WILDLIFE DATA CENTRE

Featured Species – Moose

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At a Glance

Moose, from the Algonquin word *moosu* for "twig biter" or "he strips off young tree bark", are the largest member of the North American deer family weighing up to 700 kgs (1,600 lbs.) and standing nearly 2 meters (6.5 ft.) tall at the shoulder. Numbering between 130,000 – 225,000, British Columbia's Moose population is down from an estimated 300,000 in the 1960s, but continues to be one of the largest of any jurisdiction in the world.

Moose possess long legs and a light to dark brown coat (Figure 1) of hollow hair. They are excellent swimmers and divers and possess the faculties which allow them to travel through and exploit, wetlands including swamps, lakes and rivers, high mountain terrain, downed timber and deep snows. They are cold adapted and are seldom found in areas where mean annual winter temperatures exceed -5 degrees Celsius or mean summer temperatures exceed 15 degrees Celsius. Distinctive physical features of Moose include:

- A long muzzle with a large flexible overhanging upper lip, distinctive shoulder hump and a dewlap or bell of skin and hair that hangs from the throat region.

- Males weigh up to 700 kgs (1,600 lbs.), stand nearly 2 meters (6.6 ft.) tall at the shoulder and are on average larger than females.

- Moose possess some of the largest antlers of the deer family. Antlers are deciduous, beginning to grow in late April to early May and are shed between November and March.

Figure 1. Female Moose can be distinguished from bulls by a lack of antlers, a brown face and the presence of a white vulval patch just under the tail. Prince George, BC. October 2006 (Roy V. Rea).

- Females are distinguished from antlerless males in winter by a lighter coloured face and the presence of a white rump or vulval patch (Figure 1).

***Other names*:** Latin binomial *Alces alces* which in Latin means elk elk; described by Linnaeus in 1758; note: some taxonomists use *Alces americanus;* French: Orignal, European Elk, Moose-Deer, American Black Elk, Forest Oxen, Swamp Donkey (slang)

***Similar species*:** Elk (*Cervus elaphus*) and Caribou (*Rangifer tarandus*) are native ungulates sometimes mistaken for Moose, but are much lighter in colour and slighter in build relative to the dark- to blackish-brown and sometimes grayish- or reddish-brown Moose. Moose are similar in size to a saddle horse and are sometimes mistaken for such, especially bay or black horses.

Tracks of Moose can be used to distinguish them from other similar species (Figure 2). Calf tracks are less than 7.5 cm (3 in.) in width. Cows more than one year of age generally leave tracks that are between nine and 11 cm (4.3 in.), whereas mature bulls make tracks that are generally larger than cows and can be as wide as 14 cm (5.5 in.). The size and shape of the

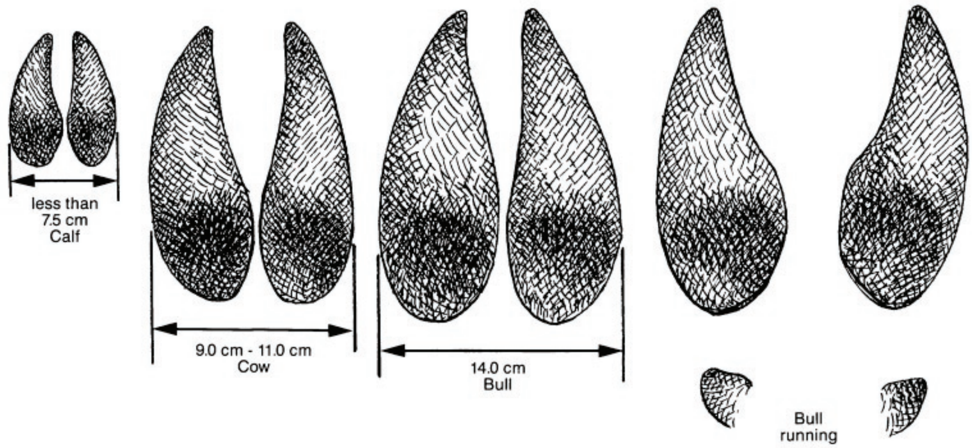

Figure 2. Shape and size of tracks can help identify relative age and sex of Moose (from Timmerman 1990).

track can help in the determination of the sex of the owner. Cow tracks tend to be long and pointed. Bull tracks, on the other hand, besides being generally larger are often accompanied by impressions of the dewclaws and are often round at the tips because of wear from the vigorous pawing activity and traveling during the rut.

Moose droppings (Figure 3) are also generally distinctive from those of closely related species. In the summer, when vegetation is fresh and green, Moose droppings look much like those of domestic cattle. But, in the autumn and winter, Moose begin to feed on woody browse - which has low moisture, but high fiber content. Because of the lower water content of twigs, autumn and winter pellets are drier than in summer and shaped like a large olive. These drier pellets can be used to help identify the age and sex class of Moose. Calf pellets are small about 2.5 cm (1 in.) in length. Cow pellets are about 4.0 cm (1.6 in.) in length, long and narrow in shape and usually are pointed and dimpled at the ends. Adult bull pellets are longer (greater than 4.5 cm (1.8 in.) in length), greater in diameter and blockier in shape when compared to the pellets of cows and calves.

Where and When

World Range

Moose occur throughout the circumpolar north from Fennoscandia through Poland, Russia, and China on the Eurasian Continent and in North America from Alaska across Canada and the northern United States to Newfoundland where they were translocated in 1904. Much of the present range in the Rocky Mountain chain of the western United States has been recently occupied by Moose. Ten Moose were also introduced to the Fiordlands of New Zealand from Alberta in 1910 and were thought to have died off until a naturalist reportedly collected hair samples in 2002.

British Columbia

British Columbia is home to three of the four so-called subspecies of extant Moose in North America. The Shira's or Yellowstone Moose (*Alces alces shirasi)* has the smallest antlers of all the North American Moose (bulls weigh less than 370 kg (816 lbs.)) and lives in the southeastern parts of

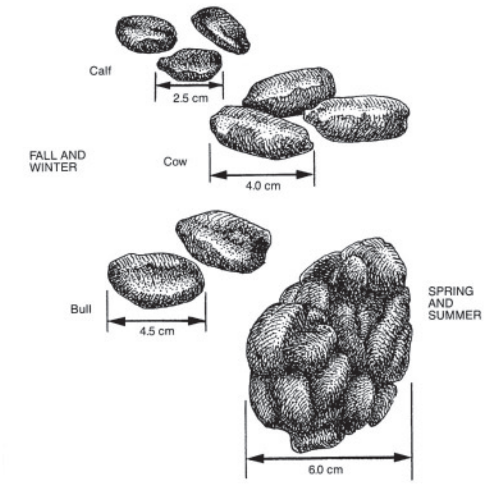

Figure 3. Moose droppings are distinctive in size and shape. Seasonal changes in Moose droppings can be useful to identify the age and sex of Moose (from Timmerman 1990). The Loonie in the image to the right gives scale to this pile of pellets left by a Moose near the Prince George Airport, BC. 23 February 2008 (Roy V. Rea).

the province. The Northwestern Moose (*Alces alces andersoni*), is a medium-sized Moose differing from other North American Moose in some of its cranial details and lives throughout the central interior of the province. The Alaskan/Yukon or Tundra Moose (*Alces alces gigas*) is the largest of all North American Moose (bulls weigh over 700 kgs (1,500 lbs.)) and resides in the northwestern parts of BC. In North America, only the Eastern or Taiga Moose (*Alces alces americana*) - a resident of eastern north America - resides outside of British Columbia.

It is estimated that ancestors of the current Moose evolved approximately 2 million years ago, originating in Fennoscandia where they spread across Eurasia and probably arrived in North America before man by way of the Bering Strait land bridge between 70,000 and 10,000 years B.P.

Northern British Columbia has long been home to Moose, but it is believed that interior and southern British Columbia have only recently experienced robust population increases. Although Moose have historically fluctuated between times of abundance and scarcity, Moose are known to have been part of the oral traditions of First Nations and in written records of the early explorers and settlers in British Columbia for at least the last 200 years, suggesting that Moose probably have resided in the province for a much longer period of time. It appears that the population of Moose in the boreal mountains was so healthy in the 1870's that the Cassiar country gained a world-wide reputation as a Mecca for Moose hunting. Why such population fluctuations have occurred is speculative, but can likely be attributed to interactions between varying intensities of winter weather severity, predation, habitat change and to a lesser extent, hunting, disease, and migratory movements.

In 1892, increasing hunting pressure from Europeans and First Nations newly equipped with firearms was thought to be so intense that the provincial government passed legislation to protect cow Moose. This legislative sanction was the genesis of Moose management and harvest regulations that have been practiced since those times to the present day.

Severely cold winters with deep snow during the late 1700s and early 1800s (part of the "Little Ice Age") likely took their toll on populations of Moose in British Columbia, but historical records are scant and speculative at best.

Historical documents indicate that subsequent to the closure of the Little Ice Age, Moose numbers began to increase in many parts of the province. These increases appear to coincide with habitat changes caused by land-use practices of the early settlers moving into the province. Although natural fires burned in pre-contact British Columbia, the rapid conversion of climax forests to early successional habitats in the wake of land clearing, road and railway construction and man-caused fire created an accelerated rate of habitat conversion favouring Moose. Small and isolated populations of Moose exploited these newly created ranges. As human development continued to expand in the early 20th century, predator control programs aimed largely at reducing Grey Wolf (*Canis lupus*) predation to protect livestock and promote wild ungulate populations coupled with favourable winters, enabled the expansion of Moose in British Columbia.

***Current Status*:** Government records since the 1950's indicate that Moose populations have fluctuated during the last half of the 20th century but are predominantly stable and are increasing in most regional jurisdictions (Table 1). However, populations are reported to be declining in some parts of the Peace River Region of northeastern British Columbia. Winter densities in the province are reported to range from 0.3 to 1.5 Moose per km^2 (0.8 to 3.9 per mi^2) but vary from place to place, in response to availability of winter browse, cover, density and presence of predators, and snow depth. An extraordinarily deep snow pack (approximately double the average) during the winter of 2006/2007 is believed by some Ministry of Environment staff to be responsible for as much as a 70% decline in Moose numbers in northern British Columbia within an 8-month period.

***Occurrence and Distribution*:** Moose are one of the most widely distributed ungulates in British Columbia (Figure 4), inhabiting nearly all parts of the province except for interior grasslands in the Thompson and Okanagan and the Pacific coastal islands. Although absent from a few dry southern valleys, Moose are common in most of the province's mountainous valleys. Recently, Moose have been reported to have expanded their ranges westward

Table 1. Population estimates and status of Moose in British Columbia by Administration Region and Management Area.

Administration Region	Management Area	Estimated Moose Population	Population Trend
1	Vancouver Island*	10 – 20	Stable
2	Lower Mainland	60 - 100	Stable
3	Thompson-Nicola	6000 – 10000	Increasing
8	Okanagan	2300 – 3000	Increasing
4	East Kootenay	4500 - 5500	Stable
	West Kootenay	1500 - 2400	Increasing
5	Cariboo	20,000 – 28,000	Stable
6	Skeena	28,000 – 47,000	Stable
7	Omineca	30,000 – 50,000	Stable
8	Peace	40,000 - 80,000	Variable
Estimated Total		**130,000 – 225,000**	**Stable**

* The Vancouver Island Region includes some areas of the mainland (*e.g.,* Klinaklini River) where Moose are found. No Moose have been reported from Vancouver Island itself.

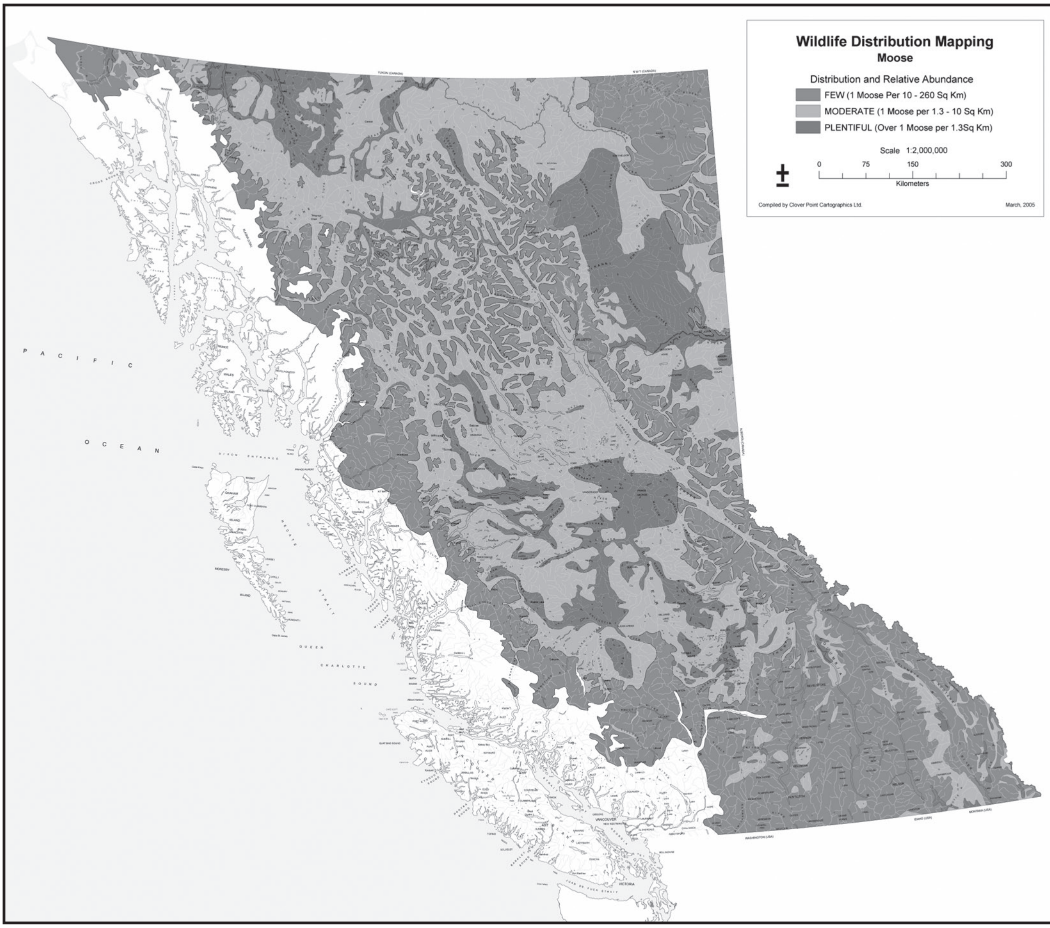

Figure 4. Distribution and relative abundance of Moose in British Columbia. Areas in dark grey contain the highest densities of Moose in the province while light grey and medium grey support relatively fewer Moose. Reprinted with permission from BC Ministry of Environment.

into the coastal temperate rainforests. They are most abundant in the central and sub-boreal forests in the interior, the northern boreal mountains, and the boreal plains of northeastern British Columbia. Over 70 % of Moose in British Columbia live in northern regions; the remainder resides in the Cariboo-Chilcotin, Thompson-Okanagan, and Kootenay regions.

Population Anomalies**:** British Columbia is home to a small population of white (non-albino) Moose near Fraser Lake, BC. In this small isolated population, calves are born brown, but begin to turn to a whitish-gray colour in the second year of life (Figure 5). What mechanism causes this condition in Moose is unknown, but the condition may be related to the presence of a gene similar to that found in gray horses (*Equus caballus*) that are known to gray prematurely in life. This "Gray" gene is thought to reduce pigment deposition in the hair follicles with the advance of age. If the gene is received from both parents, graying advances faster than if inherited from a single parent. True albinism, on the other hand, has been occasionally reported to occur in Moose in the province.

Figure 5. A small population of Moose that are born brown, but begin to turn white in the second year of life (and are therefore not albinos) live near Fraser Lake, BC. Although unstudied, the phenomenon may be attributable to processes that similarly change horses from coloured to grayish-white with advancing age. Fraser Lake, BC. January 2001 (Tony Zagwyn).

Habitat

Moose successfully occupy a large variety of habitats including boreal forest, mixed forest, flood plains, tidewater wetlands, stream valley bottoms, alpine meadows, tundra and sub-alpine shrub communities. Use of habitat is primarily related to the presence and availability of food and cover (Figure 6), but predators, human activities, pathogens, insects, snow cover, fire history, seasonal requirements, climate and competition for forage with other Moose and other ungulates including cattle also influence Moose movements and habitat selection.

Moose habitats can be generally characterized as stable and transitory. Stable habitats are those that remain on the landscape indefinitely and include high elevation shrub communities and riparian areas along watercourses and in deltas where alluvial soils and periodic flooding preclude establishment of coniferous forest stands. Transitory habitats include areas of the boreal forest where either natural (fire, avalanche, American Beaver (*Castor canadensis*) activity) or man-made disturbances (land clearing, logging) have created early seral shrub communities interspersed throughout islands of mature forest cover. These sites are characterized by stands of willow (*Salix* spp.), trembling aspen (*Populus tremuloides*), poplar (*Populus* spp.), alder (*Alnus* spp.) and other deciduous browses and assure the needed essentials are available to Moose for their growth, reproduction and survival. Moose living in stable habitats will move to transient habitats as they become available. Here, they exploit the newly created resources, and rebuild their population numbers only to retreat to more stable habitats as climax stands become re-established through succession.

In British Columbia, Moose are found in nearly all of the province's biogeoclimatic zones, but occur only intermittently in the Coastal Western Hemlock and adjacent Mountain Hemlock biogeoclimatic zones. Moose are not commonly found in unforested or sparsely forested areas such as the Alpine Tundra, Bunchgrass, and Ponderosa Pine zones, but occasional sightings in these areas are testament to the adaptability of the species to various habitats

Figure 6. Lakes, marshes, and swamps are important summer habitats for Moose because of the rich supply of aquatic food plants they provide; the openness of these habitats however imposes risk. Near Chetwynd, BC. 6 July 2003 (R. Wayne Campbell).

that they frequent during their movements between seasonal ranges.

Migration and Dispersal

In mountainous regions, Moose inhabit exposed sunny southerly slopes of birch and willow and are known to seek and remain in aspen stands in the valleys during winter. In spring and summer, Moose venture upslope to the alpine fir thickets which may involve movements of up to 60 kms, but some may remain in the valley bottoms year-round. On mountain plateaus, however, Moose spread out over the landscape during summer months, often frequenting lake shores, swamps, and beaver ponds. In autumn, they may remain on high-elevation ranges much longer than Elk, Deer, or Mountain Sheep (*Ovis* spp.) only to return to the valley-bottom ranges gradually over a period of weeks or months depending on snowfall.

In winter, Moose seek out the denser forest stands along rivers, around wetlands, in burns, adjacent to logged over areas, and on the lower reaches of avalanche chutes in the sub-alpine Spruce-Willow-Birch zone to seek cover, shelter, food and escape from predators. Recent research from the Kootenays suggests that crown closure appears to play a less important role in habitat selection than elevation. Low to mid-elevation sites with gentle slopes and higher solar insolation favor Moose, and because snow conditions can increase energetic costs associated with movement, Moose tend to select sites with a favourable snow pack.

Habitat and Snow

Snow density and depth (if exceeding 70-100 cm) restricts Moose movements. Light, powdery snow permits ease of movement, whereas wet and dense snow conditions can hinder habitat use. A crusted snow pack can make travel difficult and increase risk of injury or pre-dispose individuals to predation by wolves that move easily atop the hardened snow pack while hunting.

If snow accumulation is minimal in early winter, Moose may remain at mid-elevations in mountainous terrain until late winter or early springtime. During a winter thaw, when snow conditions favour travel, Moose may move upslope to their spring ranges.

Habitat Selection and Predation

In the days preceding calving, cow Moose in southeastern British Columbia exhibit two distinct habitat selection strategies for calving – some move up in elevation while others show little change in elevation relative to larger home ranges. Cows that climb to higher elevations select for areas that are characterized by reduced tree density (open canopy), reduced forage quality and quantity, an increased distance from water and especially, where risk to predation by grizzly bears is minimal. Non climbing cows, on the other hand, seemingly trade off increased predation risk by selecting for areas with increased forage, decreased distance to water and more level terrain, but where tree density is reduced and visibility is clearer.

Recent research in the Muskwa-Kechika area in northeastern British Columbia indicates that seasonal ranges of Moose are smallest during calving and largest in summer. Moose in this part of the province generally select for mid-elevations given the topographical diversity of the area and against steep slopes. They tend to move down in elevation from early winter until spring and remain at lower elevations during calving. Moose use pine spruce and sub-alpine areas extensively, and also select for older burned areas and sedge (*Carex* spp.) meadows in all seasons.

Life History

Life Span

Although Moose are known to live for more than 20 years, mean life expectancy in unhunted populations is between 7 and 8 years with females outliving males by an average of about 1 year. The life span of a bull Moose is generally less than that of cows in most hunted populations as well because of the tendency for hunters to select antlered males and the bias against killing females.

Social Organization

Moose are the least gregarious member of the North American Cervids. Although Moose are considered to be solitary forest dwellers, they are known to form temporary "social" aggregations. When several Moose are attracted to a mineral lick or a superior feeding location, they may form a small group, but these groups lack social structure and are temporary in nature. Bulls are generally solitary for most of the year but will, during the breeding season, assemble in groups of 8 to 10 on or near rut arenas and compete for breeding rights to receptive females. This habit is more common in northern shrublands than in forested habitats. It is within these aggregations that Moose are known to use vocalizations and signals among conspecifics to aid in sizing up rivals and in mate determinations, although such modes of communication are not exclusive to the rut and are used between all age and sex classes.

The strongest family bond is formed between cows and their newborn calves which may persist from birth to 28 months of age. Usually a calf remains with its mother until shortly before the birth of a younger sibling in the following spring. At times, the calf, now a yearling, may rejoin the company of its mother and remain with it and the newborn calf for a second year. The general rule, however, is that the cow chases the yearling away facilitating its maturation, independence and its induction into the larger group.

In autumn, forage consumption declines to near zero in rutting bulls causing them to greatly reduce or even deplete the fat they stored during the summer. Where the mature bull component in a Moose population is small (*i.e.,* a preponderance of young bulls and a paucity of older bulls), the rut can become prolonged and bulls can become too physically exhausted to survive any but a milder than average winter. After the rut, bulls depart, and after a short time of interacting with other bulls, move to winter ranges to feed and rest in order to restore their fat reserves to prepare for winter. At this time Moose have also been observed to aggregate or "yard" together (Figure 7) while foraging. Yards are often characterized by a mix of relatively closed canopied, multilayered coniferous forest types intermixed with an abundant shrub layer, but can also be located in clear cuts. Such yards are often located on gentle south-facing slopes that have less snow pack than surrounding areas which facilitates a savings in the animal's energy expenditures used for locomotion.

Figure 7. Although the more outwardly polygamous Tundra Moose form breeding aggregations in the autumn, this appears to be less common in other subspecies. However, Moose are known to yard up in winter, especially in November and December when testosterone levels in bulls drop and they become more tolerant of each other. Such behaviour by the northwestern subspecies in open areas such as this frozen surface on Tezzeron Lake near Fort St. James, may be an adaptation to increased predation risk from Wolves at this time of the year. 16 December 2006 (Dexter P. Hodder).

Such areas allow Moose to regain some of their strength that was lost to the demands of the rut in order to embrace the onset of winter, withstand the demands of heavy snow, and to face their natural predator, the wolf.

Antler Growth, Architecture and Rutting Behaviour

Growth: Antler development is relatively similar among bull Moose of similar age, but different ages show patterns that reflect social positions of the male. Unlike horns, which grow continually through the life of the animal (*e.g.,* as in Bighorn Sheep; *Ovis canadensis*), antlers are shed each year. With the exception of Caribou, antlers are found only on males in all members of the deer family, although on rare occasions antler structures have been found on cow Moose. From the time a bull Moose is one year of age until it reaches its prime, each new set of antlers becomes larger in size, heavier in weight and more elaborate in design, adding branching and "points" that together signal a bull's social rank and reproductive status.

Antler growth follows the same cycle year after year. In late April or early May, antlers begin to grow at definite points on the top of the skull, called *pedicles* (Figure 8), which are located on the outer face of the frontal bone of the skull. Here, the tissue commonly called the *velvet* begins to develop. This is a furry textured skin which covers the entire surface of the growing antler. Beneath this covering, a rich supply of nerves and blood vessels serves the developing, soft bony-like material that eventually hardens into the new antler. While growing, the antlers are tender and fragile and sensitive to touch; they easily bleed if injured and may cause the animal considerable pain if damaged or broken. Unusually shaped antlers may result from injury during the early stages of growth which distort the symmetry and arrangement of the bone-forming cells of the antler when in velvet. By the beginning of September, antlers have reached their full size. The bone near the base becomes denser and eventually cuts off the blood supply to the growing antler. Subsequently, antlers harden, the velvet degenerates, dries and falls off, and the antlers become exposed to be polished by rubbing them on shrubs or trees. The continual rubbing, combined with dried blood, resins, gums and dirt produces the typical brown colour of antlers so characteristic of Moose antlers in the autumn.

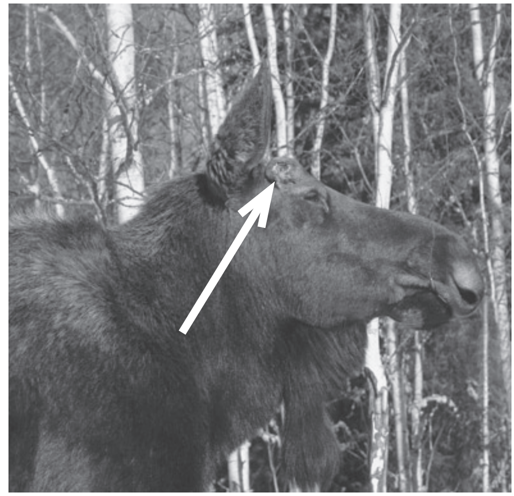

Figure 8. This bull Moose has recently lost its antlers and has formed scabs over the pedicels (white arrow) where the antlers were attached to the skull. Note the pendulous bell hanging from the jawline. Northern Lights Wildlife Shelter, Smithers, BC. 19 February 2005 (Dexter P. Hodder).

Architecture: Two distinct types of Moose antlers are recognized in British Columbia. These are the "palmate" or shovel-horn type characterized by broad up-reaching parallel palms, and the "cervina" or "pole-horn" type, having long tines or spike-like architectures (Figure 9). The palmated antlers are either fully palmated in shape or of a split-palm, butterfly-like design. In the southeastern region, the Shiras Moose sport antlers typical of the pole-horn or cervina type whereas in the northwestern area of the province, Moose typically carry antlers similar in size and shape as that sported by their Alaskan and Yukon cousins.

Although antlers may be used for thermoregulation in summer, for defense or other purposes, antlers appear to play their largest role in intimidation or when threatening a rival bull in order to gain possession of mating rights to receptive cows. Usually, the display

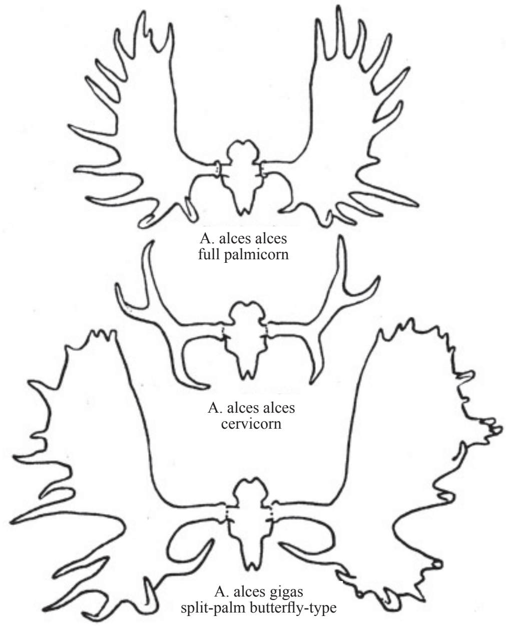

Figure 9. Typical shapes of antlers of Moose in British Columbia (from Timmerman 1990).

of a large bull is sufficient to frighten a younger and/or weaker male. It is at this time, that if two bulls of near equal social rank come together, intimidation gives way to sparring, antler wrestling and head-on fights. With declines in testosterone following the rut, antlers are shed sometime between mid- November to March and the males become sexually inactive until the spring when the cycle begins to repeat itself. Generally, the older bulls shed their antlers sooner than their younger counterparts. Young bulls, on the other hand, have been known to retain their antlers well into late winter or early spring.

Behaviour: Antler architecture is the fingerprint of an animal's identity as it pertains to social rank and consequently, reproductive fitness. Until a bull reaches prime (5–10 years of age), antlers are of an offensive design (spike-like, Figure 10) but as the bull ages, with increasing development and improvement, the antlers take on the more typical defensive palmate form. At maximum development a bull Moose may carry antlers that are double-shoveled and heavily palmated, a signature of a bull in its prime and of high rank in the herd (Figure 11). As the bull passes through prime and his reproductive fitness begins to wane, antler architecture changes in response to physiological and hormonal changes that

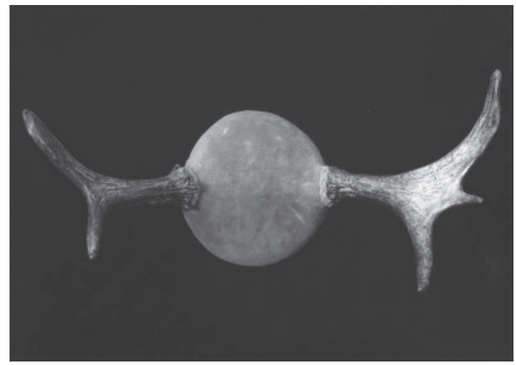

Figure 10. An antler of a yearling male, an offensive structure usually has two or three points on each side. Some may have four or more points on each antler branch or a small palm (Maximus Studios, Prince George).

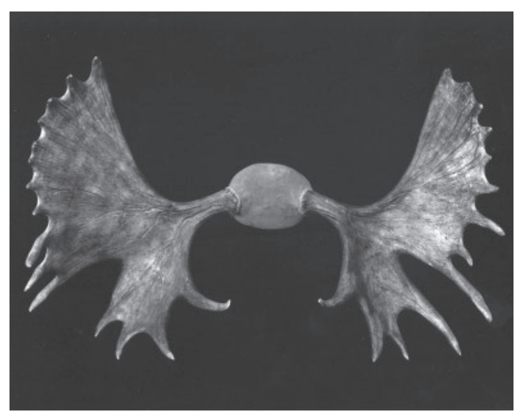

Figure 11. Antlers of a bull Moose in its prime-of-life. Antlers are a butterfly or split-palm type. Note the palmations on the brow palm and the protective architecture afforded by the short distance between the innermost points on the brow palms covering the face and eyes. (Maximus Studios, Prince George).

begin to signify the animal's changing social status. Antlers begin to regress in overall size and shape with age, gradually taking on the appearance more typical of juvenile antler structures (Figure 12). The number of points decrease, palmations degenerate in shape, and overall size and area are reduced. The protective pattern is eventually lost and the more offensive juvenile spike-like structures typical of younger male architectures are present. As the bulls advance into their senior years (11+), their antler architectures continue to regress and degenerate into grotesque and asymmetrical shapes, even misshapen beyond recognition as typical Moose antlers.

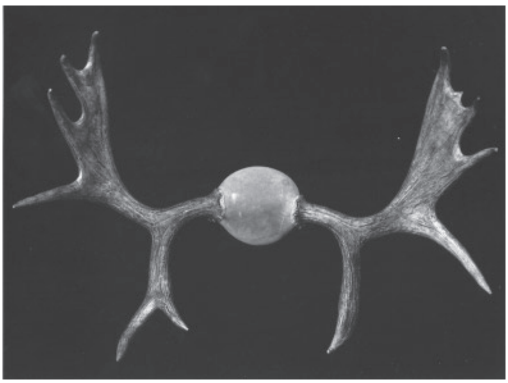

Figure 12. Antlers of a late senior bull Moose that has passed his "prime-of-life". Note the reduction in the number of antler points, regression of palmations and accentuation of the more juvenile offensive characteristics on the brow palms. (Maximus Studios, Prince George).

Although antlers do not indicate accurately an animal's age, they do give us some insight into the social life of the bull Moose. Growth patterns are generally similar among bulls of equal age except, of course, for genetic and food-related variations amongst individuals. Architectural changes are also obvious among bull Moose of different ages. Proportional changes that occur in the design, shape and arrangement of antler components (points and palmations) tell something about the social position, and reproductive fitness of each bull. These design features also tell us something about the condition of their summer ranges because the largest and heaviest antlers are often reflective of the nutritional history of bulls on a high quality forage base during the previous year.

Antler architecture is increasingly becoming important to regulate hunter selection and control harvest levels of Moose in British Columbia. Hunters are required to identify legal bull Moose by antler architecture in several management zones in the central and northern areas of the province in order to achieve Moose management objectives, sustain harvest levels and recreational benefits, but more importantly to ensure that the well-being of Moose as a resource is maintained.

The Breeding [Rut] Season

The annual reproductive cycle for the male begins in spring with the initiation of antler growth. Bull Moose are capable of breeding in their second autumn, but usually are prevented from doing so by intimidation from older, mature bulls providing that these mature bulls are present in the population and have not been reduced by overhunting. Puberty in cows first occurs at 16 to 28 months of age. Female Moose can breed as yearlings if habitat conditions are good, but they usually conceive for the first time as two-year-olds. Most cows produce one or two calves every year during their lifetime with the maximum reproductive output occurring between ages 4 and 7 with steep declines after 13 years of age. Reproductive tracts collected from Moose in the north central interior of British Columbia from between 1977 to 1995 indicate that pregnancy rates among cows varies according to age and was 19%, 73% and 80% for yearlings, 2 year olds and 3-19 year olds, respectively.

The estrous cycle or "heat" lasts between 20 and 30 days and is influenced by climatic conditions, nutritional condition of the cow and genetics. If cows do not conceive in their first estrous, they can re-cycle up to six times into March. Gestation is about 230 days, but can vary between individuals and populations. Data from Wells Gray Park, BC suggest that Moose in the interior do not breed until 2 years of age – age of first breeding being related to the growth rate and body size of the cow Moose, both of which are tied to range quality. Cows usually give birth to single calves. Twinning is common from females living on high quality ranges; triplets, and even quadruplets have been reported as well.

During the rut, cows emit a long, moaning call that is audible for up to 3 km (2 mi). This call attracts a bull or bulls in forested habitats where visual contact is limited. Several cows gather around a prime bull, or two competing bulls, and wallow in the urine soaked rutting pits that are made by the bulls to advertise their sexual status. Bull Moose, as a rule, do not form a harem, but prime bulls, if of equal size and social rank may engage in serious shoving matches to test their superiority (or reproductive fitness) and by such contests win the breeding rights to nearby receptive cows. During these encounters or "rut battles" bull Moose might infrequently lock their antlers together and if unable to free themselves, both combatants could die (Figure 13). Unlike other ungulates, cows are quite aggressive towards one another, and receptive females actively choose their mate, rather than leaving the choice of breeding partner solely to the male.

The Birthing [Calving] Season

Birthing occurs in late May and early June. Pregnant females seek seclusion and chase away their young of the previous year. Newborn calves typically weigh 11 to 16 kg (24 to 35 lbs.) and can stand on their feet within 24 hours after birth. The cow licks them dry to reduce the calf's attractiveness to predators which at the same time, helps establish the maternal cow-calf bond. Cows produce at least 150 liters (40 US Gallons) of milk from June to September, which is important for the calves' early nutrition and growth. Calves initiate light foraging within two to three weeks after birth. During this time, calves acquire the rumen microbes necessary for them to digest plant matter. Calves are generally weaned by late autumn although occasional nursing bouts between mother and calf have been observed

Figure 13. When two mature bull Moose of near equal social rank come together at the rut, they may test their fitness and breeding rights by intimidative gestures or by sparring and antler contact. In some instances, antlers lock together and both combatants die. Summit Lake, near Prince George, BC. December 1983 (Kenneth N. Child).

into late winter. Calves grow rapidly during their first summer and weigh 135 to 180 kg (297 to 396 lbs.) by early winter.

The Cow-Calf Bond

The maternal bond between the cow and her calf is very close and remains so right up to a sibling birth. This bond is essential for the survival of the calf, for it depends on the cow for defense against predators. When the cow confronts a predator, the calf positions itself behind the cow to shield itself, but if separated from its mother, a calf can quickly fall victim to predators.

During their first days of life, calves follow their mothers at a close distance. This following behaviour can be risky to the calf's survival because calves are likely to follow large moving objects, other than their mother. Given this propensity, calves may follow moving objects close to its birth site such as its sibling yearling, humans who may happen upon a new born calf and at times have even been observed to be "adopted" by domestic livestock. This is why it's important for the cow to chase other Moose, particularly, its yearling from the area or seek a secluded and undisturbed birth site. The exclusion of the yearling and other potential distractions is therefore important to the successful establishment of the cow-calf bond and the calf's survival. Yearlings, for example, are characterized by random wanderings to find suitable transient habitat and if not aggressively removed or chased away by the cow from the birthing area, it is then likely that the calf might follow the yearling and become separated and lost. The same fate may fall on calves that are seemingly orphaned and rescued by well-intentioned humans (Figure 14a and 14b).

During the height of the breeding season, both calves and yearlings become inconspicuous by distancing themselves from their mothers and breeding bulls. Bulls are aggressive and generally intolerant of others during this courtship time. Calves hide nearby and normally will join their mother after she has been bred. Yearlings, on the other hand, being expelled from the rut arena by their mothers

Figure 14a. Moose have been integral to the lives of British Columbians since the times of early settlement. Here a young boy near Prince George feeds an adopted Moose. (Exploration Place Archives, Prince George, BC).

Figure 14b. Orphaned Moose have been domesticated and trained for a variety of purposes (*e.g.,* to serve as draught animals, as pets, for livestock and research). (Exploration Place Archives, Prince George, BC. 2008).

will begin their wanderings to find suitable habitat in order to establish their own home range. However, some yearlings may rejoin the cow and her calf and remain with them through the winter until springtime just prior to calving.

Feeding and Diet

Moose preferences for food items vary seasonally and regionally, with different populations selecting different forage items. Moose are ruminants (possess a four-chambered stomach) and although they consume plant parts from a variety of species, they are mainly browsers that predominantly consume tree and shrub leaves and shoots that contain high cell-soluble sugars that will readily ferment in the rumen. Moose are better adapted to forage on coarse woody browse than other hoofed animals that share their range. Moose produce copious amounts of saliva that contains tannin-binding proteins. These compounds are used for inactivating tannins that are commonly found in their food items and which reduce plant digestibility, precipitate proteins and are toxic.

In summer, aquatic plants such as horsetail, bur weed, and submerged pondweeds are important foods (Figure 15). Moose also eat new leaves on a variety of shrubs and herbs in summer. The nutritive quality of leaves generally exceeds that of twigs, and for this reason even fallen leaves make up a substantial proportion of the diet of Moose in fall and winter, allowing them to maintain a higher intake of digestible dry matter than if consuming woody twigs alone. Both deciduous and evergreen leaves and twigs are consumed year round, but especially in winter when leaves, forbs and aquatics are difficult to locate.

Moose depend primarily on willows for winter food. Red-osier dogwood (*Cornus stolonifera*), black cottonwood (*Betula balsamifera*), paper birch (*Betula* balsamifera), aspen, Saskatoon (*Amelanchier alnifolia*) high-bush cranberry (*Viburnum edule*), false box (*Paxistima myrsinites*), sub-alpine fir (*Abies lasiocarpa*) and Pacific yew (*Taxus brevifolia*)

Figure 15. In summer, Moose can often be found in lakes and ponds where they forage for aquatic plants such as rushes and pondweeds. John Prince Research Forest, Fort St. James, BC. 3 June 2004 (Roy V. Rea).

are also important foods. Moose can reach twigs up to 2.5 m (8.2 ft.) above the ground, chew off large-diameter twigs (up to 7mm (0.28 in) and larger) and often break down branches with their jaws to get at tips that are out of reach. Bark stripping of hardwoods such as willow (Figure 16), black cottonwood and trembling aspen is also commonly observed in winter and early spring on both standing and fallen trees. Because of their large size, the high energy demands placed on them by their environment (particularly in winter) and the low total digestible nutrient content of their food, Moose must consume between 20 and 30 kg (44 to 66 lbs.) of forage per day.

Mortality

Moose fall prey to many forms of mortality both natural and man-caused. Hunting is usually the major cause of mortality in managed Moose populations. Moose are drowned in rivers, struck by trains, automobiles and airplanes, entangled in fencing, and succumb to many other forms of incidental mortality (Figures 17 and 18), including being eaten by Killer Whales (*Orcinus orca*). During the most severe winters when the snow cover is unusually deep and long-lasting, Moose may become malnourished and susceptible to death from starvation or attacks by wolves.

Natural Predation

Predation is a major mortality factor of Moose calves. The largest take by predators occurs among the new born calves within the first 6 weeks of life. Black Bears (*Ursus americanus*) and Grizzly Bears (*Ursus arctos*) can kill up to 50% of newborns, while Wolves are known to take a mere 2 to 18% of calves. Cougars (*Puma concolor*) occasionally kill Moose in the Cariboo-Chilcotin and southern interior regions of the province. Overall, predation can be a significant mortality factor on Moose populations particularly when environmental (*i.e.,* snow pack) or demographic (*e.g.,* disease) factors make Moose more susceptible.

Despite the centuries old tradition of predator control and eradication in Russia and Europe, and decades of experience and study in Alaska and elsewhere in North America, the control of predators, primarily Wolves, for the enhancement of big game populations continues to be an extremely controversial wildlife management issue. British Columbia is no exception and public opposition can

Figure 16. Moose such as these two orphans raised by the Langens at the Northern Lights Wildlife Shelter in Smithers, BC strip bark in late winter from both standing and fallen willows. 18 February 2007 (Roy V. Rea).

be expected whenever reductions in wolf densities are proposed to increase Moose or other game species. Where wolves may be responsible for the decline of Moose or other wildlife species, especially at risk or endangered species such as Woodland Caribou (*R. tarandus caribou*), and the Vancouver Island Marmot (*Marmota vancouverensis*), corrective measures might be prescribed to adjust the predator-prey ratio in order to achieve provincial wildlife management objectives. Public consultation is essential, however, in order to ensure that the course of action taken is both socially acceptable and biologically justifiable.

Hunting

With their wide distribution in British Columbia, Moose support many uses and benefits including recreational, sustenance, cultural and commercial interests. In recent decades, Moose have been one of the most important game species in British Columbia, providing more recreational opportunities and more meat than all other ungulates combined. Mature bull Moose are also highly valued as trophy animals for both the hunter and non-hunter. The average annual provincial harvest of 11,500 Moose has generated considerable license revenue for management, habitat enhancement, and enforcement programs, as well as income for guide outfitters and their assistants in British Columbia. A recent report produced by the province's Labour Ministry estimated that hunting, of which Moose hunting constitutes a significant portion, supports 1,730 jobs in the province and contributes $48 million in resident and non-resident hunter spending to the provincial GDP. Other benefits from Moose include several hundred thousand days of recreation for hunters and the meat that the successful hunters take home. The Moose also has aesthetic value as a symbol of the northern wilderness. Many outdoor non-hunting recreationists have been thrilled at the sight of a mature bull or a cow with her calf-at-heel.

Figure 17. A bizarre form of incidental mortality in which electric workers were reportedly stringing power lines near Fairbanks, Alaska when, unknown to them, a bull Moose became entangled in the cable and was subsequently hoisted into the air when the line was winched to the top of the utility poles. 5 October 2004 (City Electric Inc.)

Figure 18. Caslin Rea inspects the carcass of a Moose in the spring that died after becoming entangled in a farmers fence during the previous winter. Near Vanderhoof, BC. May 2004 (Roy V. Rea).

Disease and Parasites

Meningeal Worms: Meningeal worms (*Parelaphostrongylus tenuis*) are parasitic round worms that occur in the brain tissues of Moose and their relatives. These worms are transmitted from one animal to another by way of an intermediate land snail or slug host which is incidentally ingested with forage while animals feed. Once inside, worms migrate to the spinal cord and brain. This infection causes severe tissue damage, neurological dysfunction and death. Moose sickness, remains unreported in British Columbia.

Liver Flukes: Large liver flukes (*Fascioloides magna*) are parasitic flatworms. Flukes attack Moose, deer and Elk, but Moose are the most severely affected of the cervids. Flukes are transmitted by water snails which serve as the intermediate host. Adult flukes are found in the liver. Eggs are discharged via the bile duct into the small intestine then eliminated with the feces. The eggs hatch into a free-swimming larva when in water. The larva then seeks a snail as its intermediate host. Subsequently, the fluke leaves the snail and attaches to aquatic vegetation where it remains until consumed by a Moose. When ingested, the flukes burrow through the intestinal wall and migrate to the liver and the life cycle begins anew. Although generally not considered a major mortality factor of British Columbia Moose, extensive infections of Moose by flukes have been reported in some parts of the province (*e.g.,* 85% of Moose in Kootenay National Park were infected between 1984 and 1989).

Winter Ticks: The winter tick (*Dermacentor albipictus*) is an external parasite that feeds on blood and is considered the most important pest of Moose. In British Columbia, Moose become infested with ticks to varying degrees. As many as 50,000 ticks have been reported on a single Moose.

Female ticks, engorged with blood, drop from Moose in late March or early April and lay 3,000 to 8,000 eggs on ground vegetation. The eggs hatch in late summer. The larvae migrate to the growing tips of vegetation and, upon contact, are transferred to Moose in the autumn. The larvae begin their blood feast from November to mid February when they moult into sexually mature adults. Fertilized females become engorged (up to 1 cm (0.5 in.)) with blood. Engorged females drop from their host in mid March to early April, when the cycle repeats itself.

One consequence of tick presence on Moose is damage to the winter coat that results from excessive itching and grooming in response to the irritation from the ticks. Hair damage usually begins in March on the neck and shoulders and progresses along the shoulders and back to anywhere on the body that Moose can scratch or rub. The energy expended to groom, as well as the extra energy required to stay warm, can push Moose, exhausted and emaciated from a long winter, over the "edge". Young Moose often succumb to these extra energy costs because their large surface area to volume ratios put them at a disadvantage for heat loss at a time of the year when nights are still very cool. In late spring, as ticks become engorged with blood, Moose often become so preoccupied with grooming, and distracted by the infestation, they appear docile and aloof, ignoring threats from humans, predators and vehicles. As a result of this long winter "battle" the longer guard hairs of Moose become broken and Moose take on the lighter colour of their undercoat that earns them the name "Ghost Moose" (Figure 19).

Figure 19. In an effort to rub off ticks, Moose break off their long hairs exposing the whiter undercoat which results in Moose having a mangy white appearance. Isle Royale National Park (Rolf Peterson).

Roads, Railways and Collision Impacts

Moose frequent valley bottoms to a large degree and because they are adaptable to artificially disturbed habitats they are often found in close proximity to roads, railways and other linear corridors (pipelines and powerlines) (Figure 20). These corridors intersect important habitat components, such as forage areas, water and cover, as well as migration and daily travel routes. Because corridors often provide an "edge" of mature forest adjacent to well groomed shrub fields (Figure 21), railways and roads serve as "ecotonal traps", and present an environment of high risk to Moose (Figure 22).

Figure 20. Linear features offer the juxtaposition of early seral vegetation to mature forest for Moose and as such provide a forage base in close proximity to thermal and security cover. Tabor Burn Viewing Area near Prince George, BC. November 2002 (Roy V. Rea).

In winter, Moose use railbeds for easy travel (Figure 23), but in winters of heavy to near record snowfalls, more than 1,000 Moose are believed to be killed within a year by collisions with trains throughout central British Columbia. Interestingly, however, Moose are struck year-round and research into the cause of rail kills and what can be done is a newly emerging issue in the province that must be addressed.

Property damages from collisions are indeed costly and of major socio-economic concern, particularly when human injury or death accompany the incident. The Insurance Corporation of British

Figure 21. Roadside brush-cutting increases sight lines for motorists and keeps vegetation from reaching into power lines, but also rejuvenates browse species used by Moose. In this way brush-cutting can increase the odds of motorists encountering Moose. Near Vanderhoof, BC. July 1997 (Roy V. Rea).

Figure 22. Moose in British Columbia are most often struck by vehicles in mid winter but can be struck at almost any time of the year. Near Fort St. James, BC. October 2003 (Dexter P. Hodder).

Figure 23. Moose using train tracks for ease of travel in winter are reluctant to leave the railbed to enter the deep snow when trains approach, which in many cases leads to their demise. This Moose, struck west of Houston, BC lies near a railbed where the snowpack on either side of the track exceeded 150 cm (59 in.). February 2004 (Roy V. Rea).

Columbia reports an average of approximately 700 collisions with Moose per year (1996-2005) in British Columbia. Material damages from such collisions average $5,500 per vehicle, but claims have been known to exceed $25,000 per vehicle. The severity of damage depends largely on vehicle design and traveling speed at the time of collision, as well as the size of the Moose and how it was struck. On average, Moose are three to six times the weight of deer and damage to vehicles and injury to humans are increased accordingly. Because of their large size and long legs (*i.e.,* high centre of gravity), Moose are often swept up onto the hood of the car and into the windshield as opposed to being thrown underneath or to the side of the vehicle as often occurs in a deer-vehicle collision. Collisions with Moose cause injuries to the head, neck, face, and upper extremities of motorists. Collisions with Moose are considered severe, often totaling the vehicle and injuring and possibly killing vehicle occupants. Between one and four British Columbians are killed each year as a result of Moose-vehicle collisions.

A significant number of Moose that are struck move off the roadbed to die, and are later scavenged, or retrieved by passing motorists. This results in an under-reporting of Moose strikes that leaves managers without any real sense of how many animals are actually lost to this form of mortality. It has been established in some jurisdictions outside of British Columbia (*e.g.,* New England states) that as much as 194% of the allowable annual harvest (AAH) of Moose is lost to Moose-vehicle collisions. In British Columbia, it has been estimated that 10 to 30 % of the AAH of Moose is lost to Moose-vehicle collisions.

Recent research from northern British Columbia suggests that Moose collisions occur most often between November and January and are most prevalent in the early evening hours (between 17:00 and 20:00 hrs PST). Moose using plowed roads and accessing de-icing salts and roadside browse appears to account for some of the increase in collisions; days, however, are also much shorter at this time of year and so drivers are spending proportionately more time driving in low light conditions with poorer visibility. A smaller peak in Moose-vehicle collisions occurs in July when newborn calves are learning about the dangers that roads can present, and when adults switch their diets and are using roadside mineral licks.

Urban and rural roads can pose similar threats to Moose and some cities and towns in northern British Columbia that are home to Moose (Figure 24) are also host to dozens of Moose-vehicle collisions each year. Fortunately, current research and co-operative inter-agency mitigation programs such as the Prince George Wildlife Collision Working Group (comprised of members from the British Columbia Conservation Foundation, the University of Northern BC, the RCMP, Insurance Corporation of British Columbia, the Conservation Officer Service, the Ministry of Transportation, and the Northern Health Authority) are beginning to address this chronic Moose management problem and raise public and industry awareness on the need to mitigate vehicle impacts to the resource and address public safety issues surrounding Moose strikes.

Figure 24. Throughout their range, Moose can become habituated to human habitations which are typically built in traditional winter ranges such as valley bottoms and along rivers. Such interrelationships become problematic when Moose become agents of damage or attempt to share urban roads with motorists. Prince George, BC. 31 October 2006 (Roy V. Rea).

Research funded by the Habitat Conservation Trust Fund, the Insurance Corporation of British Columbia, the Ministry of Transportation, the AutoPlan Brokers, the RoadHealth Task Force and the North Central Guide Outfitters is ongoing in order to assess Moose-vehicle collision “hotspots” in northern British Columbia. The research, conducted at the University of Northern BC, seeks to understand better the ecology of Moose collisions within some of the most hazardous hotspots in the province. Determining how to outfit these areas with site- and species-specific collision countermeasures is the primary objective of the project. Specialized signage installations are one option for mitigating collisions at hotspots (Figure 25). Other mitigation being proposed includes deactivation of roadside mineral licks, adjustment in the time of brush-cutting, and the use of less palatable road salts. Fencing, bridges and underpasses may be used in more densely populated areas and national parks. The education of drivers about when and where to expect Moose and other

Figure 25. Specialized signage, such as this one near Grand Prairie Alberta can be used to alert drivers to areas of recurrent Moose-vehicle collisions. Changing signs regularly and placing them in seasonally relevant places along the highways inhibits desensitization of motorists to wildlife warning signage. 16 April 2006 (Roy V. Rea).

wildlife along highways is a major focus of the Wildlife Collision Prevention Program of the British Columbia Conservation Foundation (http://www.wildlifecollisions.ca).

Management and Conservation

Habitat Management and Conversion

Timber harvesting and other resource extraction activities are common throughout the range of Moose. Although Moose are considered highly adaptable, very little research exists on the limits of Moose adaptability to human alterations of habitat. Even though small-scale changes in habitat may have seemingly imperceptible effects on Moose at any given time, such impacts can be cumulative over the longer term.

Associated access impacts notwithstanding, any activity that converts mature forest into early seral classes improves habitat for Moose, as long as the openings remain small and edges are close together (Figure 26). Management requires knowledge of Moose biology, habitat preferences and ecology and how silvicultural treatments will influence future stand dynamics and provisions for cover and forage. In British Columbia, habitat management goals have included:

- the creation and maintenance of habitat mosaics across the landscape;
- increasing edge habitat;
- rejuvenating older successional stands;
- improving winter browse quality, and;
- developing Moose sensitive access management plans.

Browse enhancement can be accomplished through modified timber harvesting practices, prescribed burning, and the crushing or cutting of decadent deciduous stands. Programs in British Columbia are generally undertaken on a project-specific basis and funded through agencies such as the Habitat Conservation Trust Fund, the Peace Williston Fish/Wildlife Compensation Program, and the John Prince Research Forest. Although these efforts can be expensive relative to the amount of area treated, they ultimately enhance habitat for local Moose populations and provide employment opportunities for those involved. Such projects (*e.g.,* rejuvenating decadent deciduous stands in the John Prince Research Forest) are often tied to long-term monitoring of local Moose numbers.

Forest companies committed to maintaining healthy Moose populations during timber harvesting can help Moose populations by selecting short- and long-term forest harvesting and stand tending methods that maintain highly productive sites for Moose in their harvesting areas. Short-term goals should include: the creation of smaller, irregularly-shaped cut blocks and the retention of buffer strips that obscure Moose from hunters and poachers traveling along roads. Shoreline reserves near aquatic feeding areas, travel corridors, sensitive habitat features such as mineral licks, calving sites and “islands” of mature forest should be left within the cut blocks to provide food and cover. Long term goals should include provisions to ensure that late winter habitats and habitat mosaics are always available to Moose in any given area – forests that provide only optimal summer habitat are useless to

Figure 26. Conversion of older forests to early seral stands dominated by shrubs is beneficial to Moose, but maintaining forest connectivity through corridors, and retaining forest patches within large cuts, is also beneficial as it provides protective cover from hunters, poachers, and predators, and escape from extreme summer heat or deep winter snow. Graham River watershed, BC. 19 June 2006 (Michael I. Preston).

animals that would otherwise overwinter nearby.

The impact that resource roads can have on wildlife should not be underestimated. Uncontrolled access, particularly in Moose autumn and winter ranges, may result in disturbance and increased hunter harvest, which together may result in population reductions, increased stress to the animals and the eventual abandonment of logged habitats by Moose. For this reason, road networks in harvesting areas should be minimized and deactivated for up to 10 years after harvesting until vegetation within the cut blocks has grown tall enough to obscure Moose from vehicular traffic.

The consequences of various management actions on Moose are still poorly understood, particularly where such actions alter factors such as disease, parasitism, predation dynamics, microclimate and forage availability and quality. Careful testing and landscape level experimentation is needed if we are to understand how to optimize and sustain populations of Moose while extracting resources from the habitats in which they live.

Moose as Agents of Damage

Moose are regulators of forest ecosystem processes and alter community composition and structure (Figure 27). Through consumption of forest plant biomass and deposition of fecal material, Moose can have strong and long-lasting impacts to the nutrient cycles and soil productivity of boreal forests. Specifically, when Moose densities are high and browsing pressures are intense, nitrogen content and primary production are depressed because browse species are incapable of returning high quality leaf litter (utilized by Moose) to the forest floor. In some places, this depression of primary production is exacerbated by the fact that Moose do not feed heavily upon the less palatable species such as Spruce (*Picea* spp.) which produce slowly decomposing, nitrogen-poor leaf litter. When browsing pressures from Moose are too intense, forests can be converted to “Moose-spruce savannas” that rarely support healthy forest stands or high crop yields.

Moose browse commercially important conifer trees such as Scott’s pine (*Pinus sylvestris*) and Red Cedar (*Thuja plicata*) in many parts of their circumpolar range, especially where access to high quality deciduous winter browse is limiting. Browsing of Red Cedar plantations in the Revelstoke valley of British Columbia is often intense. Moose will browse leaders and branches of sub-alpine fir and Douglas-fir (*Pseudotsuga menziesii*) and where Moose densities are high or where resources are limited, such damage can be significant. When leaders of young plantation trees are browsed, growth form is altered and quality is negatively impacted.

Uprooting of seedlings, bark stripping and snapping the tops of saplings has also been reported. Damage can occur at any time of the year, but tends to be most intense during spring leaf flush and in winter when shoots comprise the majority of the Moose diet. Bull Moose also damage conifers when rubbing the velvet from their antlers; young bulls tend to direct their sparing activities at younger trees and shrubs before taking on larger bulls. In the Vanderhoof Forest District, pruned pine plantations that were 15-20 years old have been targeted as “rubs” by bulls in autumn, which has led to full and circumferential debarking at a height of about 1.5 meters (4.5 ft.). Without an intact vascular system, the affected trees

Figure 27. Browsing of shrubs and small trees by Moose influences ecosystem processes, but over-browsing may suppress successful regeneration of forest stands. Denali National Park, AK. 22 August 1993 (Michael I. Preston).

die in the growing season that follows debarking.

In parts of the province where hardwoods are commercially harvested, the influence of Moose on standing crops can be more serious and intense. Damage to aspen crops can occur at any stage of tree development, from the browsing of aspen sucker sprouts, to the debarking of older trees. Research underway in the Aleza Lake Research Forest in northern British Columbia is seeking to determine the influence that Moose have on regenerating stands of birch. Birch may become more economically important, as a result of the downfall in timber supply caused by the mountain pine beetle (*Dendroctonus ponderosae*) epidemic. Similary, balsam fir, a preferred browse species of Moose, may become more valued as a commercial crop. Therefore, what was previously considered acceptable damage by Moose to economically marginal crops may require re-evaluation.

Silviculture and Herbicides

Because of fire suppression practices, disturbed areas encountered by Moose today differ from the historic ranges that were once created by fire. Although clear cuts differ in many respects to landscapes left after a fire event, Moose do appear to thrive in post-logging habitats. Moose are most often found within 100 m of a forest edge. Because of a higher edge to area ratio, smaller cut blocks provide better habitat for Moose. Moose tend to select cutovers that are 10 to 20 years in age and that are well-stocked with deciduous browse. Once conifers are established and the shrubs are replaced, Moose will search for suitable habitat.

One factor that can significantly alter cutover range quality, and the likelihood of Moose not using cutblocks, is the application of forest herbicides. Herbicides such as glyphosate kill deciduous cover and release conifer plantations to freely grow. Such herbicide applications reduce browse production for many years and as a result may shift habitat use patterns of Moose.

Unlike herbicide applications, brush-cutting stimulates the production of browse in the years following harvest. Depending on the time of year that brush is cut, cutting can even increase the quality of browse for Moose while at the same time meeting brushing and weeding objectives and providing employment opportunities for forest workers.

Insect Infestations and Removal of Forest Canopy

The forests of central interior British Columbia are undergoing conversions to early seral stages as a result of salvage logging in the wake of mountain pine beetle infestation. Initially, the early successional forests appear beneficial to Moose. Conversion of lodgepole pine (*Pinus contorta*) stands without provisions for movement corridors and cover, however, may result in poorer quality habitats. Additionally, the creation of access to facilitate salvage logging is a major concern because previously remote areas are now open to increased hunting, poaching and predation.

Management Challenges

Hunting

Where Moose populations are healthy, Moose hunting seasons have been established. However, where hunting pressures are excessive, it is necessary to restrict or limit the harvest to certain portions of the population so that the population remains healthy and productive. Such regulations are used to achieve management goals and provide maximum benefits to both the hunting and non-hunting public. General open hunting seasons have traditionally offered hunters the opportunity to hunt bulls, cows and/or calves in some regions of the province. In areas of high hunting pressure, however, general open seasons are unable to sustain harvests and recreational objectives within acceptable levels. In these areas, limited entry hunting strategies and harvest quotas assigned to guide-outfitters have gradually replaced the general open seasons.

Where opposition to limited entry hunting and guide outfitter quotas from hunters and guide outfitters respectively has prevailed, the B.C. Fish and Wildlife Branch has imposed regulations that target certain classes of animals such as the largest and the smallest antlered bulls. These regulations may result in the removal of excessive numbers of prime breeding bulls which reportedly impacts productivity. In comparison to the harem breeders such as Elk, Caribou and Mule deer, Moose require a high proportion of mature males in the population in order to maximize reproductive output. In many parts of North America, including British Columbia, hunting traditions have favoured the harvesting of large antlered bull Moose. In areas where hunting pressure has been excessive for long periods of time on these males, with protection afforded the younger male segments (spike-fork antlered bulls), calves and females, the genetic pool will be degraded. Therefore, it is imperative that the harvest is structured and hunter take is selective in order to safeguard the well-being (genetic fitness) of the resource and to ensure that both economic and recreational benefits are sustainable. A management and philosophical dilemma exists: is hunting a product or a tool? That is, should traditional hunting practices that favour male harvests continue as practiced in British Columbia solely for the benefit of the user [the product] or, should hunters be directed to be more selective of their target [the tool] when hunting in order to benefit the resource? The dilemma remains; the debate continues; a decision is needed.

Non-Hunting Values

The challenge that continues to face Moose management in British Columbia is to ensure the long term well-being of Moose as a resource while at the same time sustaining the variety of uses in order to satisfy public demands. Historically, Moose have provided food, clothing, and tools for both First Nations people and early settlers. Moose continue to offer a variety of complimentary values; namely, hunting, license revenue, meat, antlers and hides for artisans and for both cultural and ceremonial practices, aesthetics (viewing, photography), commercial enterprise, and scientific and ecological study. As populations increase and expand their ranges throughout British Columbia, the resource promises many benefits, if managed in a sustainable manner.

Public Recreation and Associated Disturbance

Although some Moose can habituate to human activities in areas such as transportation corridors, parks, and military bases, Moose are known to be sensitive to, and react to, a variety of human related activities. Moose tend to be disturbed more by humans than by any of the machines we operate. This type of response is commonly observed among people who take photographs of seemingly docile Moose along a roadside from a car, but miss that great photograph when they step outside of the vehicle and elicit the animal's flight response. Whether such responses are a learned or an innate response is speculative, although research continues to seek to understand if Moose reactions to such stimuli are built-in predator defense strategies or something less understood.

Moose are known to flee from humans (*e.g.,* skiers, hunters and infantry personnel) and react at shorter distances from humans than from machinery such as snowmobiles and military equipment (attack helicopters, battle tanks, jet fighters). However, the distances traveled to evade equipment often surpasses distances undertaken to escape humans that are on foot. Research from Wyoming suggests that snowmobiles negatively influence a variety of Moose activities including bedding and feeding; the intensity of the disturbance increases with increased proximity, with Moose moving away from regularly used snowmobile trails as the day progresses and snowmobile traffic increases. Such reactions to machinery are problematic when activities displace Moose to less favourable habitats, particularly at times of the year when quality food resources are hard to locate. Moose do not appear to be negatively influenced by the operation of logging equipment. In fact, Moose have been observed to be attracted to sites of active logging because crown leaves and twigs become immediately available on the fallen trees (Figure 28).

Figure 28. Moose are often seen near logging operations where access to previously unaccessible tree tops appears to serve as an attractant. Prince George, BC. February 28, 2008 (Roy V. Rea).

Hydro-electric Impoundments

Flooding of low valley bottoms, characterized by riparian habitats and subclimax habitat, by hydroelectric developments constitutes a major impact on Moose that traditionally used these areas. The creation and operation of hydro reservoirs may impact Moose in a variety of ways; namely by displacement, disruption or loss of seasonal migrations, permanent habitat loss, or increased vulnerability to natural predators. With blockage of access to traditional calving and winter ranges, mass starvation may also result. Ice shelving, open water, thin ice, and floating debris may also cause direct mortality to swimming Moose. Collisions with vehicles may increase on service roads, and snow drifting may impede movement, or prevent escape from predators or vehicles.

All of these factors, being additive in nature, take their toll on Moose numbers. Thousands of Moose have died in reservoir developments in British Columbia and comparable numbers have probably died in similar hydro-electric projects across North America. The two most detrimental impacts of hydro-electric impounds are permanent loss of highly productive ranges and displacement of animals to less productive sites which together pre-dispose Moose to other mortality risks. At the Williston Reservoir (1,761 km^2) (436,000 acres) on the Peace, Parnsip, and Finlay rivers (Figure 29), thousands of Moose died, or were displaced, by rising flood waters when the impoundment was created in 1968. Resident populations declined by 70 % from the 12,500 animals estimated to be present prior to flooding. Similarly, when the Ootsa Reservoir was built in 1952 by Alcan, 398 km^2 (98,350 acres) of unlogged river valleys were flooded. In that area, traditional migrations ceased as hundreds of Moose, unable to cross on the thin ice to southern wintering areas, became entangled in the shoreline and floating debris and drowned. Disease and predators further aided the decline. With critical habitats now destroyed, post-impoundment population numbers have never recovered to their former abundance. In the Revelstoke area, creation of a 136 km^2 (33,000 acres) hydroelectric reservoir by BC Hydro on the Columbia River in 1977 resulted in similar impacts on resident Moose populations. The displacement

Figure 29. The Gordon Shrum Generation Station and WAC Bennett Dam on the eastern reach of the Peace Arm of Williston Reservoir. Constructed in 1968, the impoundment flooded about 1,761 km^2 of river valley and riparian habitat, both high quality Moose calving, summer and winter habitat. It is estimated that more than 5,000 Moose died, drowned or were displaced by the rising floodwaters (British Columbia Hydro).

of resident Moose to winter ranges of lower quality forecasted a continued declining trend in resident Moose numbers. In studies on the effects of the Mica Dam on fish and wildlife species, it was estimated that the 480 km^2 (119,000 acres) of riparian habitat and 19 km^2 (4,760 acres) of sloughs and wetland edge in the mainstream reservoir area supported 800 Moose. Now about half (400) of the pre-impoundment population is estimated to currently reside in the area of the reservoir.

To offset these impacts, compensation has been negotiated and programs are currently active for wildlife on all reservoirs in British Columbia. These Programs, which are co-operative efforts between BC Hydro, BC Environment, First Nations and non-government agencies are actively compensating for lost habitat by enhancing suitable ranges adjacent to the reservoirs, in order to re-establish or maintain existing populations of Moose and other species that have been impacted or displaced by the floods.

Oil and Gas

Generally, more roads result in an increase in Moose mortality. This is a result of both direct (automobile collisions) and indirect (access by hunters) causal factors. Oil and gas development has a similar disturbance signature to that of the construction and maintenance of linear corridors such as highways, railways, and power line rights-of-way. Moose are mostly impacted by oil and gas development activities that create early successional habitat which, being attractive to Moose, may lure them into areas of high vehicular activity and consequently high collision risk as well as exposure to hunters, poachers and possibly predators. To this end, research in British Columbia is currently being conducted in areas such as the Muskwa-Kechika in an effort to provide good science for pre-tenure planning for oil and gas exploration and development.

Pipeline construction can have negative impacts on Moose (Figure 30). Once installed, above-ground pipelines may hinder seasonal and diurnal movements of Moose, or fragment habitat. Serious considerations for effects of snow cover around elevated structures are necessary, especially in areas with high snowfall, as deep snow under pipelines has been reported to impede movement.

Figure 30. Pipeline construction can be dangerous for wildlife. Here, a bull Moose trapped in a pipeline trench had to be rescued by construction workers who used an excavator to build a ramp which the Moose used to escape. (hunting.bookpub.net/Moosephotos.html).

Figure 31. The Wolverine Mine (source mountain at top right) near Tumbler Ridge, BC threatens a nearby marsh (centre of image) where Moose were regularly observed feeding during development of the operations area for the mine (the cleared area in the foreground). 23 June 2005 (R. Wayne Campbell).

Mining

Large depressions from strip and open pit mining (Figure 31) and gravel borrow pits have claimed the lives of some Moose. Moose that have fallen into these man-made excavations either break their necks or die of exposure or starvation. Mining exploration "trenches" can be death traps for Moose. On occasion, Moose become "hog-tied" in the decking of unplanked wooden bridges on access roads or might fall victim to collision. Entanglement in discarded waste construction material (wire) has snared, crippled or strangled Moose. Local habitat alteration or fragmentation, particularly in open-pit coal mining operations in the northeast and southeast regions of the province can negatively impact local traditions but reclamation practices can, by restoring early seral shrub lands, offset severity of the local impacts. Interestingly, in north central British Columbia, the open pit copper mine at Granisle was reported to provide Moose a safe haven from predators because the mining activity displaced wolves at a distance from the mine, offering security "cover" to the Moose.

Management Recommendations

As long as forestry and land development activities in the province continue to facilitate the development of early successional habitats, with some associated matrix of mature forest, Moose can be expected to thrive. Roads and unrestricted access, hunting pressures and predator densities, obviously influence such projections. Whether in the harvesting of forests, the blazing of seismic lines, or the building of roads, however, the protection and maintenance of habitat features important to Moose must be provided for in development plans and operations. Features such as mineral licks (Figure 32), river bottoms, wallows, rut arenas, calving areas, critical winter range, and wetlands as well as adjacent forest cover should be identified, classified and protected from development activities if the importance of these features to Moose is to persist on a long-term basis.

Figure 32. Moose such as this cow with newborn calf, use mineral licks at various times of the year, but do so predominantly in the mid summer and mid winter when accessible (Trailmaster Camera Monitoring System operating in the John Prince Research Forest, July 2003).

Management strategies that disregard these concerns are damaging to the Moose resource and should become unacceptable in an enlightened society. How the results-based environment in which we now live in British Columbia will stand the test of time remains to be seen. Science-based solutions are required in order to answer questions about how resource development and extraction, and climate change for that matter, will affect

Moose. Collaborative efforts amongst stakeholders are needed now to ensure that Moose will remain a valued resource in British Columbia and that their needs are addressed.

Research and Monitoring of Moose in British Columbia

Moose populations in British Columbia are monitored through a variety of means including aerial surveys (Figure 33), pellet counts, track and browse surveys, hunter surveys (both resident and non resident) and anecdotal information from naturalists, trappers, hunters and guide/outfitters. The provincial Annual Hunter Sample and Guide-Outfitter Returns have been conducted since at least the early 1950s and are among the most extensive of any wildlife agency in North America. The Wildlife Accident Reporting System (WARS) compiled by the Ministry of Transportation uses data collected by highway maintenance contractors on road kill within highway corridors. The WARS system, and data collected on rail-killed Moose by railway personnel, holds the potential to monitor fluctuations in Moose numbers throughout the province from year to year. This monitoring potential needs further investigation to initially validate the reliability of the databases and begin to seek solutions to collision losses of Moose. The contributions of naturalists' and field biologists to the Biodiversity Centre for Wildlife Studies is encouraged in order to improve databases and compliment field studies.

British Columbia has been home to much research focused on the ecology and management of Moose. These projects have included: quantifying the impacts of forest harvesting on Moose, determining reproductive outputs of Moose, investigating annual fluctuations in browse quality, studying the impacts of silviculture on browse quality, response of plants to Moose browsing, the ecological importance of mineral licks, habitat enhancement options, the influence of snow pack on movement patterns, Moose-vehicle and Moose-train interactions, the impact of access on habitat use, habitat selection strategies, calving strategies, predator-prey dynamics in oil and gas exploration and development sites, Moose-Elk interactions and lastly, Moose-wolf predator-prey relationships.

Research is currently being conducted in the East Kootenay and throughout northern British Columbia. In northern British Columbia, research installations are found in the Muskwa Kechika area, at the John Prince Research Forest (near Fort St. James), at the Aleza Lake Research Forest (East of Prince George), within the Omineca River/Williston Reservoir, near Williams Lake, and in the Parsnip River drainage area.

Figure 33. Aerial surveys are generally conducted in the winter when Moose are easier to observe against a back drop of snow. Muskwa River, BC. March 1995 (R. Wayne Campbell).

Currently, two high profile Moose research projects underway in British Columbia are the Parsnip-Caribou Recovery Project and a similar project in the Revelstoke area. The multi-year Parsnip Caribou Recovery Project led by the Ministry of Environment and funded by the Peace/Williston Fish and Wildlife Compensation Program is a project that seeks to unravel the interactions between wolves, Moose and Caribou in a 2,500 km^2 (620,000 acres) area just north east of Prince George. The research objective is to test whether reductions in Moose populations through liberalized hunting seasons will decrease the wolf predator base sufficiently enough to reduce predation pressures on threatened Caribou populations. The interactions between Moose, wolves and Caribou have long been established, but some of the more detailed intricacies of how fluctuations in Moose numbers affect wolf predation on Caribou has, until now, been left to speculation. The Revelstoke project is addressing similar objectives.

Since the beginning of the Parsnip study in the winter of 2006/2007, 16 Caribou, 12 wolves and 23 Moose have been outfitted with GPS collars in the study area and are being monitored on a regular basis. Preliminary results suggest that Caribou are being killed by wolves and bears. Data from the project indicate that Wolves spend most of their time in valley bottoms where they prey on Moose, but make excursions into high country where they can and do kill Caribou. Just exactly how forestry and other resource extraction activities influence this predator-multi-prey relationship remains unknown. What is known, however, is that about 100 years ago, Moose populations began increasing in many parts of British Columbia and have expanded into traditional Caribou ranges across central and southern British Columbia facilitated by access development. In these areas wolves are reported to be increasingly preying on Caribou. Most of the Caribou populations have been declining for many years and have been classified as "threatened" by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) and are red-listed provincially.

Such research on Moose underscores the need to set wildlife within the larger context of the ecosystem in which it lives. Hopefully, findings from these research projects will help us begin to see how the status of Moose and those organisms with which it interacts, depend on our ability as British Columbians to view and manage our forested lands not just for ourselves, but as habitat for Moose and the myriad other species with which they co-exist.

Did You Know?

The Northern Lights Wildlife Shelter in Smithers, BC rehabilitates several orphaned Moose calves each year. After receiving proper care they are released directly into the wilderness area just north of Smithers (Figure 34).

In the wild, Moose produce about 150 litres of milk but when domesticated can produce over 400

Figure 34. Orphaned Moose calves (two pictured here with coauthor Roy Rea) are hand raised by Peter and Angelika Langen and volunteers at the Northern Lights Wildlife Shelter in Smithers, BC. 01 August 2007 (Nicole A. Klassen).

litres. Farmers in northern Sweden milk domesticated Moose and make cheese which they sell to upscale hotels and restaurants in Sweden for $ 500 CND /kg ($CND 225/lb). Heaven only knows what diners pay at the till.

Moose are known to lick salt from icy winter roads but can do it much more safely by simply licking it from stationary cars. Such "car washes" have been reported in driveways and parking lots throughout the range of Moose (Figure 35), but may come in the form of insurance claims when bulls with antlers do the licking!

The dewlap or "bell" of a Moose is a beard-like organ hanging from the throat region below the chin (see Figure 8) in all ages and both sexes of Moose. It is also found on the developing fetus. The bell is believed to be socially important as both a visual and olfactory communicator between Moose of all ages and both sex-classes. It may act as a releaser of chemical stimuli (pheromones) between bulls and cows at the rut and as a visual cue to the animal's social position.

Figure 35. Roads are not only a source of mortality, but also a source of salt. In some areas, Moose regularly lick salt from vehicles - hopefully they aren't moving when this happens. Prince George, BC. 15 January 2008 (Eric J. Brewer).

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Useful References

Andersen, R., J.D.C. Linnell, and R. Langvatn. 1996. Short term behavioural and physiological response of Moose *Alces alces* to military disturbance in Norway. Biological Conservation 77:169-176.

Ayotte, J.B., K.L. Parker, J.M. Arocena and M.P. Gillingham. 2006. Chemical composition of lick soils: functions of soil ingestion by four ungulate species. Journal of Mammology 87:878-888.

Baskin, L., J.P. Ball, and K. Danell. 2004. Moose escape behaviour in areas of high hunting pressure. Alces 40:123-131.

Blood, D.A. 2000. Moose in British Columbia: Ecology, Conservation and Management. British Columbia Ministry of Environment, Lands and Parks, Victoria, British Columbia, Canada. 6pp.

Bonar, R.L. 1975. Wildlife resources and habitat in the Williston reservoir area. British Columbia Hydro and E.L.U.C. Secretariat, Victoria, British Columbia, Canada. 96 pp.

Bonar, R.L. 1983. Winter Moose population characteristics during pre-flooding stages of hydro-electric development in British Columbia. Alces 19:222-237.

Bubenik, A.B., and H.R. Timmerman. 1982. Spermatogenesis in the taiga Moose of north central Ontario – a pilot study. Alces 18:54-93.

Canadian Cooperative Wildlife Health Center. 1996. Giant Liver fluke in Banff National Park, Alberta. Canadian Cooperative Wildlife Health Center Newsletter 4:2.

Child, K.N. 1996. Moose harvest management in British Columbia: Regulation simplification and strategy harmonization. Report to the Wildlife Branch, Ministry of Environment, Lands and Parks.

Victoria, B.C. 67pp.

Child, K.N. 1982. Moose Antlers: How they grow and what they tell you. British Columbia Wildlife Review 10:17-20.

Child, K.N., and K.M. Stuart. 1987. Vehicle and train collision fatalities of Moose: Some management and socio-economic considerations. Swedish Wildlife Research Supplement 1:699-703.

Child, K.N., S.P. Barry, and D.A. Aitken. 1991. Moose mortality on highways and railways in British Columbia. Alces 27:41-49

Colescott, J.H., and M.P. Gillingham. 1998. Reaction of Moose (*Alces alces*) to snowmobile traffic in the Greys River Valley, Wyoming. Alces 34(2):329-338.

Darimont, C.T., P.C. Paquet, T.E. Reimchen, and V. Chrichton. 2005. Range expansion by Moose into coastal temperate rainforests of British Columbia, Canada. Diversity and Distributions 11:235-239.

Demarchi, R.A., and C.L. Hartwig. 2008. Towards an improved Moose management strategy for British Columbia. HCTF Report CAT07-0-325. Victoria, B.C. 55 pp.

Dune, B. 2007. Effectiveness of above-ground crossing structures for the movement of Moose and other large mammals. Masters thesis, University of Calgary, Alberta, Canada. 136pp.

Eastman, D.S. 1974. Habitat use by Moose of burns, cutovers and forests in north-central British Columbia. Alces 10:238-256.

_____. 1984. Seasonal changes in crude protein and lignin of ten common forage species of Moose in north-central British Columbia. Alces 19:36-70.

Eastman, D.S., and R. Ritcey. 1987. Moose habitat relationships and management in British Columbia. Swedish Wildlife Research Supplement 1:101-118.

Eder, T., and D.L. Pattie. 2001. Mammals of British Columbia. Lone Pine Publishing, Vancouver, British Columbia, Canada. 296pp.

Edwards, R.Y. 1957. Dammed waters in a Moose range. Murrelet 38:1-3.

Ericsson, G., and K. Wallin. 1996. The impact of hunting on Moose movements. Alces 32:31-40.

Ferguson, M.A.D., and L.B. Keith. 1982. Influence of Nordic skiing on distribution of Moose and Elk in Elk Island National Park, Alberta. Canadian field-naturalist 96:69-78.

Franzmann, A.W. 1981. Alces alces. The American society of mammalogists. Mammalian species. No. 154. 7pp.

Franzmann, A.W., and C.S. Schwartz (eds.). 1998. Ecology and management of the North American Moose. Smithsonian Institution Press, Washington, D.C., United States. 733 pp.

Geist, V. 1963. On the behaviour of North American Moose (*Alces alces andersoni* Peterson, 1950) in British Columbia. Behaviour 20:377-416.

Gillingham, M.K., and K.L. Parker. *In Press*. Differential habitat selection by Moose and Elk in the Besa-Prophet area of northern British Columbia. Alces:

_____. *In Press*. The importance of individual variation in defining habitat selection by Moose in northern British Columbia. Alces:

Government of British Columbia. Ground - based Inventory Methods for Selected Ungulates: Moose, Elk and Deer Standards for Components of British Columbia's Biodiversity No. 33: http://ilmbwww.gov.bc.ca/risc/pubs/tebiodiv/grndb/bac.htm#p347_9914. Accessed on-line on March 11, 2008.

Hatter, I.W., and K.N. Child. 1992. An evaluation of the spike-fork bull Moose antler regulation in central British Columbia. *In* Proceedings Moose harvest workshop. 1991. Wildlife Branch, B.C. Ministry of Environment, Victoria, BC. 183 pp.

Hatter, I.W., K.N. Child, and H. Langin. 1992. Provincial Moose Management Statement for British Columbia, 1990-95. Wildlife Branch, British Columbia Environment, Victoria, British Columbia, Canada.

Hatter, I.W. 1998. Moose conservation and harvest management in Central and Northern British Columbia. British Columbia Environment, Wildlife Working Report, draft for stakeholder discussion, Victoria, British Columbia, Canada. 48 pp.

_____. 1999. An evaluation of Moose harvest management in Central and Northern British Columbia. Alces 35:91-103.

Hatter, J. 1950. The Moose of central British Columbia. Ph.D. thesis, State College of Washington, Pullman. 356pp.

Heard D., S. Barry, G. Watts, and K. Child. 1997. Fertility of female Moose (*Alces alces*) in relation to age and body composition. Alces 33:165–76

Hengeveld, P.E. 1998. Omineca river Moose forage enhancement 1992-1994. Peace/Williston Fish and Wildlife Compensation Program, Report No. 132. 8pp and appendices.

Hjeljord, O., and S. Grönvold. 1988. Glyphosate application in forest-ecological aspects VI. Browsing by Moose (*Alces alces*) in relation to chemical and mechanical brush control. Scandinavian Journal of Forest Research 3:115-121.

Kearney S.R., and F.F. Gilbert. 1976. Habitat Use by White-Tailed Deer and Moose on Sympatric Range. Journal of Wildlife Management 40:645-657.

Kunkel, K.E., and D.H. Pletscher. 2000. Habitat factors affecting vulnerability of Moose to predation by Wolves in southeastern British Columbia. Canadian Journal of Zoology 78:150-157.

Lockhart, J.G. 1890. Notes on the habits of Moose in the far north of British America in 1865. Proceedings of the United States National Museum 13:305-308.

Mech, D. 1966. The Wolves of Isle Royale. Fauna Series, No. 7. Fauna National Parks, Washington, D.C., United States.

Pastor, J., B. Dewey, R.J. Naiman, P.F. McInnes, and Y. Cohen. 1993. Moose browsing and soil fertility in the boreal forests of the Isle Royale National Park. Ecology 74:467-480.

Poole, K.G. 2007. A population review of Moose in the Kootenay region. Aurora Wildlife Research. 43pp.

Poole, K.G., and K. Stuart-Smith. 2005. Fine-scale winter habitat selection by Moose in interior montane forests. Alces 41:1-8.

_____. 2007. Winter habitat selection by female Moose in western interior montane forests. Canadian Journal of Zoology 84:1823-1832.

Poole, K.G., R. Serrouya, and K. Stuart-Smith. 2007. Moose calving strategies in interior montane ecosystems. Journal of Mammalogy 88:139-150

Rea, R.V., and M.P. Gillingham. 2001. The impact of the timing of brush management on the nutritional value of woody browse for Moose *Alces alces*. Journal of Applied Ecology 38:710-719.

Rea, R.V., D.P. Hodder, and K.N. Child. 2004. Considerations for natural mineral licks used by Moose in land use planning and development. Alces 40:161-167.

Rea, R.V. 2005. Testing the effects of road reactivation and increased traffic on Moose movements and habitat use patterns in the John Prince Research Forest. Final Report, University of Northern BC, Prince George, British Columbia, Canada. 91pp.

Rea, R.V., K.N. Child, D.P. Spata, and D. MacDonald. 2007. Influence of cutting time on brush response: Implications for herbivory in linear (transportation) corridors. Environmental Management 40:219-230.

Ritcey, R. 1992. Moose in British Columbia. Province of British Columbia, Ministry of Environment. 4pp.

Rudd, L.T., and L.L. Irwin. 1985. Wintering Moose vs. oil/gas activity in western Wyoming. Alces 21:279-298.

Samuel, B. 2004. White as a ghost: Winter ticks and Moose. Federation of Alberta Naturalists. 100pp.

Schwab, F.E., M.D. Pitt, and S.W. Schwab. 1987. Browse Burial Related to Snow Depth and Canopy Cover in Northcentral British Columbia. Journal of Wildlife Management 51:337-342.

Service BC. 2005. Hunting, Trapping and Viewing Sectors. Ministry of Labour and Citizen's Services, Victoria, B.C. 34 pp.

Sopuck L.G., and D.J. Vernam. 1986. Distribution and movements of Moose (*Alces alces*) in relation to the Trans-Alaska oil pipeline. Arctic 39:138-144.

Spalding, D.J. 1990. The early history of Moose (*Alces alces*): Distribution and Relative Abundance in British Columbia. Contributions to Natural Science 11. 12pp.

Stringham, S.F. 1974. Mother-infant relations in Moose. Naturaliste Canadien. (Quebec) 101:325-369.

Timmerman, H.R. 1971. The antlers of Moose development related to age. Ontario Fish and Wildlife Review 10:11-18.

Timmerman, H.R. 1987. Moose harvest

strategies in North America. Swedish Wildlife Research Supplement 1:565-579.

Timmerman, H. R. 1990. Basic Moose biology. Pages 1-10 in: M. Buss and R. Truman, eds., The Moose of Ontario. Book 1: Moose biology, ecology and management. Ontario Ministry of Natural Resources and Ontario Federation of Anglers and Hunters, Toronto. 78pp.

Westworth, D., L. Brusnvk, J. Roberts, and H. Veldhuzien. 1989. Winter habitat use by Moose in the vicinity of an open pit copper mine in north-central British Columbia. Alces 25: 156-166.

Weir, E. 2002. Collisions with wildlife: the rising toll. Canadian Medical Association Journal 166:775.

Wildlife Harvest Strategy. 1996. Wildlife Branch. British Columbia, Environment, Victoria, British Columbia, Canada. 70 pp.

About the Authors

Roy and Ken (Figure 37) served as co-chairs for the 43rd North American Moose Conference and Workshop held in Prince George, British Columbia from June 2-7, 2007 at the University of Northern British Columbia.

Roy, who spent most of his formative years in the bush around Vanderhoof, BC, teaches Animal Physiology, Field Applications in Resource Management and Plant Systems labs at the University of Northern British Columbia (UNBC). Roy also co-teaches Plant-Animal Interactions at UNBC and has been studying various aspects of Moose ecology for the past 12 years. Even more than chasing Moose around, Roy likes to spend time with his wife Michelle and his two daughters Caslin and Jenna just doing family stuff.

Ken, now retired, served as regional wildlife biologist for the British Columbia Ministry of Environment, Lands and Parks (1973-1992) and as a senior environmental coordinator for the Northern Region of British Columbia Hydro (1992-2005) in Prince George.

When with the Ministry, Ken specialized in Moose management and introduced a selective harvest strategy for Moose in the central interior of the province. Ken was a contributing author to the Wildlife Management Institute Book*: Ecology and Management of the North American Moose*, published in 1996. Ken continues to maintain his interest in Moose behaviour, ecology and management by collaborating with Roy on shared research interests on Moose. In his more leisurely hours, Ken and his wife, Sharron enjoy outdoor pursuits and travel off continent to visit, see and learn how others live.

Figure 37. Authors Roy Rea (left) and Ken Child. Prince George, BC. March 2008 (Mike Rutherford).