

MOOSE: COMPETING AND COMPLEMENTARY VALUES

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ABSTRACT: Moose (*Alces* spp.) are the largest and one of the most widespread land mammals in boreal and mixed-wood forests of the northern hemisphere. They provide essential food for carnivores and human subsistence users in remote areas. During the 20th century, their increasing densities and distribution in North America and Fennoscandia have provided added recreation through licensed hunting, viewing, a variety of cultural, spiritual, and commercial activities, and numerous scientific/ecological studies. In some areas, their high densities are considered unacceptable due to damage caused by moose/vehicle collisions, to commercially valuable trees, to agricultural crops, and added management costs. Most management agencies attempt to manage populations through an allocation process which includes provisions for Native harvest, licensed hunter harvest, and control of illegal harvests. Moose benefits or worth, both competing and complementary, are discussed, based on a wide array of monetary and non-monetary values reported in the literature.

ALCES VOL. 41: 85-120 (2005)

Key words: aesthetics, allocation, collision damage, commercial value, cultural/spiritual value, forest damage, hide and antler value, meat value, moose, recreational value, scientific/ecological value

Moose (*Alces alces*) are the largest and one of the most widely distributed land mammal species across Canada, portions of the USA, Sweden, Norway, and Finland (Peterson 1955). An important part of natural communities, moose are an essential food source for wolves (*Canis lupus*) and bears (*Ursus americanus*, *U. arctos*), as well as a host of scavengers including red fox (*Vulpes vulpes*) and ravens (*Corvus covax*). In addition to their intrinsic ecological role, moose have been exploited by man over the centuries, providing food, clothing, and tools for Native people and early settlers in northern latitudes (Reeves and McCabe 1998, Rodgers 2001). Moose populations generally expanded and increased during the latter half of the 20th century (Karns 1998, Timmermann and Buss 1998, Lavsund et al. 2003). Considered a renewable resource, they continue to pro-

vide many benefits and socio-economic advantages if managed in a sustainable manner (Eagen et al. 1989). We believe the current “value” of moose has never been as diverse or extensive. However, “How do we value moose and which values compete or complement one another?”

In common terms, a “value” is thought of as being usually more or less desirable, useful, important, worthwhile, worthy of esteem for its own sake, a monetary worth, or a thing or quality having intrinsic worth (Webster 1967). However, values are perceived in many different ways and are acquired by a host of interactions and experience over time (Kellert 1980, 1987). Consequently, values may change over time and circumstances, and differ among individuals (Kellert 1980, 1987). All values are not necessarily shared by everyone, nor should they be, as some values conflict to

some extent or may be harmonious to some extent, depending on the individual point of view. Not surprisingly then, sociologists, economists, and wildlife managers have developed fundamentally different notions of value. Whereas social values might be categorized as cultural, societal, psychological, and physiological, upon which relative importance or worth may be assigned (Brown and Manfredo 1987), economists may prefer to divide wildlife assets into, for example, use and nonuse values (Bishop 1987). Wildlife managers, on the other hand, tend to employ a mixture of socio-economic values. Steinhoff (1978), for example, classified big game values as either recreational (related to sports or hobbies), aesthetic (related to beauty, inspiration, or art), educational (added knowledge), biological (ecosystem component), social (non-monetary related to quality of life), or commercial (meat and trophy).

Differences among disciplines have made it very difficult to integrate their various perspectives into a generally accepted value system. For instance, wildlife managers may value wildlife using recreation expenditures based on the monetary amount hunters or others may spend in pursuit of their activities, while economists may find that approach objectionable because it may only help in understanding the local economic impacts of wildlife-related activities and does not provide a good measure of the economic value of wildlife to society as a whole (Bishop 1987). Nor can economists and wildlife managers agree entirely on their respective definitions of competing and complementary values. Whereas economists may determine the extent to which values compete or complement one another on the basis of production, such that one value may be excluded at the expense of another, wildlife managers tend to accept the co-existence of multiple values with varying levels of importance determined by

competing and complementary interactions through time.

In the absence of general agreement on terms and definitions, we have chosen, for the purposes of this discussion, to categorize moose values into two components: those we consider competing and those we consider complementary based on a literature search and personal communication with wildlife managers. Although broadly consistent with the definitions of economists, we have attempted to allow for the wider mixture of socio-economic perspectives commonly held by wildlife managers. Thus, complementary values are simply those we consider to agree with each other or those that come together, while competing values we believe to be incompatible, or which disagree with each other. These categories provide a framework within which to assess the positive and negative values of moose. Attempting to maximize meat production (a positive value), for example, will undoubtedly impact on a manager's ability to maximize trophy production (also a positive value), or to minimize forest or vehicle collision damage (negative values) at the same time. The first is an example of complementary values: both meat and trophy production are positive values that coexist but vary in their predominance through time. In this case, the production of one value increases (complements) the production of the other value. The latter is a case of competing values: maximizing the positive value of meat production by increasing the size of a moose population will also increase the negative aspects of forest or moose/vehicle collision (MVC) damage. In this way, the production of one value detracts from (competes with) the ability of wildlife managers to promote another value.

EVALUATION METHODS

Moose have substantial recreational

and economic values. Each moose has some intrinsic economic value associated with both consumptive and non-consumptive use according to Schwartz and Bartley (1991). Economists use indirect valuation approaches including travel cost, contingent valuation, and hedonic methods, or variations thereof (Steinhoff et al. 1987, Sarker and Surry 1998). Others, such as Legg and Kennedy (2000), have developed socio-economic impact models which factor in gross output, value added employment, labor income, and taxes. However, the most common approach taken by wildlife managers is to measure direct and indirect monetary costs and benefits associated with moose. Direct costs or expenditures related to hunting commonly include costs of equipment, transportation, accommodation, food and beverage, and license fees (Ruhr and Crichton 1985). Evaluation of wildlife viewing activities is assessed by a survey sample to determine the number of days spent viewing, trips taken to participate, and associated expenditures (DuWors et al. 1999). A sampling of methods used to evaluate the benefits of moose include those from; British Columbia (Reid 1997), Saskatchewan (Ross 1975, Ross and Paul 1976), Manitoba (Capel and Pandey 1973, Ruhr and Crichton 1985), Ontario (Bisset 1987, Legg 1995, Umali 1997, Sarker and Surry 1998, Legg and Kennedy 2000), Newfoundland (Condon and Adamowicz 1995), Maine (Boyle and Clark 1993), Idaho (Loomis et al. 1985), Sweden (Kriström 1987, Johansson et al. 1988, Mattsson 1990, Sylvén 1995), and Norway (Storaas et al. 2001). As it is not the intent of this paper to undertake a thorough socio-economic analysis of the value of moose, we have taken the simplest approach of providing descriptive indices of monetary costs and benefits associated with the positive and negative values of moose that are readily understood by most wildlife managers and may contribute to future in-

depth analyses. This review is restricted to studies of moose values conducted and reported in North America and Fennoscandia. Cost estimates are given in U.S. dollars using a conversion rate of \$1.00 US to \$1.30 Canadian, unless otherwise stated.

MOOSE DENSITIES

An understanding of moose densities and distribution is fundamental to any discussion concerning values. North American moose populations in 2000 were estimated at about 1 million distributed in 28 jurisdictions (Timmermann 2003). Populations occur in 11 Canadian provinces or territories and in at least 17 U.S. states with continuing range expansion in New England and several western U.S. states. In the early 1990s, North American moose densities in hunted areas varied from $\leq 0.5/\text{km}^2$ where bear and wolves are unexploited (Messier 1994) to as high as $6.0/\text{km}^2$ for specific areas on Isle Royale and >12.0 moose/ km^2 for management area 17 in Newfoundland (Brandner et al. 1990, Thompson and Curran 1993, Mercer 1995, Mercer and McLaren 2002). Crête (1987) believed the North American carrying capacity of moose in a predator-free environment to be 2.0 moose/ km^2 . Target densities in forested habitats of Newfoundland are currently $\leq 2.0/\text{km}^2$ (McLaren et al. 2004). Several herd reduction programs have occurred in Elk Island National Park, Alberta since 1960 in an effort to reduce winter densities to $2.0/\text{km}^2$ and reduce over-winter mortality (Lynch et al. 1995).

Newfoundland and Fennoscandia have consistently had the highest reported moose densities in the world (Hörnberg 1995, Harkonen 1999, Storaas et al. 2001, McLaren et al. 2004) due to little natural predation, modern forestry producing large areas of good habitat, and a closely managed human harvest system. Densities have also increased close to many urban / suburban

areas across North America, contributing to added conflicts between moose and humans (Karns 1998). High densities in Fennoscandia, primarily on winter ranges have led to many competing values, including high annual hunter harvests, significant forest damage, and loss of life, injury, and property damage from moose/vehicle collisions (Lavsund and Sandegren 1991, Heikkilä and Aarnio 2001, Storaas et al. 2001). In 2000, about 200,000 moose were harvested by hunters in all 3 Nordic countries, from a post hunt winter population estimated at 450,000 (Lavsund et al. 2003). Swedish moose densities were estimated at 0.7 - 2.2/km² in local areas during the early 1980s and a record harvest of 175,000 occurred in 1982 in an effort to reduce populations (Lavsund and Sandegren 1989, Cederlund 1996). Hunter harvest was again increased in the late 1990s to reduce densities and subsequent forest damage (Carlestål 2000). Annual harvests became stabilized at about 90,000 per year in the early 1990s by targeting a harvest of 0.3-0.6 moose/km². Populations since 1995 have again increased and in 1998/99, 101,930 moose were harvested (Faber 1999). Norwegian moose densities and harvests increased during the 1970s and 1980s. In the late 1990s densities averaged 1.0-2.0/km² and were as high as 5.0-6.0/km² during winter in some valleys (Solberg et al. 1998, 2003). Harvests fluctuated between 34,000 in 1995 and 36,000 in 1997 and peaked at 39,309 in 1999 (Storaas et al. 2001, Lavsund et al. 2003). Such high densities prompted preparation of an action plan to help reduce damage to timber plantations and MVCs to acceptable levels (Jaren et al. 1995). In Finland, moose harvests peaked at 68,843 in 1984 and averaged 27,750 per year (range 22,836-32,484) between 1995 and 1999 (Harkonen 1999, Lavsund et al. 2003). Finnish managers increased the number of moose licenses from 17,060 in 1997 to 38,134 in 1999 to

target a harvest of 50,000 and reduce damage to commercially valuable timber. In some regions of Norway moose are considered a benefit for both landowners and hunters because of consistent high densities over time (Storaas et al. 2001). Large forest companies owning land in Sweden and Finland regard moose as a recreation benefit rather than an economical resource for the local community. Timber companies typically want to reduce moose densities and their resultant damage while hunters desire densities near the maximum sustainable yield (Angelstam et al. 2000).

COMPLEMENTARY VALUES

Recreational Hunting

Reasons or motivations given for recreational hunting of moose include nature appreciation, companionship, meat and trophy value, stress release, and to practice outdoor skills (Rollins 1987, Rollins and Romano 1989, Botton 1999). Providing recreational licensed hunting opportunities has been the primary focus of most management agencies. We consider such regulated hunting as complementary to other values including cultural/spiritual, aesthetic, commercial, and scientific/ecological. Others may view these as competing values. In 2000-01, 23 North American jurisdictions managed a licensed moose hunt and an estimated 385,569 hunters harvested 82,466 moose (Timmermann 2003). Moose hunting provides a significant annual economic impact in some jurisdictions. Bisset (1987) provided a detailed review of value determination, economic concepts, techniques, and problems of evaluation. His review represents the only comprehensive attempt to estimate the total gross value of North American moose hunting related expenditures (\$375.8 million in 1982) based on limited data. Total expenditures per moose averaged \$1,688 for non-residents and \$1,285 for resident moose hunters in 1982.

Some jurisdictions have since attempted to quantify the value of moose hunting. Reid (1997) estimated a contribution of \$12.2 million for resident hunters in British Columbia in 1995. Legg and Kennedy (2000) reported an impact of \$59.2 million to the Gross Ontario Income and 1,645.8 years of employment in 1996. During that year, Ontario resident hunters spent an estimated total of \$154.46 million. Regelin and Franzmann (1998) estimated the annual economic impact of 33,000 resident and 1,000 non-resident Alaskan hunters to represent \$32.6 million in the late 1990s. In Ontario, Sarker and Surry (1998) indicated a decline in recreational moose hunting demand with higher travel costs and lower income.

In Fennoscandia, nearly 400,000 moose hunters harvested about 200,000 moose in 2000 (Lavsund et al. 2003). Storaas et al. (2001) placed the 2000 value of moose hunting at \$172-257 million in Norway.

Licenses

In North America, all hunters are required to pay a license fee for the opportunity to hunt and harvest a moose. Resident licenses in Canada in 2001 averaged \$27.54 (range \$7.70-\$44.28) and non-residents \$157.40 (range \$15.40 - \$354.20, $n = 11$, Timmermann 2003). Resident fees in the U.S. averaged \$106.00 (range \$20.00-\$310.00), while non-resident licenses averaged \$727.70 (range \$80-\$1,643, $n = 12$). Export permits or trophy fees were required in addition to license fees to transport an animal from Alaska, Northwest Territories, Alberta, and Ontario. Legg and Kennedy (2000) reported license revenue from Ontario moose hunting was approximately \$3.12 million. Umali (1997) reported that current Ontario moose license fees do not reflect the benefit hunters receive from moose hunting and that the true value is measured by hunter's willingness to pay over and above the price of a license. To

illustrate this point, some hunters have paid as high as \$19,000 (range \$7,000- \$19,000) for a single moose license at a special U.S. Governors Auction (Table 1).

Moose license revenues in Finland have ranged from \$1-3 million (Heikkilä and Aarnio 2001). Hunting fees in Norway were estimated at \$30 - \$52 per animal in 2000 according to Storaas et al. (2001). In addition to basic license fees, additional revenue is generated by a price system based on carcass weight that was introduced in 1960 to encourage hunters to select young and small moose (Jon Lykke, personal communication 2004).

Meat

Moose are highly regarded for their large size, low fat (>20 times less than lean beef), and nutritious meat quality (Hansson and Malmfors 1978, Crichton 1998a, Crichton and Redmond 1998). Moose meat contains relatively high levels of eicosapentaenoic acid (epa), a protective fatty acid not found in domestic animals. Rowland (1989) reported that epa can protect against heart attacks, hardening of the arteries, and certain types of arthritis. Midkiff (2004) has suggested moose meat is a natural product and therefore a healthy alternative to most feedlot raised beef which is driven by volume, efficiency, uniformity, and profit. Many Newfoundlanders depend on moose as a source of food (Condon and Adamowicz 1995). The monetary value of moose meat in North America is often determined by comparison to an equivalent retail cost of a kilogram or pound of domestic beef. Average yields of processed moose meat have been reported as varying between 160 kg in Ontario (Hamilton 1981) and 180 kg in Alberta (Renecker et al. 1987), whereas Hansson and Malmfors (1978) assumed an average carcass weight of 130 kg for *Alces alces*, the smaller European moose. Bisset (1987) used an average of

170 kg per moose and a retail beef price of \$6.28/kg, or an average of \$1,067.60 per animal. He applied this value to estimate the total North American value of moose meat taken by licensed hunters at \$76 million based on a 1982 harvest of 71,000. Oosenbrug et al. (1991) reported the meat value of each Newfoundland moose at \$1,016 in 1990. More recently Crichton (1998a) estimated a conservative value of \$1,084/moose using a yield of 160 kg/moose by applying a cost of \$6.78/kg (\$3.08/lb) used by Hamilton (1981). If one assumes a current value of \$8.80/kg (\$4.00/lb), the total value of moose meat taken by licensed hunters in North America could exceed \$116 million using a 2001 harvest of 82,466 as reported by Timmermann (2003).

In Fennoscandia, as opposed to North America, moose (*Alces alces*) can be sold on the free market. Storaas et al. (2001) reported moose meat in Norway has a potential value well above \$42 million based on an annual harvest of up to 40,000 in 2000. Likewise the Swedish moose harvest (105,000) contributed 13.65 million kg of meat or close to 10% of cattle production in 2001 (Sylvén 2003). The total value of moose meat taken in Finland in 1997 was about \$13 million (Heikkilä and Aarnio 2001). Only about 10% of Finnish hunters gave meat as the primary reason for hunting, compared to a much higher value placed on meat by Swedish and Norwegian moose hunters (Mattsson and Kriström 1987, Sødal 1989).

Antlers and Hides

Trophies are considered objects preserved or mounted as a memorial (Webster 1967). Trophy moose antlers provide evidence of population status (Bubenik 1989) and are highly prized and often prominently displayed on mounted heads or with a portion of the skull intact. Their value lies in a lasting symbol of a successful hunting experience

since no tender or monetary value is legally permitted in North America. Trophy antlers are rated by size and conformation and are usually from prime bulls 6.5-10.5 years of age (Timmermann 1971, Gasaway 1975). Trophies are cumulatively scored by specific measurements, the number of points and conformity between right and left palms (Boone and Crockett Club 1988). In North America 4 types of recognition are listed. The Boone and Crockett Club initiated the first standards in the early 1930s for all legally taken moose (Crichton 1998a). They designated 3 categories: the Canada moose (*A. a. americana* and *A. a. andersoni*), the Alaskan/Yukon moose (*A. a. gigas*) and the Shiras or Wyoming moose (*A. a. shirasi*). Trophy antlers taken by archers can be certified by the Pope and Young Club, those taken by muzzle loaders by the Longhunter Association, and shed antlers by the North American Shed Hunters Club (Crichton 1998a, b). Management strategies designed to maintain trophy class bulls in the population have been reported for Alaska (Smith et al. 1979, Schwartz et al. 1992) and for Sweden by Sylvén (1995). Antlers are also valued by artists for carving and items such as buttons, picture frames, furniture, and lamps (Crichton 1998a). Prices paid for shed antlers in Alaska vary from \$1-\$6 per pound according to their condition (Tom Cooper, personal communication 2004). Once processed, items can be legally sold in most jurisdictions and often fetch a high value.

Moose hides can provide a valuable source of leather. Reeves and McCabe (1998:27-32) provide an extensive review of the traditional value of moose hides used by Natives for a wide variety of clothing and footwear. Some agencies have offered incentives to hunters to submit raw moose hides which are tanned and given or sold to Native peoples for further processing to traditional clothing (Crichton 1998a). Unfortunately, today many hunters discard

Table 1. Cost of a single moose license received at U.S. Governors Moose License Auction 1996-2003 (Brimeyer 1999).

State	1996	1997	1998	1999	2003
WY	N/A	\$12,500	\$7,500	\$8,250	(\$12,500 & \$14,000) ¹
CO	\$19,000	\$9,750	\$7,000	\$7,500	
UT	N/A	N/A	N/A	\$7,250	
ME	\$8,000	\$7,200	N/A	N/A	

¹ N. A. Moose Foundation - Sun Valley ID Convention December 2003 (M. Orwig, personal communication 2004) — note: previous convention yielded \$10,500 & \$12,500 (WY).

moose hides after processing the meat. In Norway, moose hides are valued at between \$17 and \$32 (Sødal 1985). Potential current value of hides in Norway based on a harvest of 40,000 could be as high as \$1.3 million according to Storaas et al. (2001).

Cultural/Spiritual

Brownlee et al. (2002) reported finding a single moose antler along with human bones from a Cree burial site near the Manitoba/Ontario/Minnesota border. The bones, which help provide knowledge of Native heritage, were dated to 6750 B.P., the oldest yet found in Manitoba. Evidence of moose in Native culture is found in Indian pictographs dating back 500 years or more along interconnected lakes west of Lake Superior (Dewdney and Kidd 1962). Moose are depicted on several sites including those on Lac la Croix, Hegman, Blindfold, Crooked, and Darkey lakes in the Quetico Park-Boundary Waters Canoe Area of Ontario and Minnesota. Moose petroglyphs have also been reported in Kejimikujik National Park, Nova Scotia, and in Sweden and Norway (Hallström 1960, Jansson et al. 1989). Such rock carvings and paintings in Fennoscandia are commonly interpreted as the art of prehistoric man and some date back to the early 1600s (Jansson et al. 1989, Skogsstyrelsen 2002). This art bears witness to a mobile hunting and trapping culture and moose (the crucial winter prey) represents the dominant type

of figure, suggesting it was a prime target. “Flesh foods”, primarily caribou (*Rangifer* spp.) and moose were “the only significant form of sustenance” for many North American Natives in the 1600s according to Gillespie (1981:15). The entire carcass including meat, internal organs, hide, and skeleton were used. Hunting, fishing, and trapping provides over half the total income for some of Canada’s Native populations and, for some, moose accounts for a high percentage of dietary needs (Hamilton 1981, Eagan et al. 1989). Native peoples often viewed wildlife including moose as their spiritual kin where hunting success was obtained by following prescribed rituals and atonement after the kill (Feit 1987). The “rabbit and the frog” is one of several sacred legends of the Sandy Lake Cree of northwestern Ontario (Stevens 1971). The frog attacked the “windigo-moose”, by crawling up its rectum and biting a vital organ that killed the moose. Both the frog and her husband, the rabbit, ate on the moose until full. Wolves came along, and while the frog escaped by leaping into a bloody hole in the snow, the rabbit, who crawled into the carcass, was eaten by the wolves. Moose are also part of Ojibway legend in the Lake Nipigon region of Northern Ontario, as related by Morriveau (1977).

Of all the ungulates in North America, Kay (1997) believes moose were the easiest to kill. He proposed that moose biogeography in western North America

was controlled primarily by Native hunting and presented evidence supporting an Aboriginal overkill hypothesis. Crichton (1981) reported unregulated hunting by Treaty Indians in Manitoba was a prime factor responsible for reduced moose populations. Crichton (1987, 2001) and Nepinak and Payne (1988) reported many First Nations peoples are concerned over moose conservation and wish to be involved in active management programs. Feit (1987) suggested the licensed sport or recreational hunt or extensive forestry practices (clear-cutting and road access) could disrupt Native management practices in some areas. He further believes that conflicts develop when such groups of resource users do not share a common cultural heritage.

Aesthetics

The intrinsic value of wildlife often exceeds utilitarian values normally associated with monetary measures (OMNR 1991). Moose provide a challenging and rewarding subject for naturalists, photographers, painters, and outdoor recreationists (Fraser 1978). Wildlife viewing of large mammals including moose and whales were reported by 43.3% of participants in a 1996 Environment Canada study (DuWors et al. 1999). Non-consumptive use and appreciation may include direct observation, photography, painting/sketching, and exploring habitat for sign (droppings, tracks, browse, sound, shed antlers, beds, tree damage). Most management agencies recognize non-consumptive values and have developed policies to provide moose viewing opportunities. Viewing areas can be especially fruitful in locations such as provincial, state, and federal parks where densities are generally higher and hunting is prohibited (Cobus 1972, Timmermann and Buss 1998). Indeed, hunting and viewing could be considered an incompatible activity in some areas, as hunting tends to reduce densities and

conditions moose to avoid people (Yukon Renewable Resources 1996). Moose are native to at least 35 North American National Parks in 16 jurisdictions and are highly prized by residents and visiting tourists (Timmermann 2003). In Alaska, Regelin and Franzmann (1998) report moose to be a favored viewing animal for over 1 million visiting tourists each year. Many agencies promote the development of moose viewing areas along specific road corridors, rivers, and lake shores, where expectations of observing moose are high. Yukon Renewable Resources (1999) for example lists 6 popular summer and 4 fall/winter moose viewing sites. Vermont features moose viewing opportunities around selected roadside wetlands and salt-licks in the “Vermont Watchable Wildlife Guide” (Alexander 1993). In Wyoming, moose are viewed by thousands, especially in Grand Teton and Yellowstone National Parks (Hnilicka and Zornes 1994). Ontario targeted the development of specific interim (1985, 1995, and 2000) moose viewing opportunities (OMNR 1980). However, little effort was made to identify moose viewing sites and it was unclear how much progress was achieved in reaching this goal (Timmermann et al. 2002). Moose are maintained in captive conditions for display and education, scientific research, and commercial breeding (Schwartz 1992, Monska 2001). Although difficult to keep and expensive to feed, at least 29 facilities kept captive or semi-captive moose in North America in 1990 (Schwartz 1992).

Filion et al. (1983) suggested that total expenditures on North American wildlife related activities other than hunting were 3.5 times direct expenditures by hunters. Bisset (1987) used this value to speculate that the total value of moose in wildlife appreciation including non-consumptive use could be as much as \$1,315 million in 1982. In Saskatchewan, an ecotourism

outfitter's license is required to conduct moose viewing tours (Arsenault 2000). In Norway, Storaas et al. (2001) reported current moose viewing enterprises that offer a "moose viewing safari" are small and unstable, but that the potential exists to provide added economic benefits to landowners or local forest companies.

Commercial

The commercial value of moose is often associated with the economic impact of commercial outfitters who market a hunt. Outfitters generally provide a package which may include food and accommodations, a remote fly-in experience, a guide, and occasionally a license. In 2003 such a packaged hunt (1 bull tag between 4 U.S. non-residents) typically sold for \$6,000 in Ontario (Peter Davis, personal communication 2003). Assuming a tag fill rate of 50%, each harvested bull could generate \$11,600 - \$15,400 based on the 2003 currency exchange rate. Hunter outfitting packages for moose in the Northwest Territories average \$6,500 depending on travel mode, (e.g., horse, helicopter, backpacking, or use of packers; Veitch and Simmons 2002). In northern Ontario, the outfitting industry is the third largest industry, behind only forestry and mining (OMNR 1986). Competing values have resulted from increased commercial logging activities and associated roads penetrating remote areas (McKercher 1992). Tourist outfitters who provide a traditional fly-in "wilderness" hunting experience are negatively affected, while timber contractors benefit from the newly accessed wood supply. The economic benefits and costs associated with habitat management, such as controlled burns, vegetative crushing, and scarification may generate significant employment and expenditures of equipment in some areas (Oldemeyer and Regelin 1987, Al Franzmann, personal communication 2004).

Moose are used to market and sell a wide variety of products throughout North America (Appendix). Moosehead, Canada's oldest independent brewery is the leading Canadian beer imported to the U.S. "Moose, Mountains and Mounties" were Tourism Canada's marketing focus in the early 1980s. Bars, restaurants, gift shops, motels, lodges, RV parks, children's toys and books, and a host of products feature moose as a marketing tool. The distinctive shape and size of moose, and its symbolic identification with Canadian wilderness as the "Monarch of the North", lends itself to an image (an icon of the virtues of strength and independence) which attracts attention and sells products. The commercial value of such products is unknown, but thought to be significant and growing. Moose are the national animal of Norway (Storaas et al. 2001), and the official state animal of Maine (Morris and Elowe 1993). A detailed study of "moose-marketing" and its impact on the economy is needed.

Scientific/Ecological

Scientific studies of moose have been carried out by many agencies as summarized in 19 Chapters in *Ecology and Management of the North American Moose* (Franzmann and Schwartz 1998). The Alaskan Moose Research Center (MRC) located on the Kenai Peninsula has, since its inception in 1968, provided data useful in evaluating the capability of land to produce moose (Schwartz and Hundertmark 1994, Franzmann 1996). The MRC produced 90 professional journal publications, 32 publication proceedings, 12 book chapters, 8 dissertations/theses, and numerous reports up to 1996. Isle Royale boasts the longest running ecological study of wolves and moose beginning in 1959 (Peterson and Vucetich 2002). Published research on moose-related studies on the island (150+) was summarized by Jordan et al. (2000).

Future research efforts in North America will likely concentrate on new knowledge concerning the role of predators, habitat quality, and how hunting influences moose population dynamics (Crichton et al. 1998). Forest ecosystem management has replaced featured species management in North America during the late 1990s, but moose will remain a crucial management species in eastern Canada (Hénault et al. 1999). The impact of moose on forest ecology can be used as an indicator of forest health and biodiversity Crichton (1998c). In Sweden, the effects of a dense moose population on forest biodiversity and harvest regulation have been a research priority at the Grimsö Wildlife Research Station in Riddarhyttan and the Swedish University of Agricultural Sciences in Uppsala (Persson et al. 2000, Edenius et al. 2002, Sylvén 2003). The Norwegian Institute for Nature Research (NINA) in Trondheim and the Finnish Game and Fish Research Institute in Ilomantsi Finland also conduct moose research on similar topics (Andersen and Saether 1992, Jaren 1992, Härkönen et al. 1998, Angelstam et al. 2000, Heikkilä and Härkönen 2000, Danielsen 2001).

Habitat Utilization

Deciduous shrubs and trees may compete with coniferous plantation growth, but they also provide seasonal food for moose. Intense moose browsing on deciduous shrubs and trees, particularly in winter, is considered beneficial by providing a release effect on adjacent commercially more valuable coniferous tree species (Lavsund 1987, Andrén and Angelstem 1993, Posner and Jordan 2002). Summer leaf-stripping opens the canopy to more light, which helps accelerate growth and forest succession (Bubenik 1989). In addition, moderate browsing temporarily retards terminal shoot development and helps reinforce the root system of trees and saplings. Thompson and

Curran (1993) reported heavy moose browsing in some areas of Newfoundland may improve the commercial value of forests by thinning balsam dominated stands and increasing the relative spruce component. Connor et al. (2000) suggest moose have altered species composition, the quantity of remaining available browse, and influenced forest successional patterns in Gros Morne National Park, Newfoundland. Hänninen (1994) speculated one moose in Finland could provide forest cultivation worth \$400.00 per year and that density dictated the degree of cultivation. On the other hand, silvicultural practices, including use of herbicides following logging, may reduce the period of vegetative succession, thus reducing the overall value of added browse production (Kennedy and Jordan 1985, Hjeljord and Gronvold 1988, Cumming et al. 1995, Eschholz et al. 1996).

COMPETING VALUES

Resource Allocation

Moose have traditionally provided an important source of food and clothing for Native People inhabiting North American moose range (Crête 1987). Moose are publicly owned in most jurisdictions and held in trust by government (Schwartz et al. 2003). In Ontario, the Heritage Hunting and Fishing Act (2002; http://www.e-laws.gov.on.ca/DBLaws/Source/Statutes/English/2002/S02010_e.htm#TOC) recognizes the right of all persons, Native and non-Native, to hunt and fish in accordance with provincial laws. However, subsistence use by Native People as provided under treaty or other legal agreements is given priority in harvest allocation by at least 10 of 23 agencies that manage a harvest. Native People under treaty, followed by resident hunters, are typically favored over non-residents in allocating harvest opportunities (Franzmann and Schwartz 1983, Timmermann 2003). In Canada, Status Indians are

permitted under treaty to hunt for food for personal use without provincial licenses year round. In September 2003, the Supreme Court of Canada ruled that Metis people of mixed Native and European descent, who can prove a historic link to surviving Metis communities and customs, can also claim hunting and other aboriginal rights (Canadian Press 2003). Potentially 600,000 Status Indians across Canada will have to share available wildlife resources with about 300,000 Metis People. Non-Native Ontario moose hunters are fearful that some moose stocks could be overharvested and that tag allocations to non-Native residents will be reduced as a higher percentage of the sustainable moose harvest is allocated to Native and Metis People (John Kaplanis, personal communication, 2003).

Non-resident moose hunting opportunities have been significantly reduced or eliminated in many jurisdictions (Timmermann and Buss 1998). Non-resident hunter numbers in 1982 were one-third those of 1972 due in part to increased license fees, resident-only seasons, guide and registration requirements, and limited permits. Such reductions can be considered competing to the extent that they diminish the potential economic return, as non-residents typically spend an average of 25% or more per moose than resident hunters (Bisset 1987).

Illegal Harvest

The illegal kill probably comprised at least 30% of the total North American licensed harvest in the early 1980s (Wolfe 1987). This would be an illegal kill of approximately 27,000 moose based on an estimated licensed harvest of 70,300 in 1982 (Timmermann 1987). Other authors since then believe the illegal harvest in some jurisdictions may approach or exceed the annual legal harvest (Timmermann 2003). Illegal harvests and their resultant value

losses (reduced populations and economic losses to the licensing jurisdiction) are considered by many to compete with values generated by licensed legal harvests, although such harvests may also be considered positive in helping lower high moose densities and by providing a meat supply. Todesco (2004) and Pilgrim (2000) have recently reported on the impact of illegal moose kills in north-eastern Ontario and the great northern peninsula of Newfoundland. Reliable estimates of severity of illegal loss are lacking and are further compounded in some jurisdictions by unregulated removals of unknown magnitude by Native People under treaty and by a recent decision by the Canadian Supreme Court to grant Metis People specific hunting rights (Crichton 1981, Canadian Press 2003).

Fine schedules and resultant monetary penalties for illegal hunting convictions can constitute an indirect value. Most jurisdictions have established a minimum or base fine schedule for hunting infractions. Under some circumstances, the court may assess considerably higher fines or penalties. In the U.S. for example, moose liquidation or replacement costs are used to set a minimum fine schedule for illegal harvests. Replacement costs set by 13 western/mid-western states in 2002 averaged \$1,789.00 (range \$262.50 in Wisconsin to \$6,000 in Montana) and were second only to bighorn sheep (Jensen 2002). Replacement costs double in Minnesota and Montana if a moose is classified as a trophy. In Ontario, the current set fine for a resident hunting moose without a license is \$234.85. This fine would be considered a minimum penalty or out of court settlement if a ticket is issued. It does not reflect the true value of a moose (Charlie Todesco, personal communication 2003). Penalties can range from \$19,250 - \$77,000 under the Fish and Wildlife Conservation Act (1997; <http://www.e-laws.gov.on.ca:81/ISYSquery/IRLF22D.tmp/16/doc>) if a

summons is issued instead of a ticket, and the actual fine is determined in court. On December 5th, 2002, 4 Ontario hunters were fined \$21,560 in a Thunder Bay Ontario court for several hunting violations (Bob Stewart, personal communication 2003). Two of the moose hunters were fined \$7,700 each for hunting moose with an aircraft and banned from hunting for 3 years. One of this party was fined \$2,310 for shooting a firearm from a motor boat, while other fines of \$770 were levied for giving false statements. Some jurisdictions including Alaska may confiscate equipment used for illegal harvest, including aircraft, boats, and firearms, worth \$100,000 in some cases (Al Franzmann, personal communication 2004).

Lacasse (1986) proposed a formula to determine an appropriate fine for moose poaching in Quebec by considering 3 variables: animal biomass, management costs, and socio-economic losses. Two biomass values (70 kg for calves and 190 kg for all adults ≥ 1.5 yr) were used to project equivalent beef value (\$4.20/pound). Management costs included summations of expenditures for research, conservation, inventory, data processing, and administration of the hunt. A proportional factor (58-day firearm and archery season \times 365 days = 15.9%) expressed the relative significance of moose hunting activities circa 1985. This percentage was applied to estimate management costs and then divided by the estimated Quebec moose population to derive an annual expenditure per moose. Socio-economic losses considered the average number of days to kill a moose in 1984 (70) multiplied by the average daily expenses per moose hunter (\$61.60). This method proposed a lost value of \$4,620 for a calf and \$5,390 for an adult animal.

Forest Damage

Moose are a dominant or keystone species throughout much of the boreal forests

of North America (Bergerud and Manuel 1968, Paine 1988) and in pine/spruce forests of Sweden, Norway, and Finland (Lavsund 1987). Similarities between the impact of high density herds (≥ 3.0 moose/km²) on commercial stands in Newfoundland and Fennoscandia are remarkable (Thompson and Curran 1989). Balsam fir (*Abies balsamea*) stands that dominate Newfoundland commercial forests provide similar early successional moose habitats following logging as do Scots pine (*Pinus sylvestris*) in Fennoscandia (Lavsund 1981, 1987). In North America, damage by moose browsing, primarily in balsam-dominated stands has been reported by Krefting (1951, 1974) on Isle Royale and in Newfoundland (Pimlott 1963; Bergerud and Manuel 1968; Thompson and Curran 1989, 1993; McLaren et al. 2000). Concern is centered on the reduction of available food leading to declining densities and significant damage to growing commercial trees leading to serious financial costs and short-term wood supply deficits. Several moose die-offs have been reported on Isle Royale due to reduction of available browse by high density populations (Risenhoover and Maass 1987, Peterson 1997). After each reduction, moose numbers have gradually increased following habitat recovery.

Forest damage has increased, concurrent with a moose population increase in Newfoundland (McLaren et al. 2004). Moose are especially attracted to pre-commercial thinned stands (Thompson 1988) and, as such, the management challenge is to reduce commercial damage by moose in such stands. Regenerating balsam fir are commonly mechanically thinned at 10-12 years post cut to reduce stem density and enhance tree growth (Thompson and Curran 1989). Heavy moose browsing in thinned stands can remove >50% of current growth, especially in high production areas. Newfoundland currently spends >\$3

million per year in a pre-commercial thinning silvicultural program, which yields a supply $>400,000 \text{ m}^3$ of wood per year (Lingard 1997). Managers can help reduce stand damage by lowering moose densities (increasing hunter harvest), retaining hardwood competition to help re-direct browsing pressure, and delaying thinning operations until average stand height is $\geq 3\text{m}$ (i.e., 13-15 years post cut; Thompson 1988, McLaren et al. 2000).

Some of the highest densities of moose in the world are found in Fennoscandia. Low natural predation, evolution of modern forestry practices creating a checkerboard of good habitat, and a closely regulated human selective harvest in Norway (Myrberget 1979), Sweden (Cederlund and Markgren 1987), and Finland (Heikkilä and Aarnio 2001) are believed responsible. Forestry is essential to the economy of all 3 countries and much of the moose habitat is used for commercial wood production (Lavsund and Sandegren 1989). Forest products represented 25% and 40% of export markets for Sweden and Finland, respectively, in the early 1980s (Lavsund 1987). Damage to economically important Scots pine, the principle winter forage species in young plantations, is common and directly related to moose density (Ahlén 1975, Angelstam et al. 2000). Breakage of pine tops of saplings up to 3-4 m, and bark stripping by moose results in reduced future growth and wood quality (Sandgren 1980, Faber and Edenius 1998). In addition, retention of deciduous forest biodiversity is reduced (Angelstam et al. 2000). Special survey methods were recently introduced in Sweden to measure level of damage to commercially valuable trees as well as species important to biological diversity (Skogsstyrelsen 2002). In Norway, Lavsund (1987) reported that a density of 2.0 moose/km² would produce 25% damage in thinned stands. A lower density of moose in Sweden (1.7/km²)

caused up to 57% damage in pine-dominated stands according to Angelstam et al. (2000). Damage in Sweden alone was believed to be in the range of \$200 to \$500 million dollars per year, or \$1,000 per moose shot in the early 1980s (Lavsund 1989). Estimated damage to Swedish forests in 2003 could equal \$60 – \$175 million (Roger Bergström, personal communication 2004). Compensation paid to Finnish landowners varied from \$1-4 million (Heikkilä and Aarnio 2001), while estimated browsing damage to young pine in Norway was \$20 – \$40 million after 80 years (Solbraa 1998).

Many studies (50+) in Fennoscandia have resulted in attempts to quantify and reduce conflicts between forest owners who wish to lower moose populations and hunters who wish to retain or increase moose densities (Ball and Dahlgren 2002). The cost of browsing on commercial tree species in Norway according to Solbraa (1998) exceeds the present income many forest owners derive from the sale of hunting rights. Due to moose damage, densities were reduced in all 3 countries by increased harvests in the 1940s and 1950s (Dahl 1979, Myrberget 1979, Jaren 1992). Moose harvests in Sweden increased from around 35,000 per year in the mid-1960s to 132,000 in 1980 (Lavsund 1981). Populations were purposely reduced by increasing harvests from a high of 174,000 in 1982 to around 90,000 per year thereafter due to excessive damage to commercial stands (Lavsund 1987). In Sweden and Norway, Lavsund et al. (2003) reported a growing trend to replant spruce (*Picea abies*) which is much less attractive to moose than pine. This effort to reduce damage to commercial tree species and subsequent reduction in pine browse may result in lower moose densities in the future.

Agricultural Crop and Garden Damage

Moose occasionally damage agricul-

tural crops. In Newfoundland, high moose densities have impacted a growing agrifoods sector (Wicks 2002). A 2-year project tested the effectiveness of Electrobraided Fencing™ to protect 27 acres of cabbage, resulting in zero crop losses in fields that had previously suffered large crop losses. In Fairbanks, the Matanuska Valley, and Kenai Peninsula of Alaska, moose routinely forage in vegetable gardens and on ornamental trees. Preventative measures used include erecting 10-foot-high fences, placing dried bloodmeal around plants, and hanging pieces of bear hide to keep moose away (Anonymous 1998). Increasing moose populations in Idaho have caused substantial concerns to private landowners from damage to crops and breaking of fences in the late 1980s (IDFG 1990). Damage to agricultural crops (baled alfalfa, sugar beets, sunflowers, and small grains) has occurred in northwestern Minnesota and nuisance permits are occasionally issued to deal with such damage (Mark Lenarz, personal communication 2004). In Fennoscandia, governments pay compensation damage for moose damage to cultivated crops. Such costs in Norway were estimated at \$64,500 – 165,000 in 1999 (Storaas et al. 2001).

Vehicle Collisions

Moose/vehicle collisions are a serious concern in some areas of North America and Fennoscandia (Almkvist et al. 1980; Damas and Smith 1983; Sanderson 1983; Nilsson 1987; Child et al. 1991; Del Frate and Spraker 1991; Lavsund and Sandegren 1991; McDonald 1991; Oosenbrug et al. 1991; Schwartz and Bartley 1991; Child 1998; Seiler 1999, 2003; Joyce and Mahoney 2001; Redmond et al. 2004). Moose killed by vehicles rather than hunters represent an economic expense for automobile repair and human health care as well as potential economic loss from recreation. Moose are particularly attracted to some

roadsides by new growth along right-of-way edges as well as high salt concentrations resulting from winter de-icing operations (Child 1998). MVCs have a far greater average and overall economic impact than do collisions with other wildlife (Humphrey 2002). Most estimates of collision costs are conservative, as most agencies do not maintain accurate records (Child and Stuart 1987, Romin and Bissonette 1996, Sullivan and Messmer 2003). MVCs in Newfoundland varied considerably, depending on reporting sources (Table 2), and those by Joyce and Mahoney (2001) were considerably higher than those of Oosenbrug et al. (1991) and Rattey and Turner (1991). In Sweden, Seiler (2003) believes MVCs may be at least double those suggested by official statistics. In British Columbia, Child et al. (1991) reported that the number of reported MVCs may be underestimated by 2 - 6 times the actual number of moose killed, especially as an unknown number are also killed or crippled on logging, mining, and rural roads.

In Newfoundland, as moose densities and traffic volumes increased in the 1980s, collision deaths nearly doubled (Oosenbrug et al. 1986, 1991). Property damage during the 1980s averaged \$1,155 per accident in Ontario and \$1,848 in Newfoundland (Table 3). A later study by Joyce and Mahoney (2001) estimated the following annual losses based on 750 MVCs/year: \$269,500 in initial health costs, \$1,212,750 in vehicle damage, \$431,200 in consumable moose meat, and \$161,700 in losses to the outfitting and related industries or \$2,767 per moose. In Alaska, property damage averaged \$4,000 per vehicle at one auto body shop after 366 MVCs on the Kenai Peninsula during the winter of 1989/90. A decade later, nearly 300 moose fatalities were reported up to mid-February in Alaska (Anonymous 1999a). Human deaths (no year given) resulting from MVCs were reported by Child and Stuart (1987) for Newfoundland

Table 2. Estimated numbers of moose/vehicle collisions in Fennoscandia and North America.

Jurisdiction	Year	# Collisions	# Human Deaths	Reference
Sweden	1980	6,000	15	Lavsund and Sandegren (1991)
	1996	4,000	N/A	Groot-Bruinderink and Hazebroek (1996)
	2003	10,000+	10-15	Seiler (2003)
Norway	1996	1,500	N/A	Groot-Bruinderink and Hazebroek (1996)
	2002/03	2,600	N/A	Lykke (pers. com. 2004)
	2003	1,200	N/A	Seiler (2003)
Finland	1996	150	N/A	Groot-Bruinderink and Hazebroek (1996)
	2001	3,000	N/A	Rajamäki and Mänttari (2002), Heikkilä (pers. com. 2004)
North America	early 90's	3,500+	N/A	Child (1998)
NL	87-88	661	3	Rathey and Turner (1991)
	1989	897	4	Joyce and Mahoney (2001)
	1990	460	4	Oosenbrug et al. (1991)
	1990	867	4	Joyce and Mahoney (2001)
	1994	616	0	Joyce and Mahoney (2001)
	1997	595	0	Joyce (pers. com. 2004)
ME	90-92	600/yr	N/A	Morris and Elowe (1993)
	96-98	2,126	8	Humphrey (2002)
	99-01	2,068	8	Morris (pers. com. 2004)
AK	89-90 ¹	366	2	Del Frate and Spraker (1991)
	89/90	665	N/A	Schwartz and Bartley (1991)
	98/99 ¹	300	N/A	Anonymous (1999a)
	2000	689	N/A	Sullivan and Messmer (2003)
NH	2003	225	N/A	Bontaites (pers. com. 2004)
VT	1997	165	N/A	Alexander et al. (1998)
	99-03	166/yr	N/A	Alexander (pers. com. 2004)
WY	79-93	206	N/A	Hnilicka and Zornes (1994)
PQ	early 90s	265	N/A	Child (1998)
	99-03 ²	188	2-3	Lamontagne (pers. com. 2004)
NS	2003	20	1/10yrs	Power (pers. com. 2004)
BC	1990	400-1200/yr	N/A	Child et al. (1991)
	99/03	713	N/A	Child (1998)
MA	88-92 ³	10	1 (2003)	Vecellio et al. (1993)
YT	2003 ⁴	<12	0	Ward (pers. com. 2004)
CT	2003	2	0	Kilpatrick (pers. com. 2004)
NWT	99/03	4	0	Veitch (pers. com. 2004)

¹ Kenai Peninsula, severe deep-snow winter (human deaths occurred in summer).

² Average # of dead moose reported 1999-2003 (range 177-215).

³ First human death (Kilpatrick pers. com. 2004).

⁴ One human death over 20 years ago.

(6), Quebec (5), British Columbia (2), and New Brunswick (1). Economic and human impacts of MVCs in Maine have more than doubled in 10 years (1988-98). During a 3-year period (1996-98), Humphrey (2002) reported 2,126 collisions resulted in 8 human fatalities (Table 2) and 637 injuries with an estimated economic impact of \$23,600 per collision, totaling \$50.2 million. A similar pattern held for the period 1999-2001 when 2,068 MVCs caused 583 human injuries, 8 human deaths and an economic impact of \$48.59 million (Karen Morris, personal communication 2004).

MVC damage costs include; material loss to vehicles, human injuries (ambulances and medical expenses), human fatalities (life insurance, funeral expenses), call-out costs for police, veterinarians, and wildlife officials to deal with injured or dead moose, loss of meat and hunting opportunities, and the societal costs of traffic delays (Seiler 2003). Fennoscandia experiences the highest number of MVCs (Table 2). In Sweden, 500 human injuries and between 5 and 20 deaths were reported each year during the 1980s (Lavsund and Sandegren 1991). In recent years, Sweden leads Norway and Finland with an estimated 10,000+ MVCs per year (Seiler 2003). The Swedish National Road Administration calculated an average direct cost of \$7,400–\$20,000 € per MVC (Table 3), or over \$100 million € per year. Similarly, in Norway, MVC costs were believed to be between \$11 and \$17 million €. Child (1998) conservatively estimated 3,500 moose were killed annually on North American roadways in the early 1990s. This could represent a direct economic loss of \$10 million or more using average meat value and vehicle damage losses assumed by Oosenbrug et al. (1991).

Wildlife managers have historically been in conflict with transportation agencies in placing management emphasis on increasing moose populations, which cause

increasing MVCs on modern high-speed, high-traffic, highways. In the future, managers must balance the positive aspects of higher moose populations against potential negative impacts when formulating population objectives (Sullivan and Messmer 2003).

Train Collisions

Losses of moose to train collisions are considered socially unacceptable and economically costly (Rausch 1958, Child 1983). The frequency of moose/train collisions varies from year to year and is closely linked to winter snow levels, especially on winter range in mountain valleys of Alaska, British Columbia, and Norway (Rausch 1958, Becker and Grauvogel 1991, Child 1998, Gundersen et al. 1998). The majority of reported kills occur in winter when seasonally migrating moose move to valley bottoms where transportation corridors are located (Jaren et al. 1991, Modafferi 1991). In British Columbia, losses have exceeded 1,000 animals in years of above average snowfall (Child et al. 1991). Similarly, 725 moose died in Alaska in the deep snow winter of 1989-90 (Modafferi 1991). An average of 500 moose/year were killed by trains in Norway during the 1980s (Jaren et al. 1991), and rose to 1,000 in 1993 (Lavsund et al. 2003). Although poorly documented, Seiler (2003) believes Swedish trains killed at least 900 moose each year since 2000. Schwartz and Bartley (1991) believe such losses can be biologically significant to some populations. Unfortunately, most jurisdictions only subjectively report moose/train collisions and damage costs. These are often considered underestimates and are largely unspecified (Child and Stuart 1987, Schwartz and Bartley 1991).

Collisions with moose may damage trains (including derailments), cause passenger delay and physical strain on train personnel, hold population levels below potential, and reduce income to landown-

Table 3. A summary of moose value estimates given in US dollars or euros (€).

Jurisdiction	Year	\$Value/ moose	Subject	Reference
North America	1982	\$1,285	/ Res. hunter ¹	Bisset (1987)
	1982	\$1,688	/ Non-res. hunter ¹	Bisset (1987)
	1982	\$1,068	Meat	Bisset (1987)
	early 90s	\$1,082	Meat	Crichton (1998a)
United States	2002	\$1,789	Replacement ²	Jensen (2002)
AK	1990	\$4,000	MVC ³	Del Frate and Spraker (1991)
ME	2000	\$23,000	MVC ⁴	Humphrey (2002)
Canada				
ON	2003	\$11,600-15,400	/ Harvested bull ⁵	Peter Davis (pers.com. 2003)
	1980s	\$1,155	MVC	Fraser and Hristienko (1982)
PQ	1986	\$5,390-Adult \$4,620-Calf	Poaching loss ⁶	Lacasse (1986)
NL	1980s	\$1,848	MVC	Oosenbrug et al. (1986)
	1990	\$1,016	Meat	Oosenbrug et al. (1991)
	2000	\$2,767	MVC ⁷	Joyce and Mahoney (2001)
Norway	1980s	\$17-32	/ Hide	Sødal (1985)
	2000	\$1,050	Meat	Storaas et al. (2001)
Sweden	2001	\$1,143	Meat	Sylvén (2003)
	2003	\$7,400 - \$20,000 €	MVC ⁸	Seiler (2003)
Finland	1994	\$400/yr	Forest cultivation	Hänninen (1994)

¹ Total expenditures per moose.

² Average for 13 U.S. states (range - \$ 262.50 in WI to \$ 6,000 in MT).

³ Average per vehicle at one body shop.

⁴ Estimated economic impact per MVC.

⁵ One bull tag per 4 non-resident hunters (\$6,000) & a tag-fill rate of 50%.

⁶ Appropriate PQ fine formula (animal biomass, mgmt. costs, & socio-economic losses).

⁷ Average for 750 MVC (Health costs+vehicle damage+loss of meat+outfitting losses).

⁸ Average direct cost per MVC (Swedish National Road Administration).

ers with hunting rights according to Child (1983), Child and Stuart (1987), and Andersen et al. (1991). Vegetative clearing of railway right-of-ways to reduce available forage appears to hold promise in reducing collision frequency (Andersen et al. 1991, Jaren et al. 1991). Schwartz and Bartley (1991) suggested conducting a special “train hunt” during severe winters on the premise that a human harvest is a wiser use of moose than moose killed by trains. Habitat enhancement near railroad tracks and clearing escape routes away from the

railbeds has been used in Alaska to reduce moose-train collisions (Al Franzmann, personal communication 2004).

Aircraft Collision/Damage

Although rare, moose/aircraft collisions have occurred at several Alaskan airports including those at Soldotna, Kenai Municipal, and Anchorage International (Child 1998). Near-collisions of aircraft with moose have necessitated expensive airport fencing. Moose breaching these fences have been killed in special hunts within the

airport boundaries (Al Franzmann, personal communication 2004). Moose believed to be in rut caused thousands of dollars of damage to 18 parked floatplane aircraft in 1999 (Anonymous 1999b). In February, 1997, moose damaged 7 small aircraft in one week. Pre-antler cast rubbing was the suspected cause. Kastdalen (1998) reported on measures taken in Norway to minimize moose collisions with aircraft and connecting road and rail traffic to the new Gardermoen National Airport near Oslo. Complete fencing in combination with over- or underpasses were employed to prevent collisions and allow seasonal moose migration.

Prey Value

Moose provide a source of food for large carnivores including wolves, black bears, and grizzly bears, as well as an array of birds and small mammals that scavenge moose carcasses. Ballard and Van Ballenberghe (1998) provide an extensive review of moose/predator-prey relationships and suggest predation may act as a major limiting factor in many moose populations. Moose densities are generally higher in Newfoundland and Fennoscandia where predation of adult moose is low (Mercer and McLaren 2002, Lavsund et al. 2003). One might argue that predators are valuable in helping to keep densities below carrying capacity (K) by removal of less fit members of the population (Petersen et al. 1984, Ballard et al. 1987). On the other hand, Gasaway et al. (1983) and Schwartz and Franzmann (1989) proposed management actions to reduce predation and increase moose densities when prey populations are depressed (predator pit) and habitat is adequate. Predator control programs are extremely controversial and present managers with competing values; to reduce predation and increase moose populations or to allow moose to remain at low densities. In Fennoscandia and Yellowstone

National Park, wolves have been allowed to re-establish former ranges after receiving protection (Sweden 1966, Norway 1972, Yellowstone National Park, Wyoming 1995) (Andrén et al. 1999, White et al. 2003). In 1998, Wabakken et al. (2001) reported 50-72 wolves in 6 reproducing packs had been established on the Scandinavian peninsula. These increased to an estimated 97-107 wolves in the winter of 2002 (Olof Liberg, personal communication 2004). Wolves were re-introduced to Yellowstone National Park in 1995 and 1996, and by 2004 an estimated 170-180 wolves use the park at least part of the year (Rolf Peterson, personal communication 2004). White et al. (2003) and Gundersen (2003) believe hunting harvest and wolf predation to be largely additive and recommend managers reduce hunting harvest in Yellowstone and in the Koppang area of Norway's Hedmark County, respectively.

Some woody plants, including willows (*Salix* spp.), preferred by moose have been released from suppression in Yellowstone National Park following wolf establishment according to Ripple et al. (2001). In the future, the major challenge will be to set population targets and maintain and improve public understanding and local acceptance of wolves as the population increases.

Interspecific Values

Moose and woodland caribou (*Rangifer tarandus*) are sympatric over much of the boreal coniferous forests of North America (Boer 1998). As logging proceeds northwards, the habitat requirements of both species must be considered in formulating logging plans. In the past, habitat for both moose and caribou in Ontario were managed on a species-specific basis through guidelines designed to favor each species (OMNR 1988, 1999). The Crown Forest Sustainability Act (1996; http://www.e-laws.gov.on.ca/DBLaws/Statutes/English/94c25_e.htm),

directs forest managers to maintain biodiversity on all managed forests, by emulating natural disturbance and landscape patterns (OMNR 2001). Woodland caribou in Ontario are currently classified as threatened and a recovery strategy is being developed (OMNR 2003). The objective of this strategy is to maintain caribou in northern parts of their historical range by managing for larger cuts and reducing edge density, both parameters which favor caribou but not moose (John McNicol, personal communication 2004). Hence managers are forced to weigh competing values and decide whether to manage for moose or woodland caribou.

Habitat Management Costs

Certain types of new habitat created by logging (i.e., edge, early succession, residual cover) will result in increased moose reproduction, survival, and population densities. Consequently, agencies have developed habitat management guidelines aimed at sustaining or increasing moose densities (Thompson and Stewart 1998). Management of moose habitats to provide sustained moose populations will impose additional constraints and higher investment costs on timber production (Racey et al. 1989, Sarker and Surry 1998). Identification of moose habitat values may limit the time during which all or part of an area will be logged (Chamberlin 1981). With such competing values, managers must weigh the benefits from hunting and non-consumptive use against the timber values.

SUMMARY

The majestic moose, “Monarch of the North” and a symbol of wilderness, is a much valued species by Native Indians, Metis People, recreational hunters, and a host of non-consumptive users. They also provide food for a variety of mammalian and avian carnivores, including scavengers.

Moose represent a multitude of val-

ues, each representing varying levels of importance determined by compatible and incompatible interactions through time. We have attempted to identify and categorize such values as those considered positive or complementary and those which we believe to be largely negative or to compete. Our list comprises 22 values based on a literature search of known and expressed assets of moose in North America and Fennoscandia. Identified values, many of which interact, do not necessarily follow accepted economic value systems and nomenclature. Our objective was to assemble an array of recognized values that will aid economists and decision makers to better understand moose as a valuable renewable resource. We believe such knowledge should lead to a more comprehensive basis for improved evaluation and species management in an ecological context.

Knowledge of current moose densities is considered fundamental to an understanding of competing and complementary values which likely vary among individuals. Twelve complementary values are identified, including recreational hunting, license revenues, and a discussion of the worth of meat, antlers, and hides for which a monetary value can be more readily identified (Table 3). Licensed recreational harvest, for example, can help control and sustain moose densities and promote economic benefits to local economies valued in the hundreds of million dollars annually. Current license fees in North America are modest (Table 1) and do not reflect the recreational and meat value of moose harvested by licensed hunters (Table 3). Values more difficult to quantify, are identified, including those related to cultural/spiritual, aesthetics, commercial, scientific/ecological, and habitat utilization.

Ten competing values largely associated with moderate to high moose densities are identified. High densities, ($>2.0/\text{km}^2$),

although perceived desirable by many, may lead to extensive property/forest damage and loss of human life and injury. Conflicts between moose and humans have increased, especially in proximity to urban/suburban areas (Karns 1998). Consequently their presence in many areas has become more socially unacceptable. Values considered to compete include damage caused to commercial forests and agricultural crops, collisions with vehicles (MVCs - see Table 3), trains, and aircraft, as well as resource allocation conflicts, added habitat management costs, predator/prey control costs, illegal harvests, and setting interspecific priorities.

In future, some aspects of moose management may need to be more decentralized, so local knowledge and values can be used more effectively in estimating local moose densities, assessing and mitigating forestry and property damage, and taking appropriate measures in sustaining healthy populations (Lavsund and Sandegren 1989, Jaren et al. 1995). Moose viewing opportunities need to be better identified and funded to promote use of prime viewing areas in a variety of locations. Expansion and development of moose ecotourism to provide added benefits, especially in northern economically depressed areas, should receive attention. A detailed analysis of moose marketing, used to sell a growing variety of products (Appendix), and its economic impact is needed. Illegal harvests, thought to approach or exceed current licensed harvests, are believed to constitute a major competing value that begs resolution. Co-management of the resource is dependent on effective joint participation between government mandated and Native wildlife managers. MVCs appear to be significant and increasing in some jurisdictions and more research is needed to identify mitigating measures. MVC data can provide an inexpensive index to population change and managers should consider its use in improving the quality

of associated data (McCaffery 1973, Case 1978, Hicks 1993, Alexander et al. 1998). Harvest quotas in some jurisdictions may need adjustment, due to increased predation losses, following re-introductions of wolves.

Agencies need to re-examine their moose policies and objectives. A more holistic approach to management, that recognizes a rich variety of values, is needed. Production of higher densities should be balanced with added damage costs accrued. More moose are not necessarily always beneficial. Agencies need to recognize that the past policy of managing moose primarily for recreational harvest may no longer be appropriate or receive majority public support.

ACKNOWLEDGEMENTS

We would like to thank the following individuals who provided information and advice: Al Franzmann and Tom Cooper, Soldotna, AK; Rolf Peterson, Michigan Technological University, Houghton, MI; Marty Orwig, North American Moose Foundation, Mackay, ID; Bill Peterson, Libby, MT; Mark Lenarz, Minnesota Department of Natural Resources, Grand Rapids, MN; Karen Morris, Maine Department of Inland Fisheries and Wildlife, Bangor, ME; Kristine Bontaites, New Hampshire Fish and Game, New Hampton, NH; Cedric Alexander, Vermont Fish and Wildlife, St. Johnsbury, VT; Howard Kilpatrick, North Franklin, CT; Al Hicks, New York State Department of Environmental Conservation, Delmar, NY; Rick Ward, Yukon Renewable Resources, Whitehorse, YT; Alasdair Veitch, Department of Renewable Resources, Norman Wells, NWT; Ed Telfer, Edmonton, AB; Vince Crichton, Wildlife and Ecosystem Management, Manitoba Conservation, Winnipeg, MB; Gilles Lamontagne, Quebec Ministère de l'Environnement et de la Faune, Quebec City, PQ; Vince Powers,

Nova Scotia Wildlife Division, Kentville, NS; Brian McLaren, Newfoundland and Labrador Department of Tourism, Culture and Recreation, Inland Fish and Wildlife Division, Cornerbrook, NF; Bruce Ranta, Ted Armstrong, Bob Stewart, John McNicol, Bill Dalton, Charlie Todesco, and Peter Davis, Ontario Ministry of Natural Resources, Kenora, Thunder Bay, Sault Ste Marie, and Wawa, ON; John Kaplanis, Thunder Bay, ON; Mike Buss, Dwight, ON; Alex Cringan, Ft. Collins, CO; Jon Lykke, Verdal, Norway; Sten Lavsund, Uppsala, Sweden; Olof Liberg, Grimso Wildlife Research Station, Riddarhyttan, Sweden; and Risto Heikkilä, Forest Research Institute, Vantaa, Finland.

We are especially indebted to Ed Addison, Al Franzmann, Ed Telfer, Mike Buss, John McNicol, Alex Cringan, Michael Wolfe, and Nicole McCoy for providing constructive comments on an earlier draft, and to Susan Rodgers for preparation of the manuscript.

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APPENDIX

A sampling of moose related items or products sold commercially.

Antique Store-

Flying Moose Antique Mall, Wichita, Kansas, USA

Auto Dealers-

Moose Motors Incorporated —112 Lindgren Road West, Huntsville Ontario, Canada, P1H 1YZ

Bars and Restaurants-

Loose Moose, Toronto, Ontario, Canada

Lonely Moose Bar, Anchorage, Alaska, USA

Moose Tooth Pub & Pizza, Anchorage, Alaska, USA

The Moose is Loose, Sterling, Alaska, USA

Moosquitos Bar, Sterling, Alaska, USA

Moose's Saloon— Kalispell, Montana, USA

Moose Winooski's— Brantford & Kitchener, Ontario Canada

Moose Delaney's Sports Grill— 3 Cann Street, Huntsville Ontario, Canada. P1H 1H3

Rustic Moose—Ketchum, Idaho, USA

Moosehead Lounge, Glenwood, Newfoundland, Canada.

Bedroom Items-

Berber Throw Pillow (with bull moose illustration)—Woolrich Company—\$19.99 US

Flannel Sheet set-- (illustrated with moose, geese, & trees)—Woolrich Company — \$24.99 US

Beer-

Moosehead Beer—Moosehead Brewer-

ies, St. John New Brunswick Canada
 Moose Drool Beer— Big Sky Brewing
 Co., Missoula Montana, USA
 Moose Tooth Beer— Moose Tooth
 Brewing Co., Anchorage Alaska, USA

Candy-

Maple Moose Pops, Bread & Chocolate
 Incorporated, Wells, Vermont, USA

Childrens Books-

Deneki, an Alaskan moose. by W.D.
 Berry. 1965. Macmillan Publishing Com-
 pany, New York. USA

Thidwick the Moose— Dr. Seuss

Moose for Kids— J. Fair

A Moose for Jessica—1987— P. A
 Wakefield and L. Carrara, E.P. Dutton,
 New York

Mickey Moose by Bob Reese — Aro
 Publishing, Provo, Utah 1986

Chocolates-

Harry and Davids Moose Munch
 Bar— www.harryanddavid.com

The Chocolate Moose— 2839 Bathurst
 Street, North York, Ontario, Canada M6B
 3A4

Moose droppings— chocolates shaped
 like moose droppings

Christmas Ornaments-

30 inch Holiday Standing Moose—
 Safeways (\$12.99 US) — Nov. 11/ 03
 flyer

Coffee Table Books-

Moose: Giant of the Northern Forest.
 Bill Silliker, Jr., Key Porter Books, 1998;
 \$28.95 CND (hardcover), \$19.95 US (soft-
 cover)

Canning Moose, by Richard E. McCabe.
 Rusty Rock East Press, P.O. Box 34646,
 Washington, D.C. 20034. USA— \$10.95
 + \$1.50 shipping (US)

Moose by Daniel Wood., Whitecap

Books Limited., 351 Lynn Avenue, North
 Vancouver, B.C., Canada V7J 2C4

Wild Moose Country, by Paul I.V.
 Strong. Northwood Press, Incorporated.
 Minnetonka, Minnesota., USA (\$39.00 US;
 \$55.00 Cnd— hardcover or \$19.95 US &
 \$27.95 Cnd softcover

Moose, by Art Rodgers 2001, World
 Life Library, Voyageur Press, Stillwater,
 Minnesota, USA

Welcome to the world of moose. by
 Diane Swanson. 27pp. (\$6.95 Cnd, \$5.95
 US)

Compact Discs-

Moose Music— V. Crichton, 1046,
 McIvor Avenue, Winnipeg, Manitoba,
 Canada, R2G 2J9

Computer Consultants-

Moose Eagle Computers — 416-422
 0505

Cookbooks-

Moosewood Restaurant (New Recipes)
 — 1996 Vegetable Kingdom, Incorpo-
 rated

Moose in the Pot— Tim Lundt, Mat-
 Su Alternative School, 1775 West Parks
 Highway, Wasilla, Alaska, USA

Low Bush Moose and other Alaskan
 recipes 1978. Alaska NorthWest Publish-
 ing Company

The Moose— National Meat Institute,
 Montreal Quebec, Canada. 1970.

Fruits & Vegetables-

Red Moose — Gourmet Toma-
 toes on the Vine—Great Northern Hy-
 droponics, Ruthven, Ontario, Canada

Gift Shops-

Blue Moose— Grand Marais, Min-
 nesota, USA

The Purple Moose—Skagway, Alaska,
 USA

Moose Creek Antler Lighting and Decor— Libby, Montana, USA

Moosetrack Quilts — Whitefish, Montana, USA

Mostly Moose's— Kalispell, Montana, USA

Moose Crossing, Incorporated, Marion, Montana, USA

Golf Course-

Moose Run Golf Course, Anchorage, Alaska, USA

Hockey Teams-

Manitoba Moose, American Hockey League, Winnipeg, Manitoba, Canada

Halifax Mooseheads, Halifax, Nova Scotia, Canada

Insignias, Emblems, Coats of Arms, State Seals-

Hudsons Bay Company

Coats of arms — Ontario, Canada, Maine, USA, Michigan, USA

Hawker Hurricane Fighter Squadron #242 Canadian & 503rd Bombardment — WW 2

Royal Canadian Airforce Squadron # 419, Badge: moose attacking, Motto: Moose aswayita (Beware of the moose), Authority: King George 6th, June 1944

Community Crests— Ft. Resolution, Ft. Simpson, Kakisa, Ft. Simpson, Northwest Territories, Canada

Internet Provider-

Moose Web Corporation, Kalispell, Montana, USA

Jewelery-Moose Beads—

Dale Peterson, Libby, MT, USA
<mooses@libby.org>

Limited Edition Prints-

Robert Bateman- Autumn Overture— Bull Moose- 1981

Stefen Lyman- 1988

Location Names-

Moosejaw, Saskatchewan, Canada, Mooseonee, Ontario, Canada, Moosomin Saskatchewan, Canada, Moose Factory, Ontario, Canada, Moose Lake, Minnesota, USA, Moosic Village, 6 miles south of Scranton Pennsylvania, USA. Moose Pass, Alaska, Moose, Wyoming, USA, Mooseup, Connecticut, USA, Moosehide, Klondike, Yukon, Moosehorn, Manitoba, Canada, Moose Creek, Ontario, Canada, Moosejaw Creek, Saskatchewan Canada

79 based on moose in Maine, USA including Moosehead Lake

81 based on moose in Alaska

Mascots-

Moose mascot— Seattle Mariners Baseball team, Seattle, Washington, USA

Moose Marketing— A Sampling-

www.mooseworld.com

Moose Visitor Centre-

Gould CO, USA— CO State Parks— the moose viewing capital of CO

Motels-

The Moose Head Inn, Kenosee Lake Sask., Canada

Moose River RV, Sterling, Alaska, USA

Moose Lane B&B, Anchorage, Alaska, USA

Moose Hollow, B&B, Soldotna, Alaska, USA

Moose Creek Lodge, Soldotna, Alaska, USA

Moose Motel 226 Highway #11, Smooth Rock Falls, Ontario, Canada, P0L 2B0

Movies-

Brother Bear— Walt Disney— 2003, Rutt and Tuke— Canadian moose brothers,

inspired by Bob & Doug McKenzie “The moose are hilarious, and Phil Colin’s music is terrific!”— Leonard Matlin, Maclean’s November, 24, 2003:66

‘Rocky and Bullwinkle’

National Animal-

Norway (Storaas et al. 2001)

Naval Ship-

Moose— Commissioned Quebec City, Sept. 8th, 1939 & assigned to Halifax NS Local Defence Force until May 1942, transferred to Sydney & employed as a training ship until July 1945

Organizations-

Loyal Order of Moose— an International Fraternal & benevolent organization

North American Moose Foundation— (610 W. Custer, PO Box 30, Mackay, Idaho, USA 83251

Outdoor Clothing-

Moose Creek brand, USA. (made in China)— shirts, vests, jackets

Shirts @ moose figures— Cabella’s & L.L. Bean, Coldwater Creek, Abercrombie’s

Outdoor Equipment-

The Moose Hunter & Outfitter. RR# 2 Hwy 11-17, Thunder Bay Ontario, Canada

Outfitters-

Moose Point Camps — Portage Maine, USA

Pasta-

Moose Pasta (’Pâtes D”Original) — Gourmet du Village, Morin Heights Canada, JOR 1HO

Politics-

Bull Moose Progressive Party— Teddy

Roosevelt’s unsuccessful bid for a 3rd term 1912

Postage Stamps—

Canada Post’s new \$5.00 Stamp issued December 19, 2003, by wildlife artist David Preston-Smith

Radio Station-

Moose Radio Muskoka— 50 Balls Drive, Bracebridge Ontario, Canada, P1L 1T1

Real Estate Brokers-

Moose Realty Limited, 877 Jane Street, York, Ontario, Canada, M6N 4C4

Soap-

Moose Drool soap—Montana, USA
Moose Spit soap— British Columbia, Canada

Song-

Gotta Get Me Moose, B’y— written by Kevin Blackmore, Wayne Chaulk and Ray Johnson

State Animal-

Maine (Morris and Elowe (1993)

State Parks-

Moose Lake State Park, Moose Lake, Minnesota, USA

Moose River Resort, Sterling, Alaska, USA

Tattoos-

Rub-on moose tattoos

Theater Company-

Mooseberry Theater Company, Moomsomin, Saskatchewan, Canada
Tourist Advertizing-

“Moose, Mountains and Mounties”— Tourism Canada’s marketing focus— early 1980s (Noto 1985)

“Moose in the City”—Toronto, Ontario, Canada’s Millennium event (2000)—100’s of life-sized moose sculptures gracing city streets (The Moose Call 2001, 12:25)

Toys / Ornaments-

Chocolate Moose—(Fun Puppet & Animated Plush—Chocolate Scented)—(\$9.99 US)—Dandie International Limited, 106 Harbor Drive, Jersey City USA—Walgreens.com—Nov. 2003

2-Piece Pet and People Moose Antlers (\$9.99 US)—Petsmart—<PETSMART.com>

Moose BookEnds—Cabellas

Videos-

Moose Hunt, a Guide to Success—Interesting Services Incorporated. 1989

Moose Close-up—V. Crichton, 1046, McIvor Avenue, Winnipeg, Manitoba, Canada

In the Company of Moose. Gisele Benoit, Films Franc-Sud—CBC, Quebec, Canada

The High Season of the Moose

Wood Carving-

The Canadian Carver, Hwy. # 17, Pancake Bay, Lake Superior, Ontario, Canada