Gasaway method. This method involves stratification based on population densities assessed from a pre-flight census. The current recognized standard Saskatchewan uses for conducting aerial surveys is described by Gasaway et al. (1986) and Lynch and Shumaker 1995).

2.2.2 Population Characteristics

Data for this section was compiled from annual Saskatchewan Game Management Reports, aerial survey data and/or personal communications with regional wildlife specialists. The information was collected on a WMZ basis and presented on an MMU basis as defined by Table 2.

2.2.2.1 Population Size and Growth

The estimated finite rate of population increase (r) for moose in North American studies ranged from 1.15 to 1.30, with a mean of 1.23 (VanBallenberghe 1983, Van Ballenberghe and Ballard 1998); a value of 1.00 reflects numerical stability and a value less than 1.00 reflects a declining population. Highest rates of population growth (*r*) can be expected when most adults are in the “prime” age classes (5 - 10 years old) where fecundity and survival are maximum (VanBallenberghe 1983).

2.2.2.2 Population Density

Normal population densities vary from 0.1 - 1.1 moose/km^2 throughout its range (Nowak 1999), but are generally below 0.5 moose/km^2 in the boreal forest of North America (Crête 1987, Messier 1994, Schneider and Wasel 2000, Timmermann and Buss 1998). Moose are dispersed at an average density of 0.1 - 0.3/km^2 in mature forest (Loranger et al. 1991). Moose population densities for Saskatchewan are presented in Appendix 1. The 10-year weighted average moose density for Saskatchewan is 0.29 moose/km^2. The current population densities are substantially higher than the provincial average, and most of North American moose range, in the Pasquia Hills (0.60 moose/km^2) and Porcupine Hills (0.88 moose/km^2) MMUs (east side of Saskatchewan) (Appendix 1). Population densities in MMUs in the central and west boreal plain ecozone also tend to be moderately higher than the provincial average density, but are historically lower that east side moose densities. Moose population densities in MMUs north of the boreal plain ecozone are typically lower than the provincial average.

2.2.2.3 Adult Sex Ratios

Adult sex ratios (bulls/100 cows) are used to determine if they meet the requirements needed for normal reproductive performance. The energetic expense of the rut results in higher natural mortality of males, which results in sex ratios slightly skewed towards females. In unhunted moose populations, adult sex ratios range from 92 - 100 bulls/100 cows to 29 bulls/100 cows (Schwartz 1998). In populations with a selective harvest pressure on bulls, the adult sex ratio can be highly skewed, as low as 5 - 12 bulls/100 cows (Baker 1975, Schwartz 1998).

There is no clear answer as to what an adequate bull/cow ratio should be in a hunted population (Schwartz 1998). Timmermann (1992) recommended that the adult sex ratio of moose populations at a density of 0.30 moose/km^2 should remain at or above 50 bulls/100 cows (Figure 4). Messier (1996) recommended adult sex ratios of 40 - 50 bulls/100 cows to maximize sustainable harvest levels of 0.025 moose/km^2 (under a selective harvest regime) for moose populations at densities of 0.28 - 0.35 moose/km^2 (Figure 4). Figure 4 presents the relationship between the adult age ratio and moose density for populations sampled by quadrat aerial survey methods in Saskatchewan. Populations widely distributed at a low density require higher bull/cow ratios to ensure adequate reproduction (Schwartz 1998). These recommendations are consistent with data for Saskatchewan moose populations presented in Figure 4 and Appendix 2. At least 50% of the male segment in age classes $\geq$5 years old is recommended, to maintain a productive moose population distributed at a density of 0.30 moose/km^2 (Aitken and Child 1992, Crête et al. 1981, Timmermann 1992). Population management should strive to attain moose adult sex structures as close as possible to (or above) the curvilinear line presented in Figure 4 for the respective moose densities, to ensure adequate reproduction.

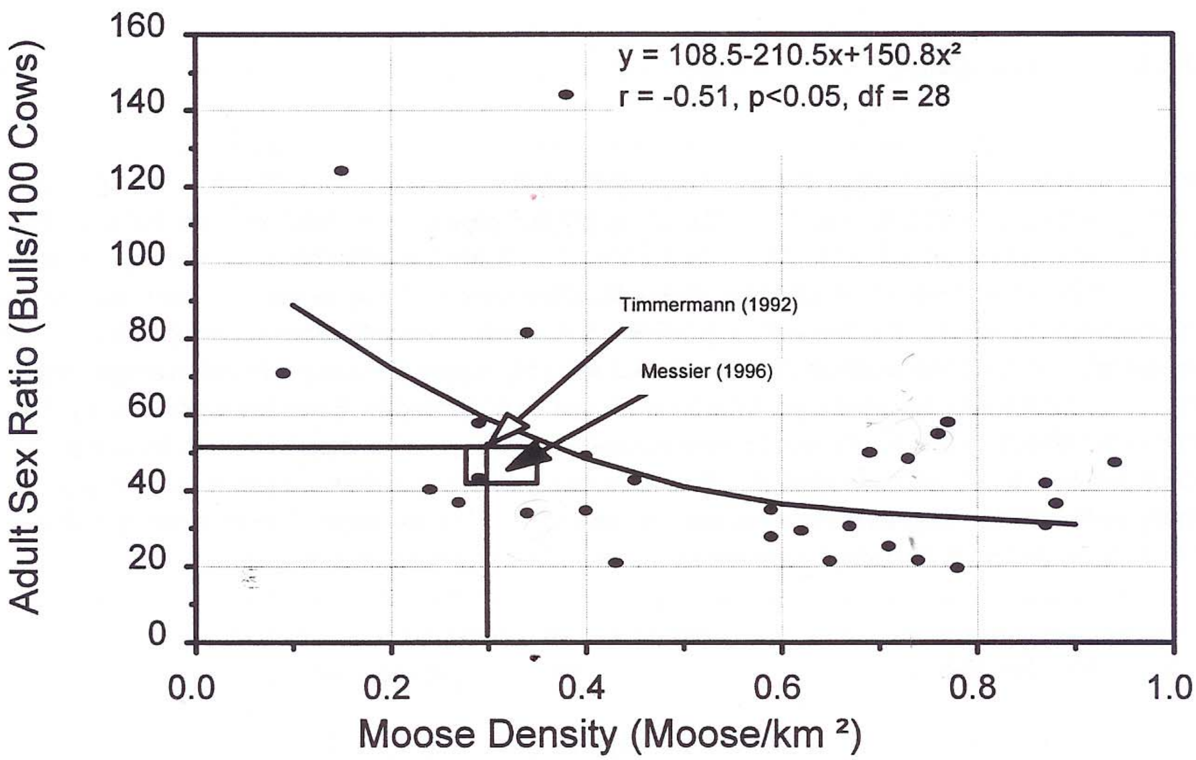

Figure 4. Relationship of adult sex ratio to moose density for healthy, stable moose populations in Saskatchewan (based on survey data from 1984-1999).

The relative rate of increase in a moose population is greater when the population is skewed in favour of females (Van Ballenberghe 1983), provided the population is at a density high enough to ensure adequate reproduction (Schwartz 1998), and that an adequate number of breeding bulls are present to:

1. Maximize the number of estrous females bred.
2. Ensure timely reproduction (ie. avoid variation about the mean conception date), and
3. Avoid late breeding that results in late calves, which likely wouldn't survive a harsh winter (Aitken and Child 1992, Bailey and Bangs 1980, Child and Aitken 1989, Schneider and Wasel 2000, Schwartz and Hundertmark 1993).

Mature bulls (5 - 12 years old) exhibit fully developed courtship behavior and are better breeders because they produce larger volumes of semen and viable sperm than young bulls, they enter the rut 3-6 weeks earlier than young bulls, and are much more effective at inducing ovulation in females via scent-urination in wallows (Bubenik 1987, Bubenik and Timmermann 1982). When bulls are heavily hunted their average age will be low (Baker 1975). Moose populations can withstand substantial hunting pressure, so long as is focussed on adult males, and so long as there are enough mature males to effectively breed receptive cows (Schneider and Wasel 2000). Young bulls show little searching activity for females compared to mature bulls (Baker 1975). Aitken and Child (1993) demonstrated that as the proportion of mature breeding bulls in the population increased, the incidence of twin calves among bred females increased. A higher proportion of bulls will result in availability of more trophy class bulls. Loss of prime bulls erodes the biological resistance of the species to disease and parasites.

2.2.2.4 Calf/Cow Ratios

The mid-winter ratio of calves/100 cows are used to assess rearing success and calf recruitment. These ratios should be used with extreme caution because they are a function of fecundity and calf survival rates. Relatively fewer yearling and 2-year old females would have calves at their sides even though they may be physiologically capable of having calves. These two age classes have a large representation (e.g. 24% of females in Isle Royale, Michigan; Van Ballenberghe and Ballard 1998) in the female age class structure of a moose population relative to older age classes. About 16% of breeding aged cows don't get bred in any single year. In addition, 25-40% of cows that produced a calf will have lost their calf by the end of the hunting season to predators (including hunters). All of these factors would result in the perception of "dry cows" by early winter.

Average litter sizes are greatest with 4.5 - 5.5 year old cows, and smaller with younger and older (≥9.5 years) cows (Saether and Haagenrud 1983). Knowledge of age structure of the population is required to effectively interpret productivity ratios. Average production and calf survival to mid-winter in Saskatchewan is typically > 40 calves/100 cows (Figure 5, Appendix 3), although this is a function of hunter harvest and predation rates, and is not related to population density.

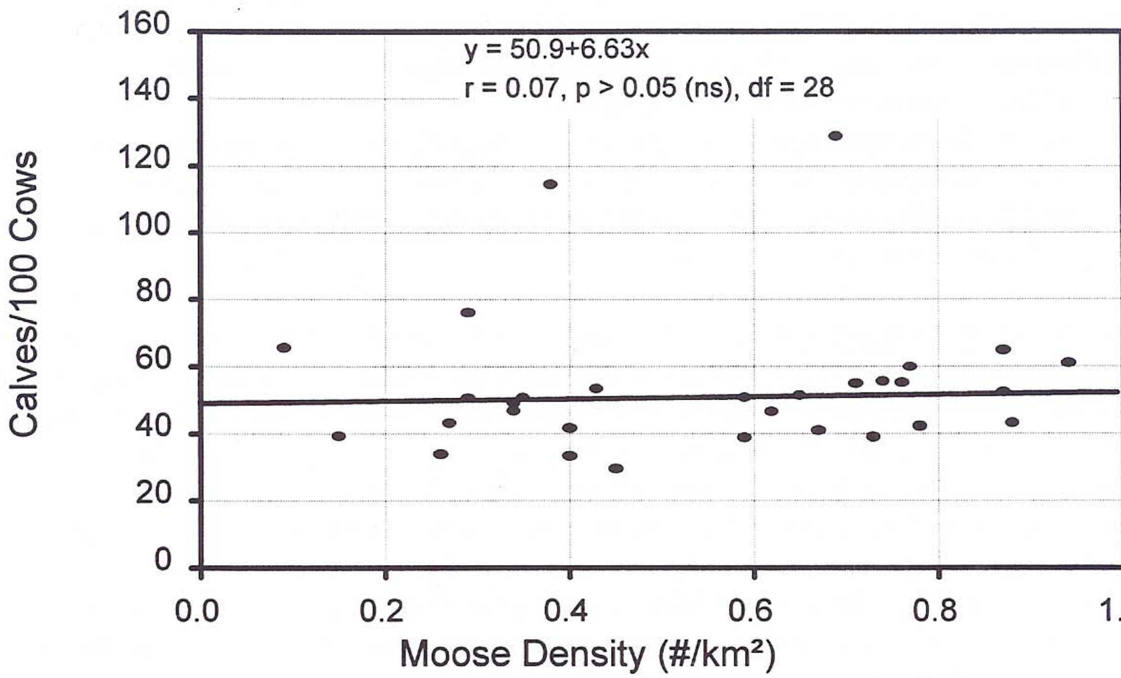

Figure 5. Mid-winter calf/cow ratios relative to moose population density in Saskatchewan.

2.2.2.5 Cementum Harvest Structure

Cementum data from harvested moose have been collected annually to monitor the proportion of young animals in the harvest structure. These data have inherent age and sex-specific biases because hunters select for bulls and against calves, but are generally considered representative of the bull harvest. Therefore, these data are not representative of the true age structure of a population. A population at low density is most likely to have a young age distribution and therefore would be sensitive to increases in hunting pressure (p. 24, Alberta Forestry, Lands and Wildl. 1992).

This information is also used to assess the impact of changes in allocation to population segments. Figure 6 illustrates a gradual decline in average age of bulls since implementation of the sex and age selective harvest strategy in 1977 from a grand mean of 4.8 yr (1967-1976) to 4.2 years (1977-1998). This was an expected result stemming from greater harvest pressure on bulls relative to cows and calves. Interpretation of age data for cows is problematic because of small sample sizes, particularly since 1997 when draw quotas were substantially reduced. The apparent trend in Figure 6 is that cow age has remained stable under the existing harvest strategy. Concern is warranted when the mean age of harvested animals is consistently younger than 4 years of age (Crighton 1992). A summary of harvested moose cementum data is presented in Appendix 4.

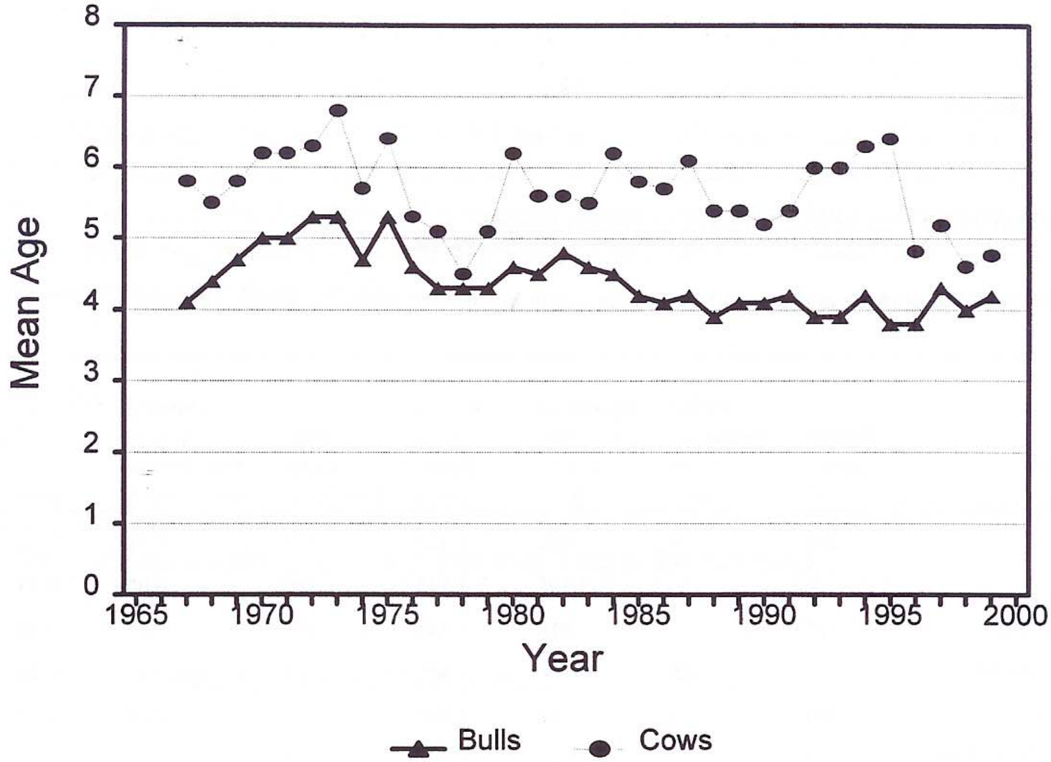

Figure 6. Annual changes in mean age of harvested moose $\geq$2.5 years (cementum) age. Sample sizes for cows for years 1996 to present are too small to be meaningful.

2.2.3 Projected Future Supply of Moose

The 1999/00 winter population is estimated to be 45,516 moose (Figure 2). By maintaining hunted moose populations at their long term average population density, restoring Cumberland Delta MMU moose population to its long-term average, and allowing unhunted island populations to grow at their current rate of increase, a proposed long-term provincial winter population objective of 50,265 $\pm$10% moose could be maintained for future years. This is contingent on the accuracy of population estimates, rate of population growth, hunter success, level of exploitation hunters (subsistence, recreational and commercial), and maintenance of habitat integrity to continue supporting current moose populations. This projection should be reviewed in 5 years to assess progress toward long-term MMU population objectives.

2.3 Habitat

2.3.1 Supply

Table 3 summarizes habitat use by Saskatchewan moose.

Table 3. Summary of primary and secondary moose range in Saskatchewan by MMU, 1999/00.

Moose Management Unit	Primary Range (km^2)	Forest Secondary Range (km^2)	Agriculture Secondary Range (km^2)	Total Range (km^2)	1999/00 Winter Population	Primary Range Pop. Density (moose/km^2)	Secondary Range Pop. Density (moose/km^2) Forest	Agric.
Cypress Hills	233	-	890	1,123	312	0.72	0.00	0.16
Kindersley	-	-	1,105	1,105	126	0.00	0.00	0.08
Moose Mountain	527	-	919	1,446	387	0.47	0.00	0.15
Eastern QuAppelle	-	585	-	585	29	-	0.05	-
Duck Mountain	600	-	421	1,022	316	0.46	0.00	0.10
Parkerview-Good Spirit	-	-	1,488	1,488	74	-	-	0.05
Barrier Valley	519	260	2,203	2,983	387	0.27	0.10	0.10
MacDowall Forest	98	1,475	455	2,028	146	0.35	0.06	0.05
FALC	1,557	809	2,319	4,685	767	0.25	0.20	0.09
Sonningdale	164	-	814	977	81	0.24	-	0.05
Porcupine Hills	6,387	-	2,360	8,748	5,769	0.88	0.00	0.05
Pasquia Hills	7,548	806	3,259	11,613	4,732	0.60	0.05	0.05
Cumberland Delta	11,596	4	2	11,601	3,060	0.26	0.05	0.05
Candle Lake/Cub Hills	10,807	1,135	2	11,944	3,889	0.35	0.10	0.10
Sled-PANP	15,024	212	17	15,252	2,746	0.18	0.10	0.00
Bronson Forest	3,743	-	2,718	6,461	1,446	0.34	0.00	0.05
Divide Forest	8,840	320	7,090	16,251	4,265	0.44	0.05	0.05
Thickwood Hills	1,808	229	1,543	3,580	729	0.35	0.10	0.05
Meadow Lake-PAWR	11,125	2,400	26	13,551	3,064	0.26	0.05	0.00
Creighton	8,372	687	0	9,058	711	0.08	0.05	0.00
Churchill	18,814	69,186	-	88,001	5,997	0.13	0.05	0.00
Boreal Shield	-	185,045	-	185,045	6,484	0.00	0.04	0.00
TOTAL	107,762	263,154	27,632	398,547	45,516	0.29	0.05	0.07

- Primary Range is the high quality suitable habitats in the boreal plain ecozone, which traditionally or potentially support high-density moose populations (Figure 1).
- Forest Secondary Range consists of lower quality habitat (poorer forage and cover, colder temperatures) in the boreal shield and taiga shield ecozones, which cannot sustain high-density moose populations.
- Agricultural Secondary Range is habitat in the boreal plain ecozone that has limitations to supporting high-density moose populations because of combinations of intensive agriculture (farming, livestock production, etc.), settlement, greater ambient temperature, and/or increased access.

2.3.2 Habitat Requirements

To have an effective population size of 50 prime breeding male moose (per Reed et al. 1986), a total population of 590 moose is required with a post calving population structure of 34 bulls/100 cows/97 calves. If this population was dispersed at the average Saskatchewan moose population density of 0.30 moose/km², it would require about 1,384 km² of primary range, 3,377 km² of secondary forest range, and 326 km² of secondary agricultural range.

2.3.3 Management

The vast majority of moose habitat is not protected. Habitat management for moose must be integrated with the needs of other wildlife species, and with other uses of the land base.

2.3.3.1 Forest Management Lease Areas (FMLA)

The Weyerhaeuser FMLA affects wildlife species in the Divide (east ½), Sled/PANP, Churchill (southern portion) and Candle/Cub MMUs. The proposed 20-year Weyerhaeuser FMLA forest cutting plan would work towards achieving a forest age distribution similar to that which would occur under a 70-year fire cycle, thereby reducing the mean age of the forest under this lease and significant reduction of area of older aged forest stands. This cycle is longer than the 30 - 50 year fire cycle (which occurred prior to 1900), but is significantly less than the current 205 year cycle resulting from Saskatchewan's policy of fire suppression (which began in the 1940s). The proposed cutting practice will attempt to mimic the natural range and variability of forest stands that occur naturally due to fire. Within cut-overs, the plan is to retain a range of 1-5% (average 3%) of the trees as single trees and clumps of trees for wildlife. Proposed cut block sizes will average 40 - 50 ha but may range from 10 - 1000 ha (mimics fire patch size). Shape would follow natural land contours and forest growth patterns. Proposed changes would likely benefit moose and other wildlife populations, which prefer earlier successional stages of forest provided access and cover concerns are addressed.

SaskFor/MacMillan FMLA was taken over by Weyerhaeuser in 1999, and affects the Pasquia, Porcupine and Cumberland (south½) MMUs. A land use management plan was developed for the area in 1997 (SERM 1997). With no fire suppression, the fire cycle ranged from 50-100 years depending on stand-type and location (longer for lowland vs upland stands). The proposed logging rotation is 60 years, with 47% of the cut blocks in the 80-250 ha size range, 40% in the 20 - 80 ha size range and 17% in the 0-20 ha size range. In blocks > 20 ha a minimum 2% tree cover is to be maintained with distance to cover < 250 m. The long term cutting plan objectives in both upland and lowland areas involve a doubling of the relative amounts of young and forests at the expense of mature and old growth forest by 2050 in areas of marketable timber.

Mistik (NorSask/Millar Western) FMLA affects the Bronson, Divide (west ½), Meadow Lake/PAWR, and Churchill (west ½) MMUs. Present conditions consist of 23.4% of forest stands <40 years old, 28.7% of stands 40 - 60 years old, 28.0% of stands 60-80 years old and 19.9% older than 80 years. The cutting plan calls for increased harvest of older stands resulting in younger average age of forest stands.

Other FMLAs in Saskatchewan include Amisk-Atik (affecting Creighton MMU and WMZ 71 of the Churchill MMU), and L & M (affecting portions of the Divide MMU).

2.3.3.2 Agriculture

Across agricultural Saskatchewan, parcels of habitat on public (crown) lands that are important to the survival of game (including moose), non-game, rare, and endangered species, are protected by *The Wildlife Habitat Protection Act (1992*). Agricultural practices such as clearing and forest grazing negatively impact wildlife.

2.3.3.3 Habitat Procurement

A portion of the revenue collected from hunting license sales goes into the wildlife portion of the Fish and Wildlife Development Fund (FWDF) for the purchase of wildlife habitat. In a few instances these purchases have been cost-shared with the Saskatchewan Wildlife Federation (SWF) or Rocky Mountain Elk Foundation (RMEF) for specific retention of elk habitat. Habitat purchases specific to elk would also benefit moose, but these land acquisitions are a minor component of total moose habitat. The vast majority of habitat acquisitions through the FWDF prior to the mid 1990s focused primarily on securing white-tailed deer habitat. Currently, habitat purchases are made on their value to wildlife and importance to conservation of natural lands and biological diversity.

2.3.4 Enhancement

Habitat enhancement projects should be handled on a site-specific basis and be facilitated through regional and local integrated resource plans or co-management boards. Habitat modification should ensure sustainable habitat relationships, and compliment the coexistence of naturally occurring species, and enhance or maintain biological diversity.

Project funding and effort is acquired through a variety of partnerships involving Canada, Saskatchewan, FSIN, FWDF, SWF, RMEF and/or commercial logging companies. Priority is given to projects on public lands. Projects involve the implementation of management plans and initiatives to enhance habitat and are determined at the level of local co-management boards (e.g. Cumberland Moose Co-management Board).

Habitat manipulation to improve the productivity of public land for wildlife species may include cover manipulation, managing forest access, water development, forage conversions, exotic weed control, haying, prescribed burns, and livestock grazing.

2.3.5 Future Supply of Habitat

A Representative Areas Network (RAN) of lands consisting of FWDF lands, parks, protected areas, sanctuaries, ecological reserves, community pastures, national wildlife areas, and other important parcels of habitat are being coordinated into a network designed to preserve the ecological integrity and biodiversity of habitat in Saskatchewan. Designated lands falling under the RAN umbrella will be protected benchmark areas designated to preserve and sustain Saskatchewan's natural and environmental resources for future generations. The RAN will also identify areas where effort should be focused to protect and secure habitat in danger of degradation or loss. Future supply of moose habitat will be marginally affected by the juxtaposition of RAN priority areas in relation to moose range.

The key to future moose habitat supply depends collectively on commercial forest harvest activities, consideration of moose in the annual, 5-yr and 20-yr forest management plans of logging companies, adherence of logging companies to forest cutting and road management guidelines, degree of habitat fragmentation resulting from development, and public attitudes.

2.4 Historic and Current Harvest Management

Sustainable harvests are a dynamic variable that responds either positively or negatively to changes in ungulate density (Caughley 1969). At low ungulate density, sustainable harvest levels are nil or limited due to low stocks. At high population density, sustainable harvest levels are limited by natural population regulatory mechanisms such as predation and food competition (Messier 1996). Maximum sustainable harvests are realized at moderate population densities.

Bag limits are used to influence the sex and age composition of licensed moose harvest, the level of exploitation applied to population segments, and therefore the winter population structure. Season timing and length further refines the size and composition of moose harvest and the level of harvest pressure desired. Harvest pressure can be further refined by regulating hunter numbers through allocation of limited entry (draw) quotas and/or unlimited entry (regular) license allocations. Method of hunting (archery, muzzleloader, or rifle) is used to optimize sustainable hunting opportunities in draw and regular seasons, and to manipulate vulnerability of moose to harvest. Saskatchewan uses combinations of these harvest strategies to attain specific moose population objectives in an attempt to cater to hunter preferences.

Population management in Saskatchewan has been directed at harvest regulations, establishment of preserves to protect specific populations, and habitat acquisition on a limited scale. Refined systems of hunting regulations, selective harvests, draw season harvest quotas, and variable season lengths to handle demand for moose, have been successful in promoting healthy productive moose herds for consumptive and non-consumptive uses.

Proper moose population management requires reliable information on population size and structure (sex and age composition) of the various segments of each moose population within its delineated management unit. Also required is knowledge of carrying capacity within a MMU to optimize harvest levels of surplus moose without impacting population or habitat integrity. Carrying capacity can vary annually depending on winter and summer forage conditions. Reliable estimates of population size and composition of moose are limited, as is knowledge of carrying capacity of moose habitat. This paucity of information is a function of limited budget and manpower.

Resource management programs have been funded primarily from government general revenue and have emphasized management of consumptive resource uses. Additional revenue to support moose management is not easily or readily obtainable from non-consumptive users, although a limited amount of funding has been provided by industry (mainly forestry companies) in areas of mutual interest.

2.4.1 Subsistence Use

Moose and elk were historically less important to the North American Indian subsistence economy than were bison and white-tailed deer, but did serve as a source of food, clothing, implements, weapons, decoration, spiritualism, and as a medium of exchange (McCabe 1982). However, moose was a staple for Indians occupying the forest. Pre-Columbian Indians likely had little impact on moose populations because of limited technology, limited mobility, and the seasonal habits of moose. Native hunting of moose frequently involved water hunts (Reeves and McCabe 1998). Once moose were found in, lured to (by calling), or driven (generally involved the village, or use of fire) to water, moose swimming to escape were killed from canoes using bow and arrow, spears and clubs (Reeves and McCabe 1998). Snaring was also a widely used technique for taking moose.

Many tribes modified habitats using fire, which created early seral successional stages in the habitat mosaic that were probably quite beneficial to moose populations. Dyck (1977) states that elk and moose were important components of the diets of Indians in the Northern Plains and Parkland areas of what is now Saskatchewan.

Native Indians have a special status within North America with regard to their hunting rights, most of which have been agreed to by treaty with federal governments (Gill 1990). In Saskatchewan, Treaty Indians are entitled to hunt moose for subsistence use, at any time, all year, on lands where they have right of access. Subsistence harvest is a factor of major biological and socioeconomic significance. It is imperative for future moose management to obtain reliable estimates of the level of subsistence harvest in each MMU.

Harvest by Treaty Indians can have a significant impact on accessible moose populations. In practice, most moose harvested in Saskatchewan by subsistence hunters occurs during the fall (avg.75%) and winter (avg. 20%) period (Carriere 1995, Kay and Barks 1998, Keewatin 1995). About 90% of the subsistence harvest was composed of adult animals with slightly more males (58%) taken than females (42%). Average household size on Saskatchewan reserves ranges from 4.8 (Carriere 1995) to 6.0 (Kay and Barks 1998, Keewatin 1995). Average annual moose consumption for reserves where moose consistently occurred in local diet ranged from 0.90 moose/average household of 6.0 people (Kay and Barks 1998, Keewatin 1995) to 0.74 moose/average household of 4.8 people (Carrier 1995). Reeves and McCabe (1999) estimate annual consumption of moose for North American Indians to be 0.142 moose/person. These are similar estimates to those reported for Alberta reservations (0.810.62 SD moose/average household of 4.23 people, Alberta Forestry, Lands and Wildlife 1992), and for Yukon Indian households (0.8 -1.0 moose/household, Jingfors 1988). These are coarse estimates of consumption and require refinement to accurately assess true subsistence requirements.

2.4.2 Resident Licensed Harvest

Prior to 1946 a bulls-only license valid from mid-November to mid-December was used to regulate moose harvest (Figure 7). A series of severe winters was believed to have caused low moose populations, so recreational hunting seasons were closed from 1946 to 1953 (Figure 7). During this time, moose harvest was by special permit only for northern residents (who derived their income from trapping and fishing) because the moose population was at a low level (Maliepaard 1962).

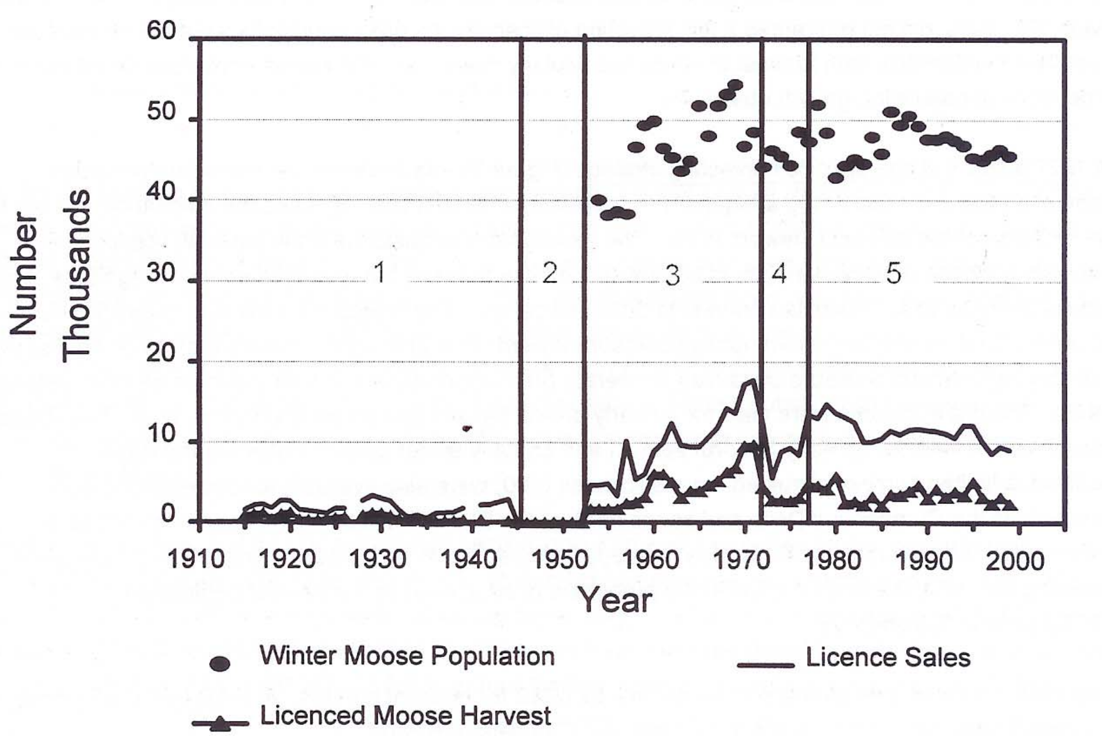

Figure 7. Winter moose populations, harvest, and license sales under different harvest management strategies (1 Unlimited Bulls-only, 2 Season Closure, 3 Liberal Either-sex, 4 Limited Entry Draw, 5 Sex and Age Specific Harvest Strategy).

By 1953, moose populations had apparently recovered to a level where an either-sex moose season, open to all residents, was established (Figure 7) from mid-November through mid-December (Maliepaard 1962). The license was an elk-moose license whereby the hunter had the choice of harvesting 1 moose or 1 elk. In 1954, an additional early moose (calling) season was set concurrent with the rut, from mid-September through early October (Maliepaard 1962). Initially this early season was in effect only for some restricted areas of the commercial forest zone, but gradually opened up throughout the moose range. In 1956 the elk-moose license was replaced by separate licenses for elk and moose. This licensed liberal either-sex harvest strategy continued until a large winter die-off of moose occurred during the late part of the 1971/72 winter, and concurrent over-harvest in several game management zones during the 1970 and 1971 hunting seasons.

The combination of declining moose populations and high harvests generated considerable public concern, resulting in placing WMZs 56-61 (Porcupine Hills, Pasquia Hills, and Cumberland Delta areas) on a compulsory draw/license quota system to limit harvest in 1972 (Figure 7). Population surveys in the winter of 1972/73 showed continued population decline, which resulted in expansion of the license-quota-allocation system to encompass all wildlife management zones in 1973. Quotas were moderately increased in 1974 in response to slight increases detected in moose density surveys the previous winter. This was concurrent with a short 1973 growing season, a severe 1973/74 winter and a late 1974 spring which resulted in poor moose productivity and recruitment (Stewart et al. 1977). This allocation system continued until 1976, but was criticized because it restricted individual hunters to hunting moose only once every 2-3 years, did not guarantee a fair allocation of licenses, moose populations were not responding, and disproportionately high harvest of adults (particularly cows) over this period were considered counter productive to population growth objectives.

In 1977 a sex and age specific harvesting strategy (Figure 7) was implemented because the moose population was not responding adequately to a system of harvest that regulated the magnitude, but not the composition of the harvest (Stewart 1978). The new system consisted of draw (special) licenses for harvesting moose of either-sex (ie. to control cow moose harvest) but restricted harvest magnitude, and regular licenses, which restricted harvest to bulls and calves. The objectives were to increase the number of prime breeding animals, direct hunting pressure towards non-productive animals (calves and bulls) by exerting high harvest pressure on calves, moderate pressure on bulls and light pressure on cows (Stewart 1978). The draw licenses were valid for an early pre-rut season and an early winter season. The regular licenses were valid for an early post-rut season and an early winter season (following the draw). In addition, a limited number of guided moose licenses (600) were also available to residents and non-residents in the Cumberland Delta and zones north of the Churchill River. Hunting and harvest data indicate that the sex/age specific harvest strategy had resulted in an increased proportion of young non-breeding moose and a large decline in the proportion of adult cows in the harvest beginning in 1977(Figure 8, Appendix 7).

Appendix 5 summarizes annual moose harvest by MMU for resident hunters. At least half of all moose harvested come from the Pasquia, Porcupine and Cumberland MMUs.

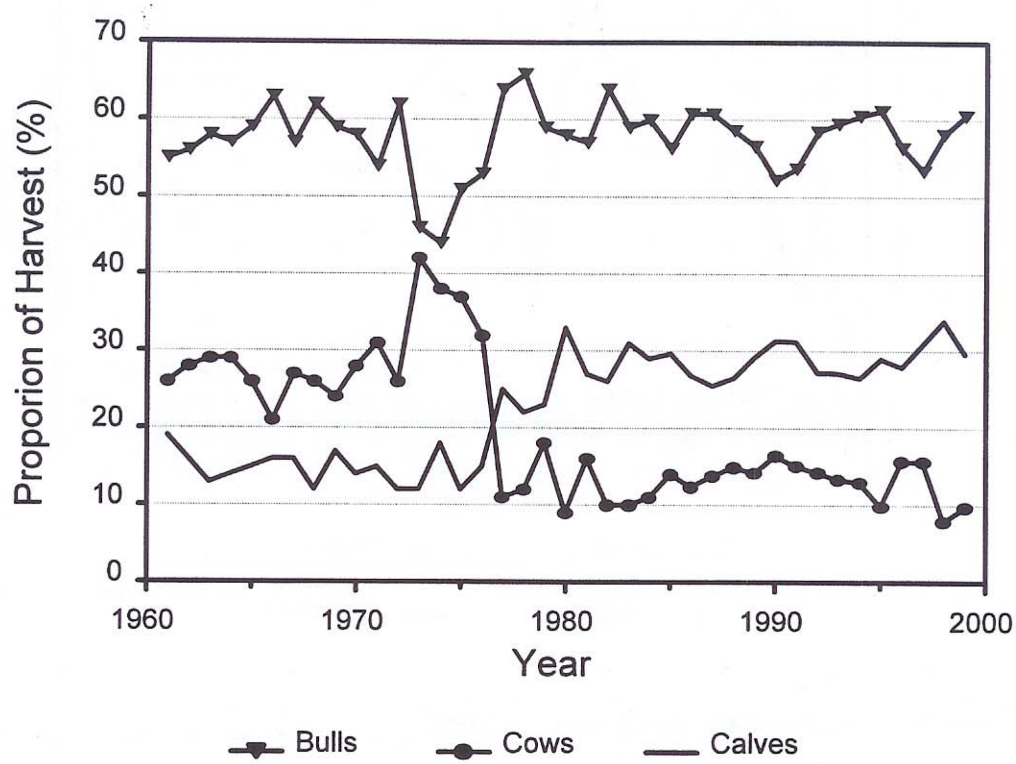

Figure 8. Annual changes in moose harvest composition.

Under the sex/age selective harvest strategy, an average of 8,947 regular (bull/calf), 2,201 draw (either-sex) and 255 guided (bull/calf) licenses have been issued annually (1977-1999). Figure 9 illustrates the annual history of license sales from 1955 -1999. Recent declines in license sales are a reflection of reduced draw quotas in the Pasquia Hills and Porcupine Hills MMUs to protect cow moose and address a perceived (1997) decline in moose populations in WMZs 56-59 and confirmed decline in Cumberland MMU (1994), as well as a decline in license sales stemming from the Grumbo decision (Saskatchewan Court of Queens Bench, August 1996) and subsequent repeal of Metis subsistence hunting rights (Saskatchewan Court of Appeal, May 1998). Appendix 6 summarizes the annual number of licenses allocated by MMU.

Despite the gradual decline in license sales, recreational demand for hunting moose remains high as demonstrated by draw applicants (Figure 10). Moose license revenues have remained relatively stable over the past 30 years relative to total annual big game revenue (Figure 11), averaging $354,952 annually. This is because moose license fee increases have been tempered by declining moose license sales (Figure 12). The mean license fee paid by a Saskatchewan resident moose hunter in 1999 was $35.35, compared to $12.00 thirty years ago. Average revenue/harvested moose has not substantially changed during the past 30 years (Table 4).

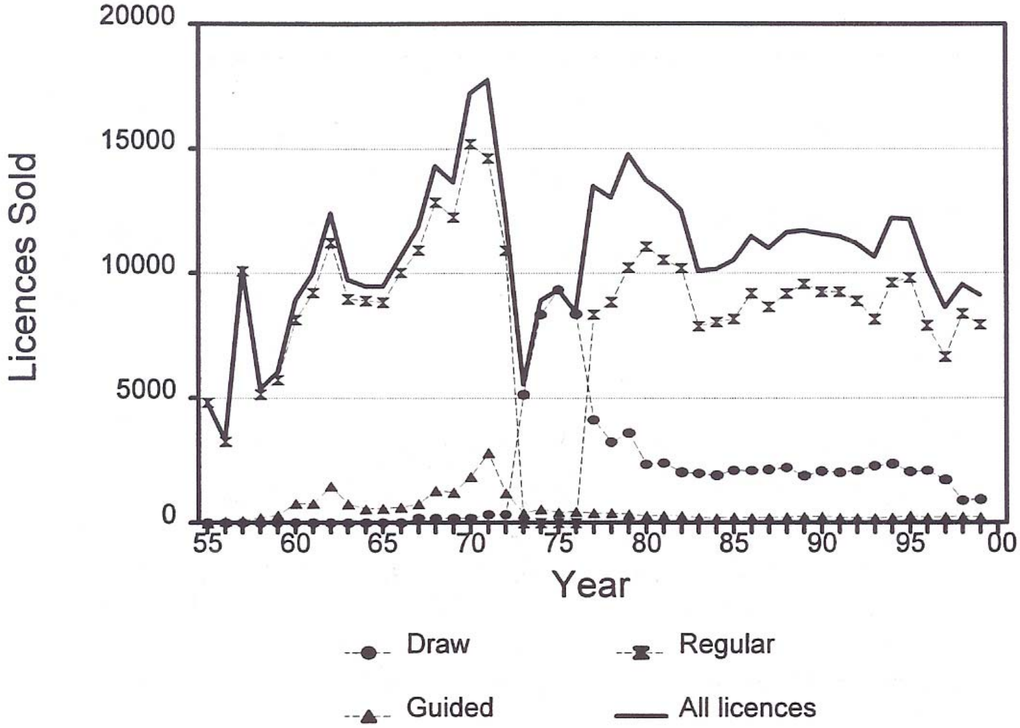

Figure 9. Annual license allocation in Saskatchewan, 1955-1999.

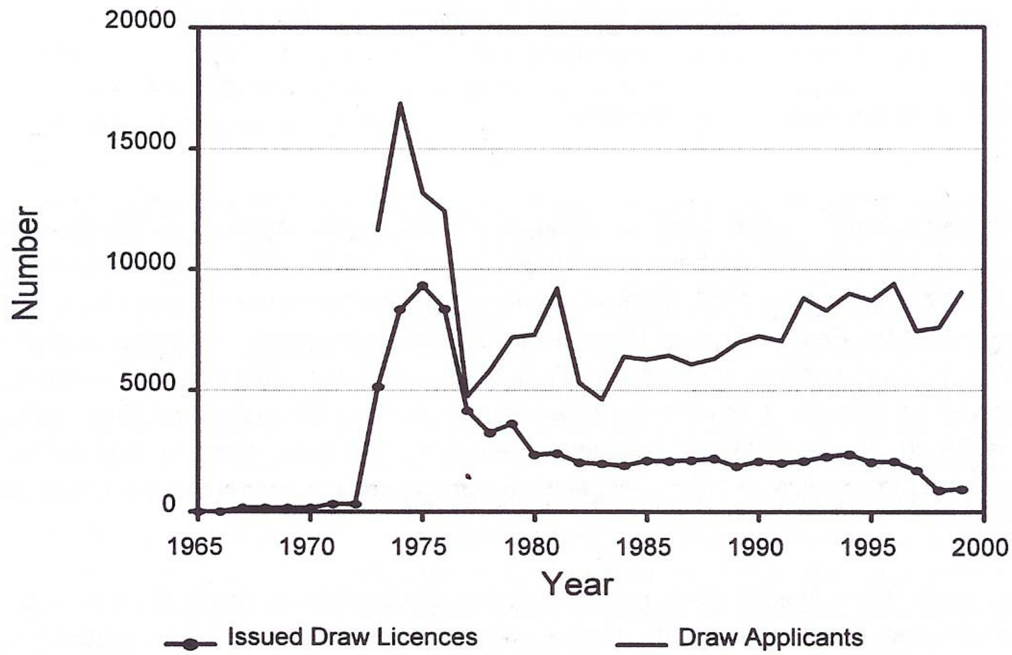

Figure 10. Annual hunter demand for draw moose licenses in Saskatchewan, 1965-1999.

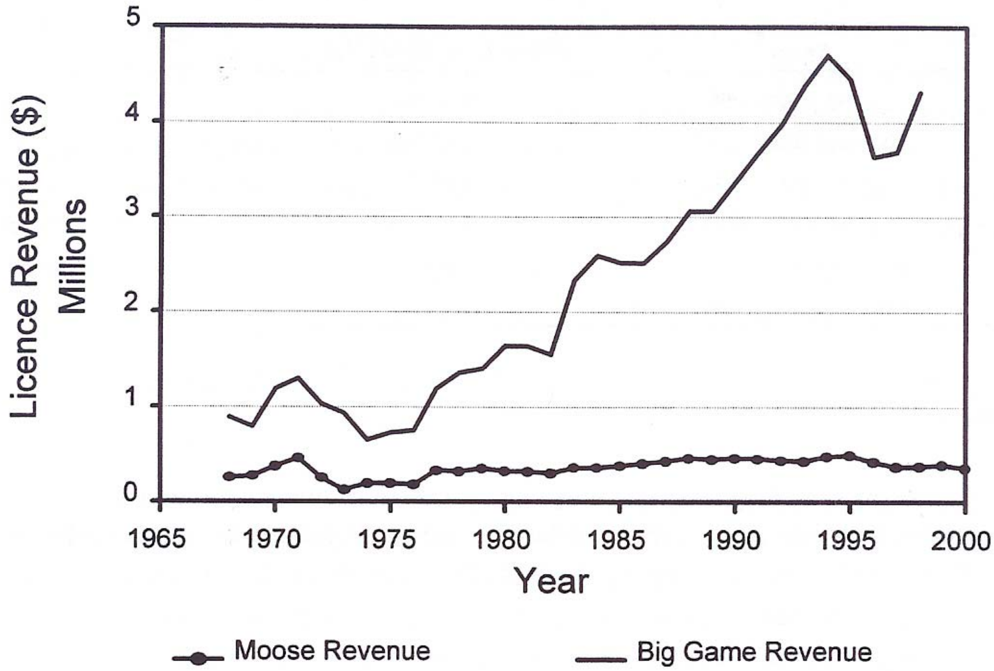

Figure 11. Moose license revenue in relation to big game license revenue, 1968-1999.

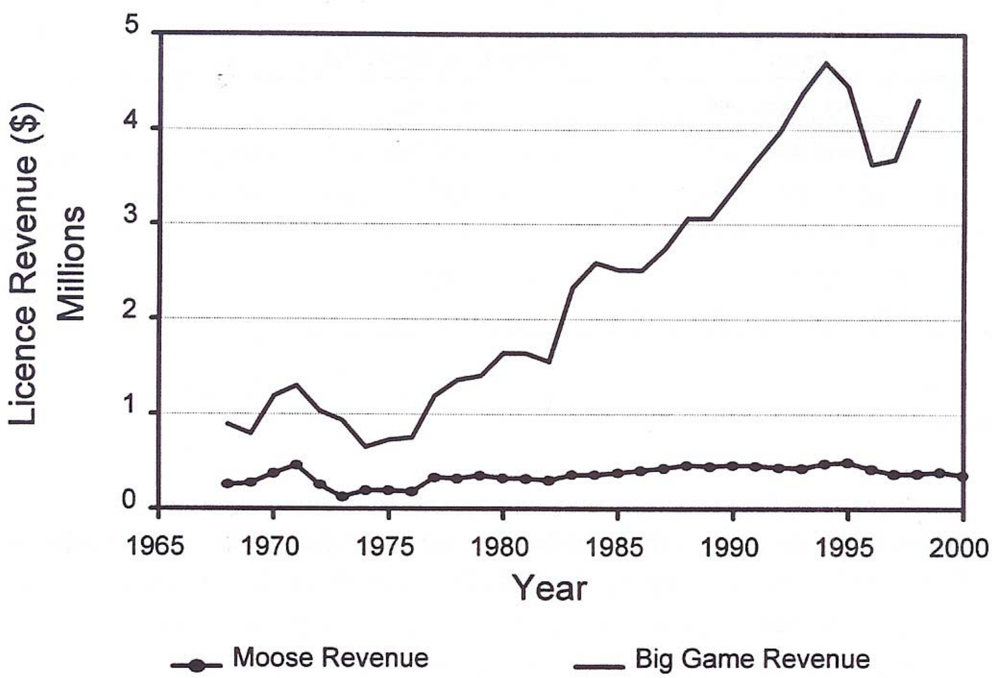

Figure 12. Number of moose hunting licenses issued in relation to annual changes in license fees, 1968-1999.

Table 4. Average moose license revenue/harvested moose in Saskatchewan.

Years	Revenue /Harvested Moose
5-yr avg (1995-1999)	$ 122.83
10-yr avg (1990-1999)	$ 123.89
15-yr avg (1985-1999)	$ 121.81
20-yr avg (1980-1999)	$ 116.70
25-yr avg (1975-1999)	$ 106.55
30-yr avg (1970-1999)	$ 91.92

2.4.3 Outfitting

The outfitting industry currently has approval to guide for resident and non-resident moose hunters in 5 MMUs (Table 5). The high demand for moose by Treaty Indians, and by resident hunters, limits guiding

Table 5. Moose outfitters and licence allocation by MMU, 1999.

MMU	WMZs	Endorsed Outfitters	Active Outfitters	Guided Licence Allocation
Cypress Hills	6, 7	0	0	0
Kindersley	25, 26, 27	0	0	0
Moose Mountain	33	0	0	0
Eastern QuAppelle	35	0	0	0
Duck Mountain	37	0	0	0
Parkerview/Good Spirit	39	0	0	0
Barrier Valley	40, 42	0	0	0
MacDowall Forest	51, 52	0	0	0
Fort a la Corne	50, 43	0	0	0
Sonningdale	45	0	0	0
Porcupine Hills	56, 57, 48	0	0	0
Pasquia Hills	58, 59, 49	0	0	0
Cumberland Delta	60, 61, 62	16	14.5	183
Candle Lake -Cub Hills	63, 64, 65	0	0	0
Sled-PANP	66, PANP	0	0	0
Bronson Forest	68N, 68S,	0	0	0
Divide Forest	67, 55, 53	0	0	0
Thickwood Hills	54	0	0	0
Meadow Lake - PAWR	69	14.5	0	0
Creighton	70	9	3	18
Churchill	71, 72, 73	45	9.5	42
Boreal Shield	74, 75, 76	47.5	14	59
Total		132	41	302

and outfitting industry for non-resident hunting in Saskatchewan. If the moose population in Saskatchewan reaches a level to satisfy demand by subsistence hunters, licensed resident hunters, and non-consumptive users, then surplus animals would be available to allocate to other groups, including the non-resident hunting/outfitting industry. Actual occurrence of guiding and outfitting is minimal with an average of 255 licences actually allocated annually (1977-1999) from an average quota of 420 licences, compared to 11,147 licences to resident hunters, since implementation of the age/sex harvest strategy in 1977 (See Appendix 6).

2.4.4 Non-consumptive Use

Wildlife management is becoming increasingly complex with growing demand for non-consumptive uses of wildlife resources, and larger emphasis on management of non-game species (O'Leary and Weeks 1979). Non-consumptive use of moose is associated with ecotourism. There are a variety of non-consumptive recreational ways to appreciate wildlife (including moose) such as observation, photography, exploring habitat for signs (scats, tracks, browse, sound, sight), maintaining, improving, or securing natural areas, feeding wildlife, television and movies, books, and conservation groups.

Management of moose populations traditionally has been funded from general government revenue but management efforts have benefited other game and non-game species, as well as non-consumptive and consumptive users. Funding from non-consumptive sources is very limited in Saskatchewan. Non-consumptive users can generate revenues to benefit population management while supporting an ecotourism industry. In Saskatchewan, an ecotourism outfitter's fee is charged to obtain a licence to conduct ecotour outfitting in the Manitou Sand Hills (Manitou Sand Hills Planning and Advisory Committee 1996). A similar process is proposed for the Pasquia/Porcupine Hills area of Saskatchewan.

A 1991 survey of the importance of Wildlife to Canadians revealed that Saskatchewan residents spent $76.7 million ($654/participant/year) primarily on non-consumptive trips, compared to $49.1 million ($660/participant/year) on hunting (Filion et al. 1993). Growing demand for non-consumptive use of wildlife, and high demand for consumptive uses requires changes from traditional species management to accommodate consumptive and non-consumptive use programs. These programs should provide information, education, quality experiences to promote good public relations, and must be based on sound integrated resource management, with a sustainable funding source.

2.4.5 Maintenance of Genetics

A variety of plans are being used to harvest moose, but there is little or no information on the plans' genetic effects. Increased vulnerability of prime breeding animals immediately prior to and during peak rut activity may compromise the gene pool by removal of individuals exhibiting physical traits linked to dominance and their potential offspring (Wilton 1992).

Economic and spatial constraints resulting in reduced population sizes of managed species results in susceptibility to genetic drift (Weishampel 1990) and reduced species fitness through loss of genetic variation (heterozygosity). An unharvested moose population of 590 is necessary to maintain an effective breeding population of 50 breeding bulls, and to restrict the incidence of inbreeding to 1% (Reed et al. 1986). Genetic variability provides a basis for populations to adapt to a changing environment (Reed et al. 1986). Loss of genetic variability, because of small population size and accumulation of deleterious alleles through inbreeding, will reduce the chance for long-term survival of a population (Reed et al. 1986).

The number of rare alleles (allelic richness) decreases with decreasing founder population size (Weishampel 1990). The level of genetic diversity in the source population, not the source population size, is the critical factor in determining whether migration or translocation will be detrimental or beneficial to the sink population (Weishampel 1990). To conserve allelic diversity, Weishampel (1990) recommended the initial founder population established should be large (>100). If the managed population is small, migration (or translocation) from a source population (at a rate of 1 migrant/every 2 generations) may be used to offset genetic drift in the managed population, and increase genetic variability (Weishampel 1990).

3.0 Conservation and Management Strategies

3.1 Policy Framework

SERM's corporate mandate is to manage, enhance and protect Saskatchewan's natural and environmental resources (wildlife, fish, forests, lands, parks and protected areas, air, water and soil) for conservation, recreation, social and economic purposes, and to ensure they are sustained for public benefit and for future generations.

The Fish and Wildlife Policy Framework defines the principles of ecosystem management which currently defines the boundaries within Fish and Wildlife Branch Programs (including moose management are developed, delivered and integrated.

3.2 Population Management

3.2.1 Goal

To ensure that viable populations of moose are maintained in their present ecological occurrence at a density and structure that is ecologically sustainable.

3.2.2 Objectives:

To establish and/or maintain optimal winter moose populations in each MMU (Table 6).

To maintain optimal winter adult sex ratios in individual MMUs by meeting or exceeding the minimum recommended ratio presented in Figure 4.

To maintain an average winter calf/cow ratios >35 calves/100 cows in all MMUs, per Figure 5.

Table 6. Moose population objectives (±10%) for Saskatchewan.

Moose Management Unit	WMZs	Winter Population 1999/00 Est.	Winter Population Long-term Obj.	MMU Winter Density (Moose/km²) 1999/00 Estimate 1° Range	1999/00 Estimate 2° Range	1999/00 Estimate Mean	Long-term Objective 1° Range	Long-term Objective 2° Range	Long-term Objective Mean
Cypress Hills	6, 7	312	325	0.72	0.16	0.28	0.78	0.16	0.29
Kindersley	25 - 27	126	150	-	0.11	0.11	-	0.14	0.14
Moose Mountain	33	387	350	0.47	0.15	0.27	0.40	0.15	0.24
Eastern QuAppelle	35	29	30	-	0.05	0.05	-	0.05	0.05
Duck Mountain	37	316	350	0.46	0.10	0.31	0.51	0.10	0.34
Parkerview/Good Spirit	39	74	75	-	0.05	0.05	-	0.05	0.05
Barrier Valley	40, 42	387	400	0.27	0.10	0.13	0.30	0.10	0.13
MacDowall Forest	51, 52	146	145	0.35	0.05	0.07	0.35	0.05	0.07
FALC	50, 43	767	750	0.25	0.12	0.16	0.24	0.10	0.16
Sonningdale	45	81	90	0.24	0.05	0.08	0.30	0.05	0.09
Porcupine Hills	48, 56, 57	5,769	5,500	0.88	0.05	0.66	0.84	0.05	0.63
Pasquia Hills	49, 58, 59	4,732	5,000	0.60	0.05	0.41	0.64	0.05	0.43
Cumberland Delta	60 - 62	3,060	5,500	0.26	0.05	0.26	0.47	0.05	0.47
Candle Lake /Cub Hills	63 - 65	3,889	4,000	0.35	0.10	0.33	0.36	0.10	0.33
Sled Lake/PANP	66, PANP	2,746	3,500	0.18	0.10	0.18	0.23	0.10	0.23
Bronson Forest	47, 68S, 68N	1,446	2,100	0.34	0.05	0.22	0.52	0.05	0.33
Divide Forest	53, 55, 67	4,265	4,900	0.44	0.05	0.26	0.52	0.05	0.30
Thickwood Hills	54	729	750	0.35	0.05	0.20	0.37	0.05	0.21
Meadow Lake/PAWR	69, PAWR	3,064	3,000	0.26	0.05	0.23	0.26	0.05	0.22
Creighton	70	711	850	0.08	0.05	0.08	0.10	0.05	0.09
Churchill	71 - 73	5,997	6,000	0.13	0.05	0.07	0.14	0.05	0.07
Boreal Shield	74 - 76	6,484	6,500	-	0.04	0.04	-	0.04	0.04
Total		45,619	50,265	0.29			0.34		

3.2.3 Issues and Strategies

1. Long-term conservation of wildlife populations must occur within the principles of ecosystem management.

   - Population management strategies must compliment the coexistence of other naturally occurring wildlife and forest resources.

2. As Treaty Indian populations grow, and subsistence rights are applied to moose and other wildlife, the result is potentially larger harvests. If subsistence harvest increases, so does the requirement to adequately assess area specific subsistence harvest of wildlife as a means to effectively manage wildlife populations on a sustainable basis.

   - Treaty Indians involvement with ungulate population management at the management unit (e.g. MMU) level is important, to determine their concerns, needs, and obtain input into decisions that may impact on their ability to exercise treaty rights to harvest wildlife for subsistence purposes.

   - Treaty Indian involvement as a major partner in moose population management should be conducted in a spirit of cooperation with the objective of maximizing benefits (within a biologically sustainable context) for all resource users and for future generations.

3. Aerial surveys are the best method available for assessing moose population status as a basis for determining sustainable harvest levels. This requires considerable effort (survey frequency and size of area surveyed) and resources (money, manpower and equipment) to effectively monitor changes in population status. Monitoring is an essential requirement for assessing the effects of harvest on wildlife populations.

   - A long-term systematic approach is required to assess and monitor provincial moose population density and structure, to quantify progress towards MMU specific objectives, and to establish a baseline from which to manage effectively. The greater the survey frequency, the more precise the estimate of rate of population increase (*r*). Sampling intensity to measure population density should strive for a minimum precision of 90% confidence intervals for density estimates of 20 to 25% (Gasaway et al. 1986, Tarleton 1988). Sampling within this level of precision is practical and adequate for moose management purposes.

   - Population density and structure surveys should be conducted by helicopter in early December, to optimize safety and survey precision (ensure identification of antler classes).

   - Moose population density and structure surveys should be conducted in primary moose range in each MMU at least once every 3 - 5 years depending on the dynamics of the specified population (Timmermann and Buss 1998). Appendix 8 presents survey schedules and priorities for each MMU.

   - Population models could be used to better understand the dynamics of individual moose populations, where sufficient amounts of population survey data are systematically collected.

   - Population status should be reviewed in 5 years to assess progress towards long-term population objectives in each MMU.

3. There is no annual program to monitor population structure.

   - Age structure of harvested moose should be monitored by collecting bottom incisors annually from licensed kills to monitor harvest age structure, to provide guidance for changes to population and allocation management strategies, and to assess the impact of changes in population and allocation management strategies.
   - The incisor sample size for harvested females is small. Mandatory return of incisors for cows is

required to increase sample size. This could be accomplished by establishing a mandatory reporting of all draw animals harvested. It is also necessary to seek the cooperation of First Nations to determine the size and composition of subsistence harvest of moose and other ungulates.

4. Habitat modification does not have a uniform effect on wildlife populations. White-tailed deer, elk and moose populations have benefited from forestry practices, which create early seral habitat, but woodland caribou have been adversely affected because they are dependant on late seral stages of forest.

    - Resource management of the Boreal Shield and Taiga Shield ecozones should ensure conservation of woodland caribou.

    - Woodland caribou conservation should have priority over moose conservation in Churchill and Boreal Shield MMUs.

5. Concomitantly, wolves and bears have also benefited from the increased and/or locally concentrated prey base, and ease of access for foraging, due to habitat modification.

    - In some situations it may be required to temporarily reduce predation to prevent critical local declines in major prey species and allow population growth where habitat modification has induced a low-density equilibrium between a particular prey species and predator. This would help ameliorate man-made environmental factors that limit or stress prey populations until the habitat and prey population has had time to recover. Predator management would require identification of specific areas where wolves, bears and their ungulate prey will be managed for specific uses, while assuring the long-term security of both predators and prey (Gasaway et al. 1992).

    - Predation can be reduced in several ways including diversionary feeding (eg. feeding bears in calving areas), increasing alternate prey if feasible, habitat enhancement, artificially reducing birth rate of predators (hormonal, chemical, immunological or surgical methods), predator relocation, public hunting and trapping of predators, and/or government sponsored predator removal.

3.3 Resource Allocation

3.3.1 Goal

Allocate surplus moose to balance economic and social benefits to Saskatchewan residents, while conserving moose populations and honoring treaty obligations.

3.3.2 Objectives

To conserve moose populations in each MMU by optimizing the sustainable harvest of moose from each MMU by all users (Table 7).

Once conservation needs are met, to provide priority allocation to Treaty Indians for subsistence food needs, second priority to resident licensed hunters, and third priority to commercial outfitting.

Table 7. Recommended sustainable moose harvest levels (±10%) for MMUs under currently used harvest strategies.

		Winter Population		Recommended Sustainable Harvest Under Currently Used Harvest Strategies		
Moose Management Unit	WMZs	1999/00 Population Estimate	Long- term Population Objective	Sustainable Harvest Rate (% of winter population objective)	Sustainable Harvest Objective (ALL Users)	Sustainable Harvest / Unit Area (Moose/km□)
Cypress Hills	6, 7	312	325	15%	49	0.044
Kindersley	25 - 27	126	150	0%	0	0.000
Moose Mountain	33	387	350	8%	28	0.019
Eastern QuAppelle	35	29	30	0%	0	0.000
Duck Mountain	37	316	350	8%	28	0.027
Parkerview/Good Spirit	39	74	75	0%	0	0.000
Barrier Valley	40, 42	387	400	15%	40	0.013
MacDowall Forest	51, 52	146	145	0%	0	0.000
FALC	50, 43	767	750	8%	60	0.013
Sonningdale	45	81	90	0%	0	0.000
Porcupine Hills	48, 56, 57	5,769	5,500	15%	825	0.094
Pasquia Hills	49, 58, 59	4,732	5,000	15%	750	0.065
Cumberland Delta	60 - 62	3,060	5,500	15%	825	0.071
Candle Lake /Cub Hills	63 - 65	3,889	4,000	15%	600	0.050
Sled Lake/PANP	66, PANP	2,746	3,500	65% hunted x 8%	182	0.016
Bronson Forest	47, 68S, 68N	1,446	2,100	15%	315	0.049
Divide Forest	53, 55, 67	4,265	4,900	15%	735	0.045
Thickwood Hills	54	729	750	15%	112	0.031
Meadow Lake/PAWR	69,, PAWR	3,064	3,000	65% hunted x 8%	156	0.020
Creighton	70	711	850	8%	68	0.008
Churchill	71 - 73	5,997	6,000	8%	480	0.005
Boreal Shield	74 - 76	6,484	6,500	4%	300	0.002
Total		45,619	50,265		5,553	

NB. Sustainable harvest is based on homogeneous harvest pressure throughout MMU.

3.3.3 Issues and Strategies

1. Systematic population inventories are the best means available to assess moose population status as a basis for determining sustainable harvest levels, and effective population management. Moose conservation (population monitoring, habitat enhancement and protection) could be ensured if adequate funding could be secured.

   - A method to obtain funding for moose conservation and management from all stakeholders is needed.

2. Conservation takes priority over all allocation.

   - Once conservation needs are met, the order of priority for allocation is subsistence hunting, resident licensed hunting, and commercial (outfitting) hunting.

   - Sustainable harvest (subsistence, recreational and commercial) levels should not exceed 15% of the winter population level for populations harvested under a selective harvest regime (Table 7) (Hatter 1998, Messier 1996).

   - Sustainable harvest levels should not exceed 8% under a non-selective harvest regime or at moose densities <0.20 moose/km² (Table 7) (Hatter 1998, Messier 1996).

   - No hunting seasons should offered for small moose populations (eg. Kindersley, MacDowall, Sonningdale, Parkerview/Good Spirit, Eastern QuAppelle) until such time as surplus animals are available. This would require the cooperation of landowners.

3. Develop a provincial harvest/allocation strategy integrating the needs of all users, and within the ecological and biological constraints presented in this report.

   - Harvest strategies for moose should protect the “primes” of the population to maximize production and direct harvest pressure to the senile and juvenile segments (Aitken and Child 1992, Baker 1975, Timmerman 1992). A light harvest of mature bulls and cows, with a more liberal harvest of younger aged individuals should result in a higher proportion of prime bulls in the adult age structure and ultimately a higher calf production.

   - A variety of strategies are available to manage harvest of moose. These options include:

     1. **Non-selective (either-sex) Harvest Strategy** - promotes herd stabilization by exerting pressure on all population segments equally. This strategy is usually associated with a limited entry draw (quota) system to control the magnitude of the harvest (essentially to limit over-harvest of cows).

2. **Sex and Age Selective Harvest Strategy** - promotes herd growth because harvest pressure is lower on the female component of the population and higher on bulls and calves, facilitating higher production and recruitment (Stewart 1978). This strategy was introduced to Saskatchewan in 1977, followed by British Columbia, Ontario and Newfoundland between 1980 and 1991 (Timmermann and Buss 1995). The strategy allows control of both size and composition of the harvest. Hunting males does not affect the long-term population growth rate or the equilibrium population size provided there are enough bulls to breed all receptive cows in the population (Messier 1996).

3. **Linked Sex Harvest Strategy** - uses the size of the harvests of each sex in relationship to the other to manage for high yield of big game, with a safety margin against overexploitation of either sex (McCullough et al. 1990). This strategy assumes the population responds in a density-dependent manner and the environment is temporally stable. It also requires accurate estimates of population size and structure.

4. **Bulls-only Harvest Strategy** - to protect females and recruitment (results in highly skewed adult sex ratios in favor of females, ineffective reproduction particularly at low population densities, and low average bull age, best applied in remote areas of low hunting pressure).

5. **Bull-calf Harvest Strategy** - to protect females and reduce pressure on bulls (results in highly skewed adult sex ratios in favor of females, best applied in areas of high moose density and low/moderate hunting pressure).

6. **Calf/yearling Harvest Strategy** would allow harvesting cows without calves and theoretically protects primes of both sexes. The result is a significant increase in vigor, productivity and sustained yield).

7. **Selective Bull Harvest Strategy** based on antler architecture has been successfully used by Alaska and British Columbia to increase the number of bulls (where low bull numbers were a concern) by diverting harvest pressure to young (spike and forked antlers) and old bulls (antlers with $\geq$3 brow tines on one antler, or larger than 106 cm spread), and away from prime bulls (Child 1983, Child and Aitken 1989, Schwartz et al. 1992, Timmermann and Buss 1995).

8. **Alternating Hunting Strategy** (combinations of bull-only, bull/calf, female draw and either-sex depending on year and location) was introduced by Quebec in 1994.

9. **Combination Elk-Moose License** (multi-species license concept)

10. **Draw Moose Party License Harvest** to maintain hunter numbers (maximize hunter recreation) and control magnitude of harvest.

11. **Elk or Moose Hunting License** whereby a hunter can hunt either elk or moose, but not both species, in a particular year.

4. Co-management requires regulations and accurate records of harvests relative to subsistence, licensed resident, and commercial hunting. There is no quantitative measure of subsistence harvest. Sustainable harvest objectives for individual MMUs are a function of moose population growth, winter population size, effectiveness of co-management efforts with stakeholders that use the moose resource and the habitats they occupy, and the harvest strategy employed.

   - Co-management is a mechanism of shared responsibilities with the goal of long-term conservation of wildlife while maximizing the benefits that can be secured from this resource. Treaty Indian cooperation and involvement as a major partner, is desired in active moose population management at the MMU level to facilitate co-management of population objectives in all MMUs. Greater First Nations involvement would drive more information exchange and better management.

   - A reporting system, or method of estimation, is required to measure subsistence harvest from each MMU to obtain the information required to better manage moose for all users. This could be facilitated through cooperative moose management programs with these Indian bands, and establishment of a working relationship with subsistence hunters to monitor their harvest and allocation of moose in Saskatchewan.

   - The annual mail-out Hunter Harvest Survey (HHS) and supplemental telephone surveys (where required) should continue to be used to assess the effectiveness of harvest strategies employed to regulate licensed resident and commercial hunting.

   - Explore alternative methods of collecting harvest data, which may increase the efficiency and accuracy of harvest data collection.

   - Consider the use of a voluntary or mandatory tag return by licensed (and possibly unlicensed hunters) as a means of monitoring harvest. A postage paid portion of the tag would be completed by the hunter, and would report the required hunting and harvest information. Alternative survey methods should be compared to the HHS to access which survey method provides better harvest statistics and optimal cost/benefit. Most (77%) North American jurisdictions have compulsory registration of moose kills (Timmermann and Buss 1998).

5. Guided moose seasons should begin the closest Monday to October 1 to accommodate water-based hunting and provide reasonable opportunity for conducting a successful moose-outfitting venture. Guided moose quotas should not be awarded or increased in a particular MMU unless subsistence and resident demands are satisfied first, and only if surplus animals are available.

6. There is no quantitative measure of non-consumptive use of moose in Saskatchewan.

3.4 Habitat Management

3.4.1 Goal

To ensure moose (and other wildlife species) are not adversely affected by land use activities occurring in moose habitat.

3.4.2 Objectives

To conserve moose range within a forest stand management logging strategy.

To limit the amount of active roads and trails in occupied primary moose range to <0.1 km/km^2 of moose habitat.

3.4.3 Issues and Strategies

1. Habitat management strategies must promote healthy habitat inter-relationships. Land management decisions that affect habitat and ecosystem health are the key to future maintenance of healthy and productive wildlife populations.

   - This requires inventory of existing conditions, identification of existing and potential conflicts with other land uses (to avoid or limit confrontation in resource allocation), and definition of long-term wildlife population objectives for the managed land base (that facilitates integration with other land use demands.

2. Habitat fragmentation caused by roads and logging activities has significant implications for moose and other resident wildlife species. Consequently, the logging industry is shifting to a forest stand management logging strategy and shifting away from an operational guidelines approach to cut-over size. Logging strategies in the boreal plain ecozone, which are designed to create a series of successional stages, and to maintain balance among forest habitats, will increase preferred habitat and late-season forage quality and quantity for early forest succession ungulates such as moose and elk.

   - Stand management should focus on access control using a regressive logging strategy which includes harvesting the furthest stands within a designated logging area first and work back to the nearest stands, with prompt reforestation of cut-overs and road retirement as logging progresses. This method would result in long-term rotations of stands, creation of mosaics of stands in several stages of succession, and would minimize road density (access) in active logging areas.

- At least 10% of the cut should remain in islands > 3 ha in size in coniferous stands, 4 ha in mixedwood stands and 5 ha in hardwood stands, to create a mosaic of feeding and thermal/hiding cover. Maximum distance to thermal cover should be <200 m within a cut-over.

- Logging activities should be restricted as much as possible in time and space to minimize disruption of wildlife.

- An adjacent drainage or drainages should remain free of disturbances during logging operations to provide a security area for displaced wildlife.

- Consultation with commercial logging companies is required to ensure ungulate habitat objectives are included as part of the biodiversity/ecosystem management priorities in annual, 5-year and 20-year operating plans of Forest Management Area (FMA) lease holders. This involves integration of forest resource management and wildlife resource management to ensure wildlife concerns are integrated with forest management plans and practices, and to develop/adopt timber harvesting policies that facilitate protection of wildlife populations within the fiscal constraints of economical timber harvesting. When planning timber harvests, habitat management recommendations should be specific to individual management units, have clearly defined objectives, and be incorporated in the planning process when timing and spatial scale distribution of harvest units are identified (Allen et al. 1991).

- Logging operations in the boreal plain ecozone, which promote enhancement of moose habitat (and wildlife habitat in general) should be encouraged, particularly if the activities enhance foraging habitat in the forest fringe and benefit other resident wildlife.

3. Control of human access and disturbance is the most practical and important ungulate management tool available. Restrictions on hunting access and regional hunting prohibitions are effective in protecting wildlife from the negative effects of forest access and harvest vulnerability. Several strategies can be used to control access and disturbance which include:

    - Reduce or eliminate post-burn and post-logging hunting in provincial forest for a minimum of 5-8 years, or until re-growth reaches sufficient height to provide escape cover, to allow access roads to deteriorate enough to reduce ease of hunter access, and to protect re-colonizing moose/wildlife.

    - Logging companies should follow a stand management/regressive logging approach to minimize road density.

    - Forest fire salvage operations should occur as quickly as possible to retire the area and restrict access.

    - Road corridor game preserves have been an effective means to protect wildlife from over-harvest in situations where road access closures are not feasible.

4. Habitat modification should ensure compatibility with other wildlife species and wildlife friendly and sustainable land use activities.

   - Habitat enhancement projects should be handled on a site-specific basis and be facilitated through regional, local integrated resource plans (depending on scale of the project), and/or co-management initiatives. Partnerships with First Nations and/or conservation groups should be formed to help support habitat programs on an MMU basis.

5. There have been no systematic studies of moose/habitat relationships (habitat use and requirements). A comprehensive analysis is needed that interprets seasonal habitat relations of moose to the various ecoregions they inhabit to develop policies for the management of habitat that moose occupy.

   - Research need - In-depth review of moose/habitat relationships in Saskatchewan because habitat use and requirements have not been systematically studied in detail for the province.

5. 20-year cutting plans for Saskfor MacMillan (affects Pasquia and Porcupine MMUs), Weyerhauser (affects Divide, Sled/PANP, and Candle/Cub MMUs), and NorSask (affects Bronson, Divide, Meadow/PAWR, and Churchill MMUs) all indicate that mean forest age will decrease.

   - Need to assess the implication of younger (productive/marketable) forest stands on long-term status of wildlife, particularly woodland caribou and moose through applied research and long-term monitoring studies.

3.5 Science and Education

3.5.1 Goal

Promotion of public and stakeholder involvement programs (science, education and information) and partnerships for managing wild moose in Saskatchewan that will enhance knowledge of moose and improve management capabilities.

3.5.2 Objective

To increase the knowledge of moose (and other sympatric cervid species) biology, ecology and management in ways consistent with SERM's ecosystem management approach.

3.5.3 Issues and Strategies

1. There is a lack of funding for SERM to conduct large-scale moose studies independently.

   - Encourage, conduct and/or direct scientific and educational activities which enhance knowledge and management of moose and other wildlife species, including partnerships with First Nations groups, universities, private organizations, federal government and adjacent jurisdictions in cooperative research and/or management studies.

2. There is no formal information available to resource users that promote the compatibility of timber harvesting and road management with wildlife management.

   - Research is required to test the ecological and functional relationships between clear-cut, forest edge, size of opening, opening shape, age, canopy/cover removal, and use by ungulates. This will provide a scientific basis for design and application of guidelines for forest cutting practices conducive to promoting vibrant ungulate populations in the boreal forest.

   - Road density (number of km/km^2) relationship to moose (ungulate) habitat use and hunter success, should be investigated to determine optimal access for maintaining stable moose (ungulate) populations. This will provide a basis and rational for establishing appropriate road management guidelines in commercially logged forests.

   - Promotional brochures for stakeholders are required to promote the compatibility of wildlife management with timber harvesting, road management, short and long-term road corridor game preserves and wildlife reserves, application of short term local predator reduction programs.

   - Support interpretive and non-consumptive activities that promote public interest in moose and other wildlife.

   - Encourage Indian bands to adopt educational programs that promote wise use of wildlife resources (eg. Project Wild, and its associated spin-off programs).

3.6 MMU Considerations

- Cypress Hills - Co-management initiatives have begun with local Indian bands.

- Kindersley - No hunting by any users.

- Moose Mountain - Island population of moose that could be co-managed with first nations.

- Eastern QuAppelle - No hunting by any users.

- Duck Mountain - may require inter-provincial management plan in the future.
- Parkerview/Good Spirit - No hunting by any users.
- Barrier Valley - growing moose population requiring population assessment.
- MacDowall Forest - No hunting by any users.
- FALC - Road closure program is high priority.
- Sonningdale - No hunting by any users.
- Porcupine Hills - Licensed harvest needs to be reduced; current resident harvest is at sustainable level, therefore total harvest has exceeded maximum sustainable level.
- Pasquia Hills -Need to increase adult sex ratio. Licensed harvest needs to be reduced; current resident harvest is at sustainable level, therefore total harvest has exceeded maximum sustainable level.
- Cumberland Delta - Adopt recommendations stemming from the Cumberland Moose Co-management Board. Need large scale prescribed burning to rejuvenate habitat.
- Candle Lake - Cub Hills - moose population survey required for this MMU.
- Sled Lake - PANP - Only 65% of this MMU is accessible for hunting.
- Bronson Forest - Forest grazing is likely limitation of moose population growth.
- Divide Forest - Forest grazing is likely limitation of moose population growth.
- Thickwood Hills - an effective co-management process is required for managing wildlife in this MMU.
- Meadow Lake - PAWR - Only 65% of this MMU is accessible for hunting.
- Creighton - Woodland caribou conservation takes priority over moose management. Portions of this MMU will be impacted by logging in the near future.
- Churchill - Woodland caribou conservation takes priority over moose management. Large portions of this MMU will be impacted by logging activities in the near future.
- Boreal Shield - Woodland caribou conservation takes priority over moose management.

4.0 Appendix

Appendix 1. Estimated annual winter moose population density.

Moose Management Unit	Area of Primary Range (km^2)	Estimated Winter Population Density (moose/km²) in Primary Range														
		1999	1998	1997	1996	1995	1994	1993	1992	1991	1990	1989	1988	1987	1986	1985
Cypress Hills	233					0.69				0.77			0.69			
Kindersley	a			0.09												
Moose Mountain	527			0.40						0.34	0.31	0.33	0.40		0.61	0.43
Eastern QuAppelle	a															
Duck Mountain	600			0.45											0.79	
Parkerview/Good Spirit	a															
Barrier Valley	519															
MacDowall Forest	98															
FALC	1,557													0.30		
Sonningdale	164							0.25								
Porcupine Hills	6,387	0.88		0.65	0.78	0.71	1.49	0.99	0.84	0.74		0.58	1.00	0.54	0.94	0.75
Pasquia Hills	7,548	0.60							0.70		0.54		0.76		0.96	0.64
Cumberland Delta	11,596			0.26			0.27					0.58		0.49	0.76	0.43
Candle Lake - Cub Hills	10,807								0.35				0.38		0.34	
Sled - PANP	15,024				0.09							0.19			0.15	0.14
Bronson Forest	3,743	0.35					0.48					0.44		0.32	0.43	0.34
Divide Forest	8,840			0.40	0.27		0.53					0.69		0.41	0.33	0.26
Thickwood Hills	1,808														0.33	
Meadow Lake - PAWR	11,126	0.18	0.29							0.12		0.12			0.27	0.14
Creighton	8,372							0.29								
Churchill	18,815															
Boreal Shield	**a**															
Provincial Estimate	**107,761**															

a See Table 3 for areas estimates of primary and secondary moose range.

Shaded numbers are results from quadrat-type surveys.

Appendix 1. (Continued)

Moose Management Unit	Area of Primary Range (km²)	Estimated Winter Population Density (moose/km²) in Primary Range														
		1984	1983	1982	1981	1980	1979	1978	1977	1976	1975	1974	1973	1972	1971	1970
Cypress Hills	233								0.73			0.35	0.25		1.78	
Kindersley	a															
Moose Mountain	527	0.51	0.53	0.63	0.30									0.25	0.28	0.23
Eastern QuAppelle	a															
Duck Mountain	600			0.48	0.32				0.52	0.56		0.70	0.75	0.53	0.56	0.56
Parkerview-Good Spirit	a															
Barrier Valley	519															
MacDowall Forest	98															
FALC	1,557			0.27					0.26	0.34	0.23	0.28	0.30	0.13	0.14	
Sonningdale	164															
Porcupine Hills	6,387	0.67	0.76	0.65	0.51	0.50	0.57	0.69	0.36	0.57	0.45	0.63	0.61	0.43	0.48	0.42
Pasquia Hills	7,548	0.68	0.57	0.58	0.65	0.91	0.92	0.85	1.03	0.95	0.48	0.92	0.46	0.56	0.66	0.87
Cumberland Delta	11,596	0.48	0.73	0.58	0.64	0.66	0.60	0.82	0.80	0.71	0.71	0.65	0.69	0.72	0.75	0.81
Candle lake -Cub Hills	10,807	0.39	0.27	0.23		0.15		0.17	0.14	0.19	0.09	0.19	0.10	0.15	0.21	0.23
Sled-PANP	15,024	0.13	0.12	0.16	0.19	0.23	0.30	0.31	0.21	0.26	0.22	0.17	0.26	0.21	0.31	0.26
Bronson Forest	3,743	0.31	0.49	0.43	0.52	0.42	0.56	0.51	0.62	0.59	0.51	0.49	0.54			
Divide Forest	8,840	0.44	0.30	0.40	0.27	0.39	0.46	0.53	0.28	0.42	0.34	0.33	0.24	0.19		
Thickwood Hills	1,808															
Meadow Lake - PAWR	11,126	0.17	0.13	0.20	0.23	0.24	0.32	0.30	0.25	0.29	0.18	0.21	0.19	0.28	0.31	0.26
Creighton	8,372				0.04	0.04	0.10									
Churchill	8,815			0.10	0.06	0.06	0.03	0.08	0.09		0.06	0.07	0.04			
Boreal Shield	a															
Provincial Estimate	107,761															

a See Table 3 for areas estimates of primary and secondary moose range.
Shaded numbers are results from quadrat-type surveys.

Appendix 1. (Continued)

Moose Management Unit	Area of Primary Range (km^2)	Estimated Winter Population Density (moose/km^2) in Primary Range															
		1969	1968	1967	1966	1965	1964	1963	1962	1961	1960	1959	1958	1957	1956	1955	1954
Cypress Hills	233																
Kindersley	a																
Moose Mountain	527										0.14	0.06	0.08	0.04	0.05	0.05	
Eastern QuAppelle	a																
Duck Mountain	600	0.81	0.57	0.72	0.47	0.37		0.33	0.22	0.15	0.34	0.48	0.29	0.31	0.19	0.13	0.14
Parkerview-Good Spirit	a																
Barrier Valley	519																
MacDowall Forest	98																
FALC	1,557								0.10	0.02	0.08	0.14	0.09	0.04	0.07	0.02	0.10
Sonningdale	164																
Porcupine Hills	6,387	0.54	0.57	0.36	0.36	0.04	0.29	0.35	0.25	0.24	0.35	0.41	0.28	0.22	0.31	0.11	0.27
Pasquia Hills	7,548	0.91	1.11	0.87	0.69	0.66	0.61	0.97	0.95								
Cumberland Delta	11,596	0.91	1.33	1.52	0.77	0.85	0.90	0.62	0.78	1.09	0.98	0.66	0.71	0.42	0.42	0.44	0.61
Candle Lake - Cub Hills	10,807	0.35	0.26	0.09	0.11	0.30	0.27	0.17	0.14	0.10	0.11	0.13	0.19	0.12	0.19		0.05
Sled - PANP	15,024	0.34	0.38	0.39	0.37	0.36	0.26	0.23	0.37	0.28	0.41	0.39	0.36	0.18	0.19	0.13	0.20
Bronson Forest	3,743																
Divide Forest	8,840		0.40	0.36	0.28	0.25	0.31	0.23	0.34	0.39	0.22	0.26	0.38	0.18	0.23	0.14	0.32
Thickwood Hills	1,808																
Meadow Lake - PAWR	11,126	0.41	0.36	0.43	0.37	0.36	0.20	0.32	0.37	0.27	0.26	0.24	0.20	0.11	0.09	0.09	0.14
Creighton	8,372																
Churchill	18,815								0.12	0.14	0.16	0.15	0.09	0.10	0.02		
Boreal Shield	a																
Provincial Estimate	107,761																

a   See Table 3 for areas estimates of primary and secondary moose range.
Shaded numbers are results from quadrat surveys

Appendix 2. Estimated annual winter moose adult sex (bulls/100 cows) ratios.

Moose Management Unit	Adult Sex Ratios of Moose (bulls/100 cows) in Management Unit														
	1999	1998	1997	1996	1995	1994	1993	1992	1991	1990	1989	1988	1987	1986	1985
Cypress Hills					136				58		69	69	88	33	29
Kindersley			71												
Moose Mountain			49												
Eastern QuAppelle															
Duck Mountain			43												
Parkerview-Good Spirit															
Barrier Valley															
MacDowall Forest															
FALC															
Sonningdale															
Porcupine Hills	35		22	17	25	29	38		22						47
Pasquia Hills	35				25	16	27		30					56	41
Cumberland Delta			40			37			45			59	80	55	61
Candle Lake - Cub Hills					59		49				80	144		82	92
Sled - PANP														90	50
Bronson Forest	35														31
Divide Forest			35												39
Thickwood Hills														26	
Meadow Lake - PAWR	37	43												39	47
Creighton							58								
Churchill															
Boreal Shield															

Appendix 2. (Continued)

Moose Management Unit	Adult Sex Ratios of Moose (bulls/100 cows) in Management Unit														
	1984	1983	1982	1981	1980	1979	1978	1977	1976	1975	1974	1973	1972	1971	1970
Cypress Hills								108							
Kindersley															
Moose Mountain															
Eastern QuAppelle															
Duck Mountain															
Parkerview-Good Spirit															
Barrier Valley															
MacDowall Forest															
FALC					43										
Sonningdale															
Porcupine Hills	36	24			39	41	36	70	80						
Pasquia Hills	41	44	49		38	64	54	107	36						
Cumberland Delta	35	49	45	42	45	42	43	40	81						
Candle Lake - Cub Hills	58	28						120	56	33					
Sled - PANP	49	55	44		100	36	35	65	25	100					
Bronson Forest	42	28	41	26	47	26		30	43						
Divide Forest	40	33	60	32	52				62						
Thickwood Hills		92													
Meadow Lake - PAWR	42	38	58		31		67	71	69	47					
Creighton								147							
Churchill								73	71	11					
Boreal Shield								84	78						

Appendix 3. Estimated annual winter moose productivity (calves/100 cows) ratios.

Moose Management Unit	Productivity Ratios of Moose (calves/100 cows) in Management Unit														
	1999	1998	1997	1996	1995	1994	1993	1992	1991	1990	1989	1988	1987	1986	1985
Cypress Hills					121				60		31	79	55	52	67
Kindersley			66												
Moose Mountain			42												
Eastern QuAppelle															
Duck Mountain			30												
Parkerview -Good Spirit															
Barrier Valley															
MacDowall Forest															
FALC															
Sonningdale															
Porcupine Hills	46		52	40	55	73	60		56						61
Pasquia Hills	39			43	67	62	46		46						42
Cumberland Delta			34			43			33					52	48
Candle Lake - Cub Hills					52		51				70	42	47	55	34
Sled - PANP												115		47	41
Bronson Forest	50													42	61
Divide Forest			34												55
Thickwood Hills														69	
Meadow Lake - PAWR	47	51												75	30
Creighton							76								
Churchill															
Boreal Shield															

Appendix 3. (Continued)

Moose Management Unit	Productivity Ratios of Moose (calves/100 cows) in Management Unit														
	1984	1983	1982	1981	1980	1979	1978	1977	1976	1975	1974	1973	1972	1971	1970
Cypress Hills								58	35						
Kindersley															
Moose Mountain															
Eastern QuAppelle															
Duck Mountain															
Parkerview-Good Spirit															
Barrier Valley															
MacDowall Forest															
FALC					47										
Sonningdale															
Porcupine Hills	50	59	68		55	61	47	37	58						
Pasquia Hills	55	37	35		46	34	41	55	54						
Cumberland Delta	43	39	31	31	41	31	52	62	72						
Candle Lake - Cub Hills	47	55			35			57	45	25					
Sled -PANP	51	21	44		41	34		78	42	50					
Bronson Forest	65	52	53	50	57	50		66	61						
Divide Forest	45	51	36	57	65	57			53						
Thickwood Hills		77													
Meadow Lake -PAWR	51	62	67		52		30	51	55	30					
Creighton								47							
Churchill								62	56	33					
Boreal Shield								63	62						

Appendix 4. Annual summary of age classes of harvested moose, 1977-1999.

Year	Sex	Age Classes of Harvested Moose																Sample Size	Mean Age of Individuals ≥ 2.5 years old	
		0.5	1.5	2.5	3.5	4.5	5.5	6.5	7.5	8.5	9.5	10.5	11.5	12.5	13.5	14.5	>15.5		Males	Females
1999	M	13	29	40	46	34	19	8	8	0	1	1	1	0	0	0	0	200	4.1	
	F	11	1	7	6	7	2	1	0	2	1	0	0	0	0	1	0	39		4.8
1998	M	50	78	61	42	25	9	12	3	2	0	3	1	1	0	0	0	287	4.0	
	F	47	6	8	6	6	4	2	1	1	2	0	0	0	0	0	0	83		4.6
1997	M	37	61	43	32	27	16	8	5	2	2	1	0	2	1	0	0	237	4.3	
	F	32	21	12	8	6	5	3	1	0	2	1	2	1	1	0	0	95		5.2
1996	M	60	42	62	49	19	14	3	7	0	1	1	2	0	0	0	0	200	3.8	
	F	62	15	21	5	6	4	2	2	5	3	0	2	0	0	0	0	66		4.8
1995	M	97	235	129	59	32	14	10	10	4	0	2	0	1	0	1	1	595	3.8	
	F	90	42	13	8	4	4	3	6	5	3	3	1	0	2	1	2	187		6.4
1994	M	109	195	109	64	25	21	13	9	6	8	1	2	2	1	1	1	567	4.2	
	F	58	30	22	13	7	4	9	3	4	4	4	3	2	1	1	3	168		6.3
1993	M	83	206	127	57	29	13	10	10	6	3	3	4	0	0	0	0	551	3.9	
	F	93	39	9	12	4	3	3	3	7	1	3	1	2	2	3	6	208		6.0
1992	M	68	165	106	50	21	17	16	6	7	1	4	0	0	0	0	0	461	3.9	
	F	44	27	19	16	9	10	5	6	7	3	3	3	3	2	0	3	160		6.0
1991	M	117	179	111	60	34	34	12	14	4	5	2	0	4	1	0	0	577	4.2	
	F	108	37	31	29	16	8	15	4	9	1	5	3	3	3	1	0	273		5.4
1990	M	133	204	122	63	47	34	15	9	9	3	2	0	2	1	0	0	544	4.1	
	F	102	53	49	35	31	8	4	6	10	7	7	6	4	1	0	1	324		5.2
1989	M	155	210	142	86	67	30	17	12	6	8	4	2	2	1	1	1	744	4.1	
	F	133	42	31	34	20	15	13	13	6	5	7	5	2	2	1	2	331		5.4
1988	M	129	218	179	115	57	31	21	3	7	6	4	4	3	0	0	0	777	3.9	
	F	144	49	39	20	17	8	8	6	9	6	6	6	2	2	1	11	334		5.4

Appendix 4. (Continued).

Year	Sex	Age Classes of Harvested Moose																Sample Size	Mean Age of Individuals $\geq$ 2.5 years old	
		0.5	1.5	2.5	3.5	4.5	5.5	6.5	7.5	8.5	9.5	10.5	11.5	12.5	13.5	14.5	>15.5		Males	Females
1987	M	115	235	168	86	47	21	16	8	10	8	8	4	5	2	0	0	733	4.2	
	F	125	44	30	28	9	8	2	2	9	7	6	4	4	1	2	6	287		6.1
1986	M	132	205	173	94	62	25	10	11	10	10	7	6	3	1	0	0	749	4.1	
	F	100	56	20	14	8	6	6	5	9	3	3	1	4	1	1	0	237		5.7
1985	M	117	164	138	88	41	22	17	14	17	12	13						643	4.2	
	F	84	47	32	20	11	4	15	7	7	6	15						248		5.8
1984	M	176	165	118	86	49	35	26	20	17	8	13						713	4.5	
	F	143	50	19	19	18	15	21	15	13	9	17						339		6.2
1983	M	158	163	92	68	24	25	16	11	7	9	19						521	4.6	
	F	101	35	30	16	17	9	15	7	5	5	13						237		5.5
1982	M		80	60	40	31	23	11	11	9	14	6						285	4.8	
	F		20	16	14	8	11	8	6	3	4	10						98		5.6
1981	M		63	46	46	28	21	20	7	9	4	2	1	0				247	4.5	
	F		15	6	9	8	2	4	7	0	2	2	1	2				58		5.6
1980	M		64	57	48	38	25	17	10	7	6	1	2	2				277	4.6	
	F		22	16	9	6	3	8	3	1	5	7	3	6				89		6.2
1979	M		81	50	41	28	10	10	3	3	5	5	1	1				238	4.3	
	F		20	22	11	14	6	6	5	7	2	5	0	1				99		5.1
1978	M		85	74	57	28	16	13	6	11	3	4	1	2				300	4.3	
	F		29	24	12	14	8	7	4	5	0	1	0	1				105		4.5
1977	M		114	79	61	36	20	15	13	7	3	5	3	1				357	4.3	
	F		30	18	16	10	4	4	3	10	0	2	0	1				98		5.1

Appendix 4. (Continued).

Year	Sex	Age Classes of Harvested Moose																Sample Size	Mean Age of Individuals $\geq$ 2.5 years old	
		0.5	1.5	2.5	3.5	4.5	5.5	6.5	7.5	8.5	9.5	10.5	11.5	12.5	13.5	14.5	□15.5		Males	Females
1976	M	115	189	96	71	34	33	22	19	15	12	30	x	x	x	x	x	636	4.6	
	F																			5.3
1975	M	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	5.3	
	F	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x		6.4
1974	M	121	173	139	95	87	61	35	43	35	26	17	35	x	x	x	X	867	4.7	
	F																			5.7
1973	M	125	111	82	74	83	58	58	60	39	21	12	44	X	x	x	x	767	5.3	
	F																			6.8
1972	M	x	x	x	x	x	x	x	x	x	x	x	x	X	x	x	x	x	5.3	
	F	x	x	x	x	x	x	x	x	x	x	x	x	X	x	x	x	x		6.3
1971	M	233	330	278	233	149	106	80	67	41	44	39	107	X	x	X	X	1707	5.0	
	F																			6.2
1970	M	204	508	234	167	125	110	73	35	25	26	38	105	X	X	X	X	1650	5.0	
	F																			6.2
1969	M	203	274	259	198	124	73	52	36	32	29	26	72	X	X	X	X	1378	4.7	
	F																			5.8
1968	M	188	407	240	125	73	43	37	38	33	31	20	42	X	X	X	X	1279	4.4	
	F																			5.5
1967	M	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	X	x	4.1	
	F	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	X	x		5.8
1966	M	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	X	x	x	x
	F	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	X	x	x	x

x No data available

Appendix 5. Proportion (%) of the provincial regulated resident moose harvest by MMU.

Moose Management Unit	1999	1998	1997	1996	1995	1994	1993	1992	1991	1990	1989	1988	1987	1986	1985
Cypress Hills	1.9	1.2	1.7	1.2	0.7	1.1	0.9	0.9	0.7	0.7	0.5	0.6	0.4	0.4	X
Kindersley	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Moose Mountain	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Eastern QuAppelle	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Duck Mountain	2.1	1.7	1.9	1.3	0.8	1.5	1.0	2.0	1.8	1.2	X	1.2	1.1	1.1	0.9
Parkerview -Good Spirit	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Barrier Valley	2.3	0.8	0.8	X	X	X	X	X	X	X	X	X	X	X	X
MacDowall Forest	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
FALC	2.4	2.0	1.9	1.8	1.5	1.9	2.7	2.2	1.8	1.7	1.4	2.6	1.5	1.5	1.6
Sonningdale	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Porcupine Hills	32.2	35.8	40.6	36.0	42.1	41.9	38.2	39.2	41.2	36.9	35.2	31.3	32.6	33.4	31.7
Pasquia Hills	22.2	20.3	20.6	25.2	26.2	20.9	23.5	19.3	21.0	20.6	29.6	28.9	23.1	23.3	24.7
Cumberland Delta	5.1	2.7	2.4	2.0	3.3	3.9	5.9	5.0	7.8	9.1	12.0	12.2	10.4	13.3	11.3
Candle Lake -Cub Hills	7.7	5.3	3.7	4.7	2.8	3.1	3.8	3.5	4.2	3.6	4.5	2.4	1.7	2.6	2.7
Sled - PANP	3.6	3.3	4.3	3.6	2.5	2.0	2.2	3.9	2.5	3.0	2.3	2.6	2.6	3.0	2.9
Bronson Forest	2.0	6.8	3.5	5.8	5.0	5.0	5.2	5.8	4.6	7.0	2.8	4.4	7.0	6.8	8.6
Divide Forest	9.6	12.4	11.9	12.0	10.4	13.9	11.5	11.5	8.9	9.4	8.8	9.4	13.6	10.8	10.8
Thickwood Hills	1.7	1.1	1.7	1.5	0.4	0.4	0.1	1.1	3.0	4.3	X	1.6	1.9	X	X
Meadow Lake -PAWR	3.3	3.3	2.4	2.5	2.4	2.0	2.5	3.2	1.4	2.1	1.4	2.2	1.9	1.4	2.4
Creighton	1.1	0.7	0.5	0.8	0.6	0.5	0.4	0.7	0.1	0.6	0.8	0.0	0.3	0.5	0.2
Churchill	1.7	1.4	0.8	0.7	0.6	0.8	0.8	1.3	0.6	0.0	0.4	0.4	1.1	1.4	1.5
Boreal Shield	1.1	1.0	1.2	0.8	0.5	1.0	1.2	0.5	0.5	0.0	0.3	0.3	0.6	0.4	0.7
Total Resident Harvest	2214	3092	2374	3181	5063	3367	3812	3098	4092	2983	4563	3857	3379	3472	2066
Guided Moose Harvest	88	122	90	67	61	113	82	174	161	98	156	157	108	96	92

x = no season

Appendix 5. (Continued).

Moose Management Unit	1984	1983	1982	1981	1980	1979	1978	1977	1976	1975	1974	1973	1972	1971	1970
Cypress Hills	X	X	X	1.0	0.0	1.6	X	0.9	X	1.8	X	1.3	X	X	X
Kindersley	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Moose Mountain	X	X	X	2.4	2.4	3.2	2.4	3.1	1.9	4.0	X	2.8	1.3	1.2	X
Eastern QuAppelle	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Duck Mountain	1.0	1.5	1.2	0.9	0.6	0.8	0.9	1.4	1.5	2.6	X	0.9	1.4	0.7	X
Parkerview - Good Spirit	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Barrier Valley	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
MacDowall Forest	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
FALC	1.6	1.7	0.7	1.4	1.4	1.2	2.0	1.7	1.3	0.9	X	X	X	X	X
Sonningdale	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Porcupine Hills	33.1	35.6	32.0	26.5	25.5	24.0	23.4	24.0	26.7	19.2	20.2	13.2	7.0	16.0	19.8
Pasquia Hills	21.6	18.7	14.5	12.3	16.0	16.9	17.4	16.5	18.9	16.3	11.6	18.2	8.6	25.8	24.0
Cumberland Delta	12.8	12.4	14.4	13.3	13.6	11.8	16.8	14.7	15.4	10.2	19.0	23.6	16.6	13.3	17.2
Candle/Cub	3.5	6.2	4.3	8.8	7.3	7.6	9.5	9.7	3.5	16.0	11.7	18.2	21.2	15.2	13.8
Sled-PANP	3.9	3.9	6.6	5.5	4.7	6.6	3.9	5.5	3.6	6.3	10.8	2.1	21.3	12.2	9.7
Bronson	7.3	10.1	10.0	14.7	10.4	13.1	10.2	8.3	9.0	10.5	9.5	2.5	10.0	7.3	5.7
Divide	10.1	5.0	8.6	6.7	8.2	7.3	6.4	5.7	8.5	6.2	5.1	1.9	5.0	2.0	3.5
Thickwood Hills	X	X	X	X	1.1	X	X	X	X	X	X	X	X	X	X
Meadow Lake	2.5	2.8	5.3	2.7	3.9	1.8	2.1	2.0	2.4	3.0	3.9	7.3	X	X	X
Creighton	0.9	0.5	0.6	0.5	1.1	0.5	1.1	0.9	2.4	1.6	a	a	a	a	a
Churchill	1.0	1.8	1.5	1.4	3.7	3.2	3.0	4.9	4.5	1.3	4.6	5.0	4.1	3.9	4.6
Boreal Shield	0.6	0.0	0.3	0.9	1.3	0.3	0.9	0.7	0.5	0.0	3.6	3.0	3.5	2.4	1.7
Total Resident Harvest	3225	2177	2610	2400	5498	4064	4371	4510	2890	2525	2602	2751	4096	9740	9493
Guided Moose Harvest	60	70	93	112	274	167	210	268	n/a	n/a	264	n/a	n/a	208	n/a

Appendix 6. Annual number of licenses allocated by MMU.

Moose Management Unit	1999		1998		1997		1996		1995		1994		1993		1992		1991		1990	
	Draw	Reg	Draw	Reg	Draw	Reg	Draw	Reg	Draw	Reg	Draw	Reg	Draw	Reg	Draw	Reg	Draw	Reg	Draw	Reg
Cypress Hills	60	---	50	---	50	---	50	---	50	---	40	---	40	---	40	---	25	---	25	---
Kindersley	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
Moose Mountain	---	---	25	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
Eastern QuAppelle	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
Duck Mountain	100	37	100	27	100	0	100	5	100	8	100	22	100	35	100	22	100	26	100	36
Parkerview - Good Spirit	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
Barrier Valley	50	---	25	---	25	---	25	---	---	---	---	---	---	---	---	---	---	---	---	---
MacDowall Forest	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
FALC	50	167	50	120	50	75	50	56	100	116	100	76	100	63	100	19	100	29	100	54
Sonningdale	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
Porcupine Hills	175	3237	175	3565	650	3036	650	3667	650	3553	550	2940	550	3407	550	3488	550	4292	550	4036
Pasquia Hills	150	2304	150	2376	500	1927	500	2199	500	2690	500	1520	300	1115	300	2032	300	2580	600	2783
Cumberland Delta	50	320	50	285	50	345	50	284	50	586	350	477	350	563	350	468	350	831	350	944
Candle Lk-Cub Hills	150	644	150	509	150	282	150	414	150	448	150	338	150	428	150	447	150	460	---	803
Sled-PANP	100	227	100	347	100	227	100	301	100	264	100	185	100	235	100	278	100	295	---	383
Bronson Forest	---	293	---	372	---	272	150	272	150	266	150	343	150	301	150	502	150	359	---	342
Divide Forest	---	900	---	1325	---	1108	200	981	200	1312	200	1059	200	1119	200	1119	200	1049	150	1121
Thickwood Hills	50	---	50	---	50	---	50	---	50	10	50	19	50	18	50	49	0	55	---	74
Meadow Lake	---	334	---	405	---	277	---	222	---	301	---	260	---	323	---	206	---	195	---	243
Creighton	---	138	---	109	---	119	---	125	---	248	---	175	---	207	---	180	---	77	---	106
Churchill	---	178	---	224	---	122	---	89	---	159	---	195	---	114	---	226	---	123	---	96
Boreal Shield	---	87	---	81	---	70	---	66	---	40	---	88	---	65	---	56	---	51	---	24
Total	935	8867	925	9745	1725	7861	2075	8681	2100	10001	2290	7697	2090	7993	2090	9092	2025	10422	1875	11045
Guided	226		249		237		223		285		213		206		206		212		249	

x = no season

Reg = Regular license allocation is based on the number of hunters estimated by Hunter Questionnaire Survey results reported in annual Game Management Reports.

Appendix 6. (Continued).

	1989		1988		1987		1986		1985		1984		1983		1982		1981		1980	
Moose Management Unit	**Draw**	**Reg**	**Draw**	**Reg**	**Draw**	**Reg**	**Draw**	**Reg**	**Draw**	**Reg**	**Draw**	**Reg**	**Draw**	**Reg**	**Draw**	**Reg**	**Draw**	**Reg**	**Draw**	**Reg**
Cypress Hills	25	x	25	x	25	x	25	x	x	x	x	x	x	x	50	x	x	x	x	x
Kindersley	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Moose Mountain	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	175	x
Eastern QuAppelle	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Duck Mountain	150	x	150	x	150	x	100	x	100	x	100	x	100	x	100	x	100	x	102	x
Parkerview – Good Spirit	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Barrier Valley	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
MacDowall Forest	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
FALC	200	37	200	59	100	76	100	26	100	36	100	x	100	x	100	x	100	x	200	x
Sonningdale	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Porcupine Hills	550	3492	550	2632	550	2334	550	2678	550	2167	450	2259	450	2479	450	2576	450	2750	451	2958
Pasquia Hills	600	2460	600	2338	600	1766	600	1912	600	1602	600	1713	700	1339	700	1721	702	1845	601	1847
Cumberland Delta	350	914	350	935	350	818	350	925	350	841	350	836	300	924	300	1443	303	1229	300	1467
Candle Lk-Cub Hills	x	502	x	369	x	284	x	439	x	438	x	502	x	795	x	1190	x	1339	x	1529
Sled-PANP	x	333	x	340	x	284	x	400	x	342	x	360	x	500	x	900	x	660	x	717
Bronson Forest	x	288	75	359	250	356	300	394	200	399	250	344	300	504	300	1200	504	974	502	985
Divide Forest	150	1156	196	1095	150	1016	150	846	200	1069	150	633	100	633	100	1068	400	900	400	969
Thickwood Hills	x	x	100	x	100	x	x	x	x	x	x	x	x	x	x	x	x	x	50	x
Meadow Lake	x	156	x	211	x	180	x	190	x	245	x	162	x	231	x	476	x	270	101	444
Creighton	x	97	x	81	x	58	x	99	x	88	x	59	x	71	x	123	x	87	x	181
Churchill	x	66	x	81	x	171	x	222	x	210	x	230	x	197	x	225	x	245	x	578
Boreal Shield	x	49	x	57	x	45	x	75	x	47	x	44	x	0	x	24	x	49	x	84
Total	2025	9550	2246	8557	2275	7388	2175	8206	2100	7484	2000	7142	2050	7674	2100	10947	2659	10347	2882	11760
Guided	252		235		217		208		239		194		212		282		289		284	

Appendix 6. (Continued)

Moose Management	1979		1978		1977		1976		1975		1974		1973		1972		1971		1970	
Unit	Draw	Reg	Draw	Reg	Draw	Reg	Draw	Reg	Draw	Reg	Draw	Reg	Draw	Reg	Draw	Reg	Draw	Reg	Draw	Reg
Cypress Hills	50	x	x	x	50	x	x	x	50	x	x	x	53	x	75	x	x	x	x	x
Kindersley	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Moose Mountain	176	x	175	x	175	x	100	x	175	x	125	x	150	x	150	x	150	x	x	x
Eastern QuAppelle	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Duck Mountain	102	x	100	x	150	x	100	x	175	x	150	x	150	x	175	x	176	x	175	x
Parkerview -Good Spirit	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Barrier Valley	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
MacDowall Forest	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
FALC	201	x	200	x	200	x	150	x	125	x	x	x	x	x	x	x	x	x	x	x
Sonningdale	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Porcupine Hills	503	2852	550	2188	1050	2064	2000	x	2000	x	1500	x	500	x	x		x		x	
Pasquia Hills	802	2018	800	1548	700	1461	1300	x	1300	x	1100	x	900	x	x		x		x	
Cumberland Delta	384	1471	400	1128	400	1065	1100	x	1050	x	1150	x	1000	x	x		x		x	
Candle Lk-Cub Hills	400	1476	400	1132	200	1068	300	x	1450	x	1300	x	1050	x	x		x		x	
Sled-PANP	102	746	100	572	100	540	300	x	300	x	900	x	100	x	x		x		x	
Bronson Forest	800	1213	800	930	600	878	800	x	700	x	700	x	100	x	x		x		x	
Divide Forest	525	857	600	657	600	620	1000	x	1000	x	500	x	100	x	x		x		x	
Thickwood Hills	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Meadow Lake	100	263	100	202	100	190	210	x	300	x	400	x	500	x	x		x		x	
Creighton	x	150	x	x	100	x	250	x	243	x	250	x	250	x	x		x		x	
Churchill	x	422	x	x	200	x	600	x	425	x	800	x	600	x	x		x		x	
Boreal Shield	x	78	x	x	100	x	150	x	115	x	300	x	300	x	x		x		x	
Total	4145	11545	4225	8856	4725	8357	8360	x	9408	x	9175	x	5753	x	400	11184	326	14885	175	15330
Guided	355		394		401		441		427		550		400		1200		2814		1853	

Appendix 7. Provincial summary of hunting and harvest data.

Year	Moose Harvest %Bulls	%Cows	%Calves	Total	Total Licensed Hunters	Hunter Success (%)	# Hunter-days	Hunter-days/ Harvested Moose
1915	---	---	---	860	1,511	56.9	---	---
1916	---	---	---	1,030	2,136	48.2	---	---
1917	---	---	---	1,215	2,250	54.0	---	---
1918	---	---	---	456	1,788	25.5	---	---
1919	---	---	---	1,101	2,764	39.8	---	---
1920	---	---	---	1,220	2,634	46.3	---	---
1921	---	---	---	409	1,568	26.1	---	---
1922	---	---	---	366	1,414	25.9	---	---
1923	---	---	---	324	1,309	24.8	---	---
1924	---	---	---	415	1,110	37.4	---	---
1925	---	---	---	585	1,736	33.7	---	---
1926	---	---	---	683	1,740	39.3	---	---
1927	---	---	---	na	na	na	---	---
1928	---	---	---	881	2,721	32.4	---	---
1929	---	---	---	1,186	3,325	35.7	---	---
1930	---	---	---	1,163	3,001	38.8	---	---
1931	---	---	---	830	2,673	31.1	---	---
1932	---	---	---	430	1,549	27.8	---	---
1933	---	---	---	236	655	36.0	---	---
1934	---	---	---	295	916	32.2	---	---
1935	---	---	---	154	506	30.4	---	---
1936	---	---	---	194	1,084	179	---	---
1937	---	---	---	198	1,191	16.6	---	---
1938	---	---	---	220	1,255	17.5	---	---
1939	---	---	---	337	1,778	19.0	---	---
1940	---	---	---	na	1,476	na	---	---
1941	---	---	---	307	2,154	14.3	---	---
1942	---	---	---	na	2,213	na	---	---
1943	---	---	---	na	2,557	na	---	---
1944	---	---	---	219	2,912	7.5	---	---
1945	---	---	---	143	4,817	3.0	---	---
1946		No Season		0	0	0	---	---
1947		No Season		0	0	0	---	---
1948		No Season		0	0	0	---	---
1949		No Season		0	0	0	---	---
1950		No Season		0	0	0	---	---
1951		No Season		0	0	0	---	---
1952		No Season		0	0	0	---	---
1953	59.9	40.1	---	1,086	4,670	23.3	---	---
1954	58.9	41.1	---	807	4,175	19.3	---	---
1955	54.5	45.5	---	1,730	5,139	33.7	---	---
1956	53.7	46.3	---	4,728	7,023	67.3	---	---

Appendix 7. (Continued)

Year	%Bulls	%Cows	%Calves	Total	Total Licensed Hunters	Hunter Success (%)	# Hunter-days	Hunter-days/ Harvested Moose
	Moose Harvest							
1957	58.9	41.1	---	2,401	5,078	47.3	---	---
1958	---	---	---	2,373	5,370	44.2	---	---
1959	---	---	---	3,240	6,050	53.6	---	---
1960	---	---	---	6,107	8,917	68.5	---	---
1961	55.0	26.0	19.0	6,054	9,997	60.6	---	---
1962	56.0	28.0	16.0	5,066	12,400	40.9	---	---
1963	58.0	29.0	13.0	3,144	9,726	32.3	---	---
1964	57.0	29.0	14.0	3,973	9,459	42.0	---	---
1965	59.0	26.0	15.0	3,960	9,467	41.8	---	---
1966	63.0	21.0	16.0	4,682	10,666	43.9	47,756	10.2
1967	57.0	27.0	16.0	5,246	11,845	44.3	51,410	9.8
1968	62.0	26.0	12.0	6,295	14,295	44.0	62,340	9.9
1969	59.0	24.0	17.0	6,863	13,643	50.3	70,688	10.3
1970	58.0	28.0	14.0	9,610	17,217	55.8	67,491	7.0
1971	54.0	31.0	15.0	9,737	17,754	54.8	72,328	7.4
1972	62.0	26.0	12.0	4,386	12,432	35.3	63,150	14.4
1973	46.0	42.0	12.0	2,780	5,550	50.1	33,033	11.9
1972	44.0	38.0	18.0	2,866	8,900	32.2	32,790	11.4
1975	51.0	37.0	12.0	2,744	9,334	29.4	38,880	14.2
1976	53.0	32.0	15.0	3,120	8,438	37.0	30,125	9.7
1977	64.0	11.0	25.0	4,778	13,483	35.4	54,373	11.4
1978	66.0	12.0	22.0	4,581	13,016	35.2	49,022	10.7
1979	59.0	18.0	23.0	4,231	14,764	28.7	61,541	14.5
1980	58.0	9.0	33.0	5,772	13,716	42.1	54,900	9.5
1981	57.0	16.0	27.0	2,512	13,232	19.0	50,790	20.2
1982	64.0	10.0	26.0	2,702	12,527	21.6	48,123	17.8
1983	59.0	10.0	31.0	2,247	10,073	22.3	38,959	17.3
1984	60.0	11.0	29.0	3,285	10,165	32.3	35,159	10.7
1985	56.3	14.0	29.7	2,158	10,507	20.5	43,208	20.0
1986	60.8	12.4	26.8	3,568	11,486	31.1	49,347	13.8
1987	60.8	13.8	25.4	3,487	11,003	31.7	42,521	12.2
1988	58.6	14.9	26.5	4,014	11,618	34.5	49,205	12.3
1989	56.6	14.2	29.2	4,719	11,692	40.4	51,030	10.8
1990	52.2	16.4	31.4	3,081	11,566	26.6	54,919	17.8
1991	53.7	15.1	31.2	4,253	11,464	37.1	50,844	12.0
1992	58.5	14.3	27.3	3,272	11,189	29.2	51,362	15.7
1993	59.5	13.4	27.1	3,894	10,639	36.6	50,481	13.0
1994	60.5	13.0	26.5	3,480	12,194	28.5	49,657	14.3
1995	61.2	9.9	29.0	5,124	12,140	42.2	56,437	11.0
1996	56.4	15.7	27.9	3,248	10,210	31.8	50,227	15.5
1997	53.4	15.7	30.9	2,464	8,622	28.6	45,481	18.5
1998	58.2	7.9	33.9	3,214	9,520	33.8	44,641	13.9
1999	60.6	9.8	29.7	2,302	9,111	25.3	45,140	19.6
Mean (1977-1999)	58.9	12.9	28.2	3,582	11,475	31.1	49,016	13.7

Appendix 8. Proposed MMU survey cycle.

Moose Management Unit	Survey Priority	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Repeat Year 1
Cypress Hills	3						X	
Kindersley	4							
Moose Mountain	3						X	
Eastern QuAppelle	4							
Duck Mountain	2		X			X		
Parkerview - Good Spirit	4							
Barrier Valley	3						X	
MacDowall Forest	4							
FALC	2		X			X		
Sonningdale	4							
Porcupine Hills	1	X			X			X
Pasquia Hills	1	X			X			X
Cumberland Delta	1	X			X			X
Candle/Cub	1		X			X		
Sled/PANP	2						X	
Bronson Forest	1			X			X	
Divide Forest	1			X			X	
Thickwood Hills	3						X	
Meadow Lk/PAWR	2			X			X	
Creighton	4							
Churchill	4							
Boreal Shield	4							

Note:

First priority surveys are for larger populations (>1,500 moose) and harvest is > 5% of provincial harvest.

Second priority surveys are for smaller populations and/or where harvest is 1.5 - 5.0% of provincial harvest.

Third priority surveys are for hunted island populations, where the survey effort can be accomplished in association with another jurisdiction.

Fourth priority is assigned to populations which are not hunted, have limited growth potential and/or limited harvest; no formal aerial survey effort is required to monitor these herds.

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