REVIEW OF THE HISTORY AND PRESENT STATUS OF MOOSE IN THE NATIONAL PARKS OF THE ATLANTIC REGION: MANAGEMENT IMPLICATIONS?

Gary Neil Corbett

Parks Canada, Historic Properties, 1869 Upper Water Street, Halifax, N.S., B3J 1S9

ABSTRACT: Moose (*Alces alces americana*) where reported to be relatively common and widespread in Canada's Maritime provinces (New Brunswick, Prince Edward Island, Nova Scotia) but absent in Newfoundland when European explorers arrived. Their distribution and abundance were to change dramatically as human settlement and land use spread across the region. In New Brunswick, moose became so scarce that hunting seasons were closed by 1937. When Fundy National Park was established in 1948 the moose population there was estimated at 160 animals, growing to 260 during the 1950s but declining to 130 in the 1960s and to 40 by 1970 where it may remain today. Kouchibouguac National Park had a moose population estimated at 30 animals when it was established in 1979, however with protection, the herd has grown to over 100 moose. On Prince Edward Island moose had disappeared by 1900, long before a national park was established there in 1937. Moose numbers declined in the area of Nova Scotia which became Kejimkujik National Park in 1974 and are rare today. Moose became rare on Cape Breton Island by 1900 and were extirpated by 1924. Cape Breton Highlands National Park was established in 1936 and moose were successfully reintroduced to the park in 1947/48 with the release of 18 moose belonging to the *andersoni* sub-species. Present population densities for the area exceed 5.0 km^2 in some forest types. Moose were successfully introducted to Newfoundland in 1904 and increased so dramatically that a moose hunting season was possible by 1935. A healthy population existed when Terra Nova National Park was established in 1957 and remains at a stable density of 0.4 moose /km^2 today. Gros Morne National Park was established in 1973; the moose population was estimated at 0.4 animals /km^2 in 1977. Protection and favourable habitat have allowed the population to grow to densities of almost 7.0 moose /km^2 in lowland areas. Sport hunting is not permitted in national parks, which are managed to maintain ecosystems in as natural a state as possible, unimpaired by human activities. However, where man has seriously altered the structure and function of park ecosystems, intervention to restore natural processes is permitted. The gray wolf (*Canis lupus*) was extirpated in Atlantic Canada by 1920. The non-native status of moose in Newfoundland and the loss of the wolf, a natural control of moose populations, could be considered a serious alteration of natural processes presenting an interesting challenge to modern policy and management of national parks.

ALCES VOL. 31 (1995) pp.255-267

Seven national parks are located in Atlantic Canada in the provinces of New Brunswick, Prince Edward Island, Nova Scotia and Newfoundland (Fig. 1). Six of the parks are inhabited by moose (*Alces alces*); neither the province of Prince Edward Island nor Prince Edward Island National Park have moose which were extirpated there before the turn of the twentieth century (Cameron, 1958). White-tailed deer (*Odocoileus virginianus*) occur in each of the four national parks located in New Brunswick and Nova Scotia but do not occur in Newfoundland. The gray wolf (*Canis lupus*) was extirpated in Atlantic Canada around the turn of this century (Banfield 1974). Eastern coyotes (*Canis latrans*) spread throughout New Brunswick, Prince Edward Island and Nova Scotia during the1970s and have now been colonizing the province of Newfoundland for several years (Warden files, Gros Morne N.P.). Although coyotes may occasionally kill moose calves, the main predator of moose in the parks with moose populations is the black bear (*Ursus americanus*).

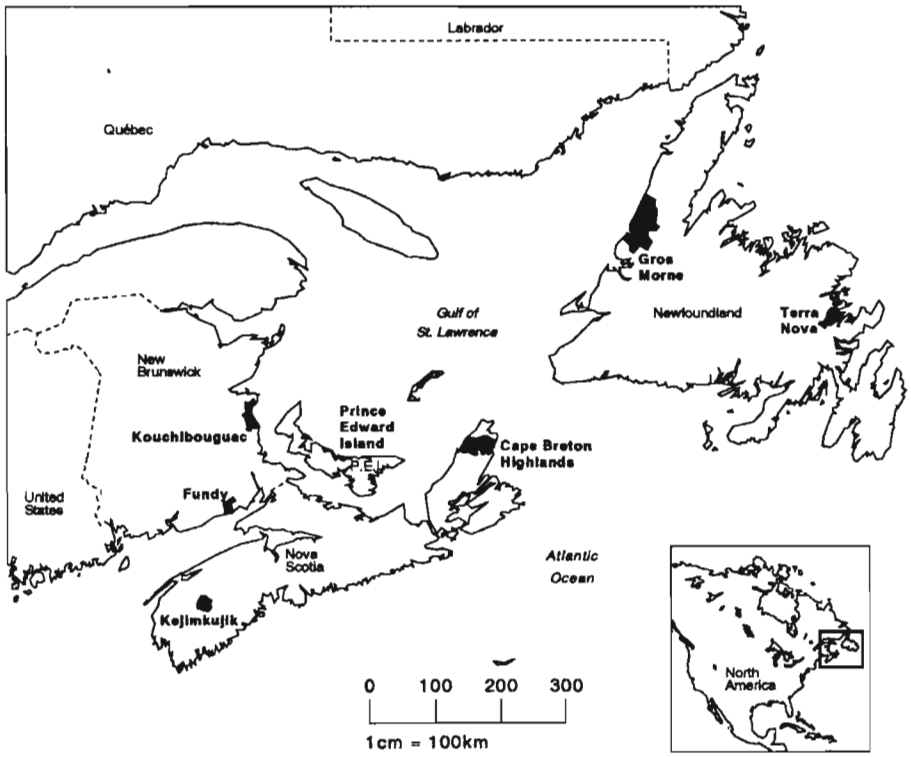

Fig. 1. National Parks in Canada's Atlantic Region

Moose are protected in the national parks and sport hunting is prohibited by law under the National Parks Act of Parliament (1930). Timber operations are also prohibited except where a special agreement provides for limited domestic harvest by local residents in Gros Morne National Park in Newfoundland. Management of national parks is directed at maintaining ecosystems in as natural a state as possible. Where the structure and function of park ecosystems have been seriously altered by human activities, intervention is permitted where natural processes cannot restore ecosystem integrity. Intervention, however, must be guided by clear, practical and measurable objectives consistent with park management plans and the rigorous application of science in the collection and interpretation of research and monitoring data (Anon. 1994). This paper synthesizes the available data on the history and present status of moose in the national parks of Atlantic Canada and explores the management implications of high moose densities, exotic status and potential impacts on ecosystem structure and function.

METHODS

Park natural resource inventory reports, aerial moose survey technical reports, historical accounts and other pertinent material were researched to obtain information and data on moose abundance and status both before and after each national parks establishment. Before 1970 Park Wardens used a combination of direct aerial and ground counts to estimate moose population size.

With the exception of a stratified random block survey in Cape Breton Highlands National Park in 1985, aerial moose surveys in the 1970s and 1980s employed parallel transects, 0.4 km apart with 100% coverage of moose habitat. Helicopter or fixed wing aircraft were used flying at an altitude of 200 meters above ground level at a speed of 120

km per hour. Crews consisted of one navigator and two observers mapping the location of all tracks and animals observed on 1:50,000 scale topographic maps. Where possible observed animals were classified as calf or adult male or female.

Aerial random block moose surveys conducted since 1990 employed 4 km² quadrats with a sample size of 20 - 25% of moose habitat. Total park areas were stratified according to winter moose habitat quality, overlain with grid blocks, and sample quadrats were chosen using random number table or generator. Flight lines at 500 meter intervals parallel to one block boundary line were drawn in each sample block. A helicopter was used for flights at an altitude of 120 meters above ground level and a speed of 100 km per hour. Crews consisted of a navigator and two observers mapping the location of all tracks and animals observed on 1:50,000 scale topographic maps. Surveys were conducted within 48 hours of a fresh snowfall; deviations from flight lines were made to follow moose tracks until animals were located. Observed animals were classified as either calf, adult, male or female.

FUNDY NATIONAL PARK

Description

Fundy National Park (Fig. 1) is 206 km² in area and located in southeastern New Brunswick, Canada (Lat: 45° 60' N; Long: 65° W). Cliffs rise up to 210 m. above the adjacent Bay of Fundy to a plateau of rolling hills cut by deep river valleys. The maximum elevation of hilltops is 380 m. Soils are podsolic and the climate is cool temperate with more precipitation on the inland plateau. Forest cover changes from a coastal zone of red spruce (*Picea rubens*) and balsam fir (*Abies balsamea*) at lower altitudes to sugar maple (*Acer saccharum*), yellow birch (*Betula alleghaniensis*) and balsam fir on the uplands as described by Rowe (1972).

Prescott and Bateman (1978) described moose habitat in the park as follows: Prior to park establishment in 1948, the forests of the area were periodically cut for lumber and fuel wood. Regeneration of the stands provided good winter browse for moose, in particular, balsam fir, birch and maple. All forest cutting ceased with park establishment and regenerating cuts were overbrowsed during the 1950s to the extent that high browse lines and dead stems could still be seen in the 1970s.

In 1975, seventy-five percent (155 km²) of the park area was good summer moose range, in particular many areas of regenerating old fields, roadsides, marshes, lake edges, small ponds and lakes. Twenty-eight percent (58 km²) of the park was good winter habitat consisting of spruce/fir and spruce/fir/birch. Balsam fir stands were extensively damaged by spruce budworm (*Choristoneura fumiferana*) in the 1970s and moose habitat improved in the 1980s as they regenerated. Today, many stands are in the pole stage and provide little winter browse.

History and Present Status

Moose were thought to be near extinction in New Brunswick in the late 1700s, the 1830s and again in the 1930s (Wright 1956). The wolf was extirpated by 1900 (Squires, 1968). In 1937 the season was closed to moose hunting, (Wright 1956) however, Kelsall (1963) reported that in 1937 moose were numerous in the area to become Fundy National Park but declined between 1938 and 1940. Moose increased during the 1940s and a population of 160 was estimated for the Fundy National Park area when it was established in 1948 (Prescott and Bateman 1978). By 1951, park staff were concerned that overbrowsing was occurring and a cull was attempted in 1955. However, due to operational problems, only 9 moose were removed (Brown 1955). Park Wardens estimated in 1959 that the moose population had increased to 260 animals and that the white-tailed deer population had increased from 150 in 1948 to 350 (Prescott and

Bateman 1978). Kelsall (1963) reported a moose die off of approximately 160 animals during the winters of 1959/60 and 1960/61 leaving a population of 129 animals in 1961. Prescott and Bateman (1978) attributed the cause of this die off as winter severity and inadequate browse supplies however no records of the physical condition of animals seems to be available. High densities of winter tick (*Dermacenter albipictus*) were observed (Brown 1955) and could have been a factor in weakening the animals. Prescott and Bateman (1978) reported that moose and deer overlapped their ranges at the 250 m. elevation and the moose disease (*Parelaphostrongylus tenuis*) could have been a factor. The link between deer and moose disease was unknown until 1964 (Whitlaw and Lankester 1994).

No further moose surveys were reported until 1971 when an aerial transect survey estimated 35 to 45 moose in the park (Wood *et al.* 1971). Additional transect surveys by Wentzell (1975) and Prescott and Bateman (1978) also estimated 35 to 45 animals which is a density of 0.2 moose /km^2. No aerial moose surveys were conducted during the 1980s; however, Park Warden George Sinclair (pers. comm.) indicated that deer were common in the mid 1980s and moose were rare. Collingwood (1990) conducted an aerial moose survey in the winter of 1989/90 observing only one moose and survey design permitted no reliable population estimate. Daigle (1993) reports an aerial random block survey conducted in 1993 which estimated a population of 123 but a wide 90% confidence interval of 33-213 could not substantiate a population increase. Daigle (pers. comm.) however indicates that moose appear to have increased somewhat particularly near the park boundary where they have access to hardwood browse regenerating on adjacent forest clearcuts. It is currently unknown, why moose did not rebound as forests regenerated after the budworm kills in the 1970s. A number of factors could be involved including predation and moose disease.

Coyotes have reduced the deer population in the park to around 30 individuals (George Sinclair pers. comm.); which could reduce the possibility of moose disease as a factor. The park moose population may increase in future years.

KOUCHIBOUGUAC NATIONAL PARK

Description

Kouchibouguac National Park (Figure 1) is 239 km^2 in area and is located on the east coast of New Brunswick (Lat: 46°50' N; Long: 65° W). This park is, entirely, on a coastal plain with maximum elevations of 30 meters. Major landscape features include extensive bogs and a 25 km long sand dune barrier beach complex. Forests are described by Rowe (1972) for the eastern lowlands section of the acadian forest region as predominately coniferous. Tree species include black spruce (*Picea mariana*), red spruce, balsam fir, white pine (*Pinus strobus*), jack pine (*Pinus banksiana*), red maple (*Acer rubrum*), sugar maple, yellow birch and white birch (*Betula papyrifera*) (Morton and Savoie 1983). Forest composition is presently 70% coniferous, 24% deciduous, 6% mixed. Peatlands involve 21% of the park area

Morton and Savoie (1983) described moose habitat in the park as follows: Prior to park establishment in 1979 scattered lumber and fuel wood harvesting occurred throughout the present park area. Small farms created edge habitat around fields to supplement that occuring around the many bogs, ponds, brooks, marshes and alder swales which occur in the area. Cover is provided by mature balsam fir, red spruce and black spruce near heath bogs, brooks and old fields. Moose are distributed throughout the park but are more concentrated in the northern sector near bogs. Over the last 15 years, forest regeneration has provided adequate browse for a growing moose population.

History and Present Status

Wright (1956) reported that moose were very scarce south of the southwest Miramichi River in 1883/84. However, by 1915 both moose and deer became plentiful. Overhunting and severe winters were suspected of causing further declines in the 1920s and 30s subsequent to the moose hunting season being closed in 1937. Since the 1950s, moose numbers gradually increased in New Brunswick (Morton and Savoie 1983). Poaching and other factors kept moose numbers low in the area that became established as Kouchibouguac National Park in 1979. Aerial transect surveys conducted just prior to park establishment estimated a population of only 15 to 20 moose in the area (Godin 1977). White-tailed deer were listed as common and widespread in a mammal inventory completed in the early 1980s (Morton and Savoie 1983). An aerial transect survey completed in 1987 estimated a continued low population of 12 to 19 moose (Fontaine 1988). Moose numbers have increased dramatically in the last 5 years. An aerial random block survey completed during the winter of 1994/95 estimates 100 to 110 moose in the park, a density of 0.4 /km^2. Sixty-one moose were observed during the survey, but no deer. An estimated 20 to 30 coyotes were also observed during the survey (Richard 1995). A number of factors could be responsible for the increase in moose numbers including a declining deer population, improved habitat and decreased poaching.

KEJIMKUJIK NATIONAL PARK

Description

Kejimkujik National Park (Fig. 1) is 381 km^2 in area and located in southwestern Nova Scotia, Canada (Lat: 44°20' N; Long: 65°20' W). The landscape is of glacial origin involving drumlins, eskers and shallow rocky lakes and streams over granite and slate bedrock. Winters are mild usually with insufficient snow to require either moose or deer to yard. The northeastern half of the park is forested with sugar maple, hemlock (*Tsuga canadensis*) and white pine while the southwestern half is forested with red spruce, hemlock and white pine. Forest cover is generally second growth mixed wood and mixed softwood (Wood 1973). This park lies in the atlantic uplands section of the acadian forest region as described by Rowe (1972). Most forest stands are now mature or reaching maturity (authors observations) and provide little browse for moose and deer. Summer and winter forage can be found around lakes, bogs, roads and campgrounds to support some moose and deer.

History and Present Status

In 1936, moose were said to be numerous and deer common (Sheldon 1936) in the area which was to become Kejimkujik National Park. When Wood (1973) prepared his mammal inventory for the park area, he conducted an aerial ungulate survey. He estimated a population of 200 deer in the area, but saw no moose during the survey. His report mentions that the brain worm, *Parelaphostrongylus tenuis*, could be one factor in the disappearance of moose since several moose with apparent moose disease were reported. The national park was established in 1974. Park Wardens did occasionally observe moose in the park over the years and still do. McKay (1982) reported that between 1973 and 1981, deer increased steadily and were numerous. Coyotes became established in the park area in the late 1980s and have been a major factor in a decline of the deer population. Tony Nette (pers. comm.) estimates that a population of 200 to 300 moose exist in areas adjacent to the park, in particular the Tobeatic Game Sanctuary.

CAPE BRETON HIGHLANDS NATIONAL PARK

Description

This park, located near the northern tip of Cape Breton Island (Fig. 1) in Nova Scotia,

Canada (Lat:46° 50' N; Long: 60°30' W) is 948 km^2 in area. Cliffs on the west coast of the park rise to a plateau at 410 m. with maximum elevations of 529 m. Elevations gradually decrease in an eastward direction over a distance of 40 km. The plateau area exhibits windswept stunted black spruce and balsam fir communities on ferro-humic-podzolic soils and in winter receives up to 4 m. of wind packed snow sufficiently dense enough to permit moose movements (Prescott 1980). Two sections of the acadian forest region are represented by this park; Cape Breton - Antigonish section on the lowlands and the Cape Breton plateau section on the uplands (Rowe 1972). Forests vary from predominantly deciduous stands of sugar maple, beech (*Fagus grandifolia*), yellow birch and red maple on slopes and in canyons to a more boreal type of vegetation with increasing altitude. Over one-half of the area of the park is boreal, forested with balsam fir, white spruce (*Picea glauca*), black spruce and white birch.

Prescott (1980) described the condition of moose habitat in the park as follows: During the 1960s and early 1970s, moose range in the park was not good because of the many bogs, barrens, mature hardwood forests and the mature and decadent condition of softwood forests. Improvement of the quality of moose range on the highlands has resulted from the recent spruce budworm defoliation of the mature balsam fir forests which is causing extensive areas of early successional white birch stands. Since 1985, moose overbrowsing has prevented regenerating hardwood and balsam fir growth from reaching pole stage height. (Randy Thompson pers. comm.)

History and Present Status

The wolf was exterminated in Cape Breton by the turn of the 20th century. Moose were also extirpated by 1924 due to excessive hunting and habitat destruction (Cameron 1958). Cape Breton Highlands National Park was established in 1936; in 1946 moose (*Alces alces andersoni*) were overabundant in Elk Island National Park (Alberta, Canada) and it was decided to use some of that stock to reintroduce the species to Cape Breton Highlands National Park. In 1947, 5 adult cows, 1 female calf and 2 male calves were released. A further release of 5 adult bulls and 5 adult cows took place in the summer of 1948 (Prescott 1980). By the early 1950s, moose were observed in many areas of the park, however, the population did not show noticeable increase until the 1970s. An aerial transect survey conducted in 1970 located only 2 moose, while a similar survey in 1975 located 66 animals. Prescott (1980) conducted an aerial transect survey in the winter of 1976/77 and estimated a population of at least 178 moose. He also conducted surveys for white-tailed deer and listed them as common and widespread throughout the summer but restricted to coastal areas and slopes during winter due to deep snow. Moose concentrated in the boreal forest on the uplands, year round. An aerial transect survey similar to Prescott's (1980) 1976/77 survey was conducted in 1980 and estimated a minimum of 228 animals (Wentzell 1985).

Wentzell (1985) employed the first stratified random block moose survey in the park during the winter of 1984/85. He calculated a mean population of 1126 moose in the park. The park was divided into 3 strata; lowlands, canyons and slopes with acadian forests observed to have medium moose densities; uplands with boreal forests having high moose densities and high barren areas on the uplands having very low moose densities. A moose population of 883 animals (95% CI 578-1193) or a density of 1.69 moose/km^2 was calculated for the boreal forest components. A population of 240 moose (95% CI:100-380) or a density of 1.15 moose/km^2 was calculated for the acadian forest component (15% of park area). Aerial transect surveys in cooperation with the Nova Scotia Department of Natural Resources, Wildlife Division have been con-

ducted both inside and adjacent to the park almost every winter since 1991/92. Although plagued by weather and mechanical breakdown problems, population estimates of 1016 moose for the winter of 1991/92 and 2052 for the winter of 1993/94 were made. The 1993/94 population estimate yielded a density of 2.7 moose/km^2 in winter habitat. The density of moose on regenerating sites where balsam fir stands were killed by the spruce budworm during the late 1970s is now up to 5.2 moose/km^2 (Randy Thompson pers. comm.). Moose numbers are expected to remain high into the foreseeable future.

TERRA NOVA NATIONAL PARK

Description

Located on the southwestern end of Bonavista Bay (Fig. 1) in Newfoundland, Canada, (Lat: 48°30' N; Long: 54° W) Terra Nova National Park is 396 km^2 in area. Forty-two kilometers of the Trans Canada Highway passes through the park area, 290 km northeast of St. John's and 80 km southeast of Gander, Newfoundland. The landscape is rocky and hilly with 130 lakes and ponds as well as 50 rivers and brooks. Climate is boreal marine and soils are podzolic. Rowe (1972) includes the park area in the Avalon section of the boreal forest region with balsam fir dominating drier soils. Black spruce either grows with balsam fir and white spruce on the better soils or dominates alone in stunted, slow growing stands on poorer upland sites. Black spruce is also prevalent on wet lowlands and white spruce is found chiefly along the coastline associated with balsam fir. White birch is associated with north-facing slopes and valleys and yellow birch is common in early succession regeneration. Balsam fir stands received extensive defoliation damage in the latter 1970s and early 1980s. Periodic fires have allowed Kalmia (*Kalmia angustifolia*) and black spruce to invade many drier sites. The abundance of kalmia has kept browse conditions poor for moose however snow cover is generally not deep enough to impede moose travel (Bateman *et al.*, 1983).

History and Present Status

Moose are not native to Newfoundland and an initial introduction in the 1870s failed. Another introduction in 1904 was successful after several moose captured in New Brunswick were released in the Howley area (Cameron 1958). Natural predation pressure was low due to the extinction of the Newfoundland wolf (*Canis lupus beothucus*) by 1920 and habitat conditions were so favourable that by 1935 it was possible to open a hunting season. By 1945 there was no restriction on the number of hunting licenses (Cameron 1958). Bateman *et al.* (1983) reports that the area which is now Terra Nova National Park had a healthy moose population by the 1940s. The park was established in 1957 and moose surveys conducted in the late 1960s indicated that with the exception of the eastern most areas of the park, moose were present throughout. It was not until 1973 that results of an aerial transect survey indicated a population of 160 or 0.4 moose/km^2 (Patey 1973). Spruce budworm infestations began in 1975 and destroyed large areas of balsam fir forest. This may have temporarily affected moose habitat quality. Results from an aerial survey in 1978 estimated a population of 69 moose (Roscoe 1980) and one in 1982 estimated only 26 animals in the park (Carr 1982).

Forest regeneration in the 1980s may have improved habitat; an aerial random block moose survey in 1989 calculated 190 moose or 0.5 / km^2 (Robinson 1989) surpassing estimates before the spruce budworm infestation. The most recent aerial random block survey was completed in 1993 and estimated a population of 170 (95% /CI: 125-215) animals and a density of 0.4 moose/km^2 (Briggs and Hicks 1993). The present density is well below the upper critical limit of 1.3 moose/km^2 set for the carrying capacity of the park (Oosenburg 1990). A definite trend in moose

numbers cannot yet be developed. Moose/vehicle collisions and habitat quality may be stabilizing moose populations in some areas of the park.

GROS MORNE NATIONAL PARK

Description

Gros Morne National Park (Fig. 1) is 1805 km² in area and located on the west coast of Newfoundland, Canada (Lat: 49°30' N; and Long: 57°40' W). The landscape is comprised of a coastal plain, piedmont moraines, long range frontal slopes rising to uplands at 800 m., southern hills and a klippe complex (Bateman 1980). The coastal plain receives 2.5-3 m. of snow while the upland gets up to 11 m. of snow in winter. Drifting snow can fill small valleys with snow to a depth of 60 m. Rowe (1972) describes this area in 3 sections; Corner Brook, Northern Peninsula and Newfoundland-Labrador Barrens of the boreal forest region. The Corner Brook section includes the southern hills and klippe complex (Bateman, 1980) where balsam fir grows well on rich soils and small stands of white birch and trembling aspen (*Populus tremuloides*) are common. The Northern Peninsula section is represented in the park by the coastal plain, moraines, frontal slopes and Long Range Mountain Uplands north of Bonne Bay. Principal tree species in this section are balsam fir, black spruce and white spruce. Poorly-drained lands have extensive development of ericaceous and moss peat (Rowe 1972). Only a small portion of uplands area is represented by Rowe's (1972) Newfoundland-Labrador Barrens section. At altitudes above 800 m. areas of sparsely forested heath and moss barrens occur throughout; a windswept terrain of rock outcrops, lakes, stunted black spruce and balsam fir. Native mammal species include Arctic hare (*Lepus arcticus*), lynx (*Lynx lynx*), black bear and the only native Cervid in Newfoundland, the woodland caribou (*Rangifer tarandus*).

History and Present Status

Moose were likely in the area which is now Gros Morne National Park by 1925 (Pimlot 1953) but they were not common until the 1950s (Caines and Deichmann 1989). Local hunting pressure maintained a very low moose population on the lowlands of the area before the park was established and hunting prohibited in 1974. Gillespie *et al.* (1971) censused the area in 1971 and estimated 250 moose. Bateman (1980) found high numbers of moose on the uplands in the mid 1970s. Moose yarding areas in balsam fir-herb virgin forests on the uplands and eastern slopes had densities of 6-9 moose/km². Browse surveys revealed rates of 73% on available balsam fir twigs and 53% of mountain maple (*Acer spicatum*) and white birch stems. In contrast, the lowland areas had good year round habitat; mature balsam fir forests interspersed with cutovers providing abundant browse.

With a continuation of domestic-use woodcutting in the park as part of a federal/provincial agreement, along with prohibited moose hunting, Bateman (1980) predicted that the moose population on the lowlands would increase. She further expressed concern that highly preferred but less common browse species such as Canada yew (*Taxus canadensis*), mountain ash (*Sorbus americana* and *decora*) and white birch would be severely damaged by heavy moose browsing. Moose numbers did increase on the lowlands of the park during the 1980s. Taylor (1991) reported on an aerial moose survey conducted in March of 1990 and estimated a minimum of 2500 animals. Preliminary results from an aerial stratified random block moose survey completed in March of 1995 indicate an overall moose density on the southern lowlands and hills of around 6.8 / km² (Eric Sullivan pers. comm.). Densities in the low stratum (uplands and some coastal areas) were estimated to be 1.1 moose/km². The mean population estimate was 7738 (+/-810).

MANAGEMENT IMPLICATIONS

Policy

National parks protect environments representative of Canada's natural heritage for the benefit of present and future generations. The challenge for Parks Canada is to maintain the ecological integrity of the parks while providing opportunities for public enjoyment and education (Anon. 1994). Maintenance of ecological integrity means maintaining park ecosystems in as natural a state as possible, unimpaired by past and present human activities. Ideally, all national parks would be inhabited by viable populations of native flora and fauna in a naturally evolving landscape, however, that is usually not the case. Most parks have colonies of non-native species to various degrees and have lost some native species. The moose is an exotic species in Newfoundland and the stock reintroduced into Cape Breton, Nova Scotia is the non-native *andersoni* subspecies. The wolf has been missing in Atlantic Canada since around the turn of the 20th century thus impairing any natural regulation of moose populations. These are just two of the many examples of changes in parks natural biodiversity that have been brought about by man. Today and in the future, the rapidly expanding human population, development and use of lands and resources will change the regional and global environment; national parks will not be immune from those effects.

National parks policy permits intervention when research confirms that the structure and function of ecosystems have been seriously altered by human activities. Management must be guided by the establishment of clear, practical and measurable objectives that are consistent with the park management plan and by the rigorous application of science in the collection and interpretation of research and monitoring data (Anon. 1994). Caution is clearly expressed in stating also that a more holistic view of the natural environment must be taken to ensure that land use decisions take into consideration the complex interactions and dynamic nature of park ecosystems and their finite capacity to withstand and recover from stress induced by human activities. This is termed an ecosystem based approach to park management.

Moose Overbrowsing

In Cape Breton Highlands National Park, most of the mature balsam fir forests (50% of park area) were destroyed by the spruce budworm during the mid 1970s and are regenerating in deciduous species such as yellow birch with lesser amounts of balsam fir. Moose browsing of 90 - 100% of available stems is commonly observed in early deciduous seral stages on the uplands (Randy Thompson pers. comm.). Lawlor and Methven (1995) studied moose browsing on regenerating tree species on early seral sites in Gros Morne National Park in 1993. They reported that browsing damage was higher on deciduous tree species than on balsam fir. Mountain ash is the lowest density tree species in the park but sustained the highest degree of browsing (87.5 - 89.6%). Balsam fir was browsed at 41.5% of available stems. They concluded that continuing high moose densities would modify forest successional patterns and change forest structure; tree mortality from browsing would eventually occur.

Other authors have concluded that herbivores can alter ecosystem development. Pastor and Naiman (1992) suggested that overbrowsing can alter the composition of the vegetation sufficiently to depress soil nitrogen availability, limiting the recovery of the vegetation on collapse of a moose population. McLaren and Peterson (1994) studied forests on Isle Royale in Lake Superior and found that the fir component was reduced from 40% in 1848 to around 5% today after arrival of moose to the island. Work by Brandner *et al.* (1990) on Isle Royale concluded that continuing canopy losses and lack of recruitment due to intensive herbivory by moose will

greatly reduce the fir component of the canopy, effectively preventing any return to the fir-dominated forest of the past. Moose densities during their study were around 5 / km^2. Thompson and Curran (1993) reexamined a study area originally measured by Bergerud and Manuel (1968) in central Newfoundland. They found that although moose had altered forest structure and heights of trees over a 30 year period, balsam fir remained common in the overstory and understorey of the area. Moose densities in that area, however, were apparently no greater than 3 / km^2 during the 30 year period.

No published studies could be found which desputed the fact that high levels of moose browsing can slow down the maturation of tree species and modify the composition of forests. This could be a matter of degree as Porter (1992) stated, in the strictest sense, any change in ungulate numbers causes some change in the species composition or dominance within the plant community. National parks are established to forever preserve representative Canadian landscapes and managed according to policy and what is possible and practical to achieve. It is unlikely that moose populations will increase much beyond levels that food resources can support after which a collapse in moose numbers will occur. The degree of collapse will depend on such things as frequency and magnitude of catastrophic weather events such as a severe protracted winter; ability and distance for moose to migrate into more favourable areas and changes in fertility rates in response to poor nutrition. Where moose are a non-native species such as in Gros Morne National Park there is a high degree of concern related to the ability of the park to exhibit, over the long term, plant communities representative of historic conditions. Additionally, natural species diversity could be greatly affected by the elimination or near elimination of less common but highly preferred browse species such as Canada yew and mountain ash. Moose can also become hazardous on highways and act aggressively towards hikers and campers. Where moose are native such as in Cape Breton Highlands National Park concern can be focused on the lack of natural population control once provided by native wolf populations. Although authors such as Cameron (1958) report the existance of wolves on Cape Breton Island around 1850, we do not know how many of them occurred there. Messier (1994) modeled moose populations with predation and predicted that in the presence of wolves, moose would stabilize at around 1.3 moose/km^2 but suggested that wolf predation can only be effective in reducing moose population growth at low densities. Van Ballenberghe and Balland (1994) reviewed recent literature on moose-predator interactions and concluded that in naturally regulated ecosystems there is strong evidence that predation by bears and wolves can be a major limiting factor of moose populations.

Ecosystem Based Management

An understanding of the evolution of forest ecosystems must unravel the complexities of natural fire regimes, insect infestations and disease, cycles, catastrophic events such as hurricanes as well as the role of consumers such as moose and wolves. Fire, insects and storms can revert large forested areas to early seral states. Moose populations can increase in response to improved forage and predation by bears and wolves or diseases such as brain worm and winter tick can limit moose numbers. If predators are reduced by disease, moose can escape levels limited by predation and perhaps reach densities limited only by food supplies. Bergerud and Snider (1988) reported that when moose inhabit ranges without wolves, densities reached 2-3 moose/ km^2 and food supplies became the limiting factor. Messier (1994) stated that at high moose densities wolves limit but do not regulate moose numbers. Peterson (1988) found that moose and wolves on Isle Royale have not

stayed in equilibrium but have continued to fluctuate. Biologists often focus upon segments of an ecosystem because of the complexities of research or special theories to be tested. Any ecosystem based approach to the management of parks must consider all possible changes and perturbations over a long term, perhaps at least 100 years. Where moose are not native, a complete characterization of the natural diversity and patterns of development of vegetation related to site conditions will be necessary to adequately assess the effects of overbrowsing on plant communities. This information should then be modeled with data on natural fire regimes and insect infestations and diseases. Rare and endangered plants that may not play an obviously important role in the natural scene but add significantly to the biological diversity of the area should be closely monitored (Warren 1991). Where moose are native but wolves are absent, the natural evolution of plant communities in the presence of moose should be modeled with plant community data. Although there are no long term studies to predict irruptions and depletions in both moose and wolves and the impact of these on ecosystems, there is evidence to suggest that they do occur (Peterson 1988; McLaren and Peterson 1994). Some effort should be put into predicting the extent and duration of irruptions in moose populations before being limited or reduced by wolves. The role of other factors such as moose predation by bears, moose diseases and historic harvest of moose by aboriginal peoples should also be studied. Goals for vegetation and objectives for moose populations can then be formulated. Each plant community type should receive an individual assessment. Where high moose populations conflict with clearly defined goals for ecosystem management, there is support in national parks policy for intervention. Underwood and Porter (1991), however, state that ungulate management objectives to meet ecosystem management goals must both be universally accepted and anchored politically within all levels of the bureaucracy. Support of the public and special interest groups is essential. While the goal (ecosystem management) is unlikely to be challenged, the objective (moose control) likely will be and the direction of the challenge will depend on the technique used for achieving the objective.

ACKNOWLEDGEMENTS

I am indebted to Parks Canada staff, Edouard Daigle, Fundy National Park; Benoit Richard, Kouchibouguac National Park; Randy Thompson, Cape Breton Highlands National Park; Philip McCabe, Terra Nova National Park; Hank Deichmann and Douglas Anions, Gros Morne National Park for providing moose data and insights into moose populations in the parks, to Penny Ormsbee who typed the manuscript and David Palmer who researched references. I would also like to acknowledge the assistance and cooperation of provincial departments; Wildlife Divisions of New Brunswick DNR, Nova Scotia DNR and Newfoundland DNR in conducting aerial moose surveys. Neil Munro, Science Advisor, Parks Canada, Atlantic Region provided encouragement and financial support.

I would like to thank the following individuals for personal communication:

Edouard Daigle - Park Warden, Fundy National Park.

Tonny Nette - Large Mammal Biologist, Nova Scotia Department of Natural Resources

George Sinclair - Park Warden, Fundy National Park

Eric Sullivan - Wildlife Division, Newfoundland Dept. of Natural Resources

Randy Thompson - Park Warden, Cape Breton Highlands National Park

This paper is dedicated to the memory of Francois Millette, Parks Ecologist, Rideau Canal, conservationist, outdoorsman and friend, killed in a car accident, Spring 1995.

REFERENCES

ANON. 1994. Parks Canada guiding principles and operational policies. Minister of Supply and Services Canada Cat. No. R62-275/1994 E ISBN 0-662-21559-1.

BANFIELD, A.W.F. 1974. The mammals of Canada. University of Toronto Press. Toronto, Ontario, Canada. ISBN 0-8020-2137-9

BATEMAN, M.C. 1980. The mammals of Gros Morne National Park. Rep. to Parks Canada by the Can. Wildl. Serv., Atlantic Region, Sackville, New Brunswick. 3 vol.

_____, J.E. BROWNLIE and B.C. ROSCOE. 1983. The mammals of Terra Nova National Park. Report to Parks Canada by the Can. Wildl. Serv., Atlantic Region, Sackville, New Brunswick.

BERGERUD, A.T. and F. MANUEL. 1968. Moose damage to balsam fir - white birch forests in central Newfoundland. J. Wildl. Manage. 32:729-746.

_____ and J.B. SNIDER. 1988. Predation in the dynamics of moose populations: a reply. J. Wildl. Manage. 52: 559-564.

BRANDNER, T.A., R.O. PETERSON and K.L. RISENHOOVER. 1990. Balsam fir on Isle Royale: effects of moose herbivory and population density. Ecology 71: 155-164.

BRIGGS, M.P. and S.A. HICKS. 1993. Aerial random block moose survey, Terra Nova National Park. Parks Can. Tech. Rep.

BROWN, A. 1955. Moose control problem report. Tech. Rep. Fundy Nat. Park, New Brunswick.

CAINES, P. and H. DEICHMANN. 1989. Resource description and analysis, Gros Morne National Park. Can. Parks Serv., Environ. Can. Tech. Rep.

CAMERON, A.W. 1958. Mammals of the islands in the Gulf of St. Lawrence. Bull. No. 154, Nat. Mus. of Canada, Queens Printer, Ottawa.

CARR, G.S. 1982. Aerial moose census report. Tech. Rep. Terra Nova Nat. Park. 15 pp.

COLLINGWOOD, L. 1990. Aerial moose survey. Tech. Rep. Fundy Nat. Park. 12 pp.

DAIGLE, E. 1993. Aerial survey of moose (*Alces alces*), results and analysis. Unpub. Man., Fundy Nat. Park, Alma, N. B. Fun/95-07.

FONTAINE, N. 1988. Aerial ungulate survey (1987). Tech. Rep., Kouchibouguac Nat. Park, New Brunswick.

GILLISPIE, D.I., W.J. LEARNING, J. TUCKER and J. PATEY. 1971. Winter ungulate census in Terra Nova National Park and the proposed area for the Gros Morne National Park. Can. Wildl. Serv. report to Parks Canada. 28 pp.

GODIN, D. 1977. Aerial ungulate surveys, 1973-77. Tech. Rep., Kouchibouguac Nat. Park, 14 p. + append + map.

KELSALL, J.P. 1963. Research and management requirements for big game in Fundy Nat. Park. Tech. Rep. Can. Wildl. Serv., 13 pp.

LAWLOR, M.F. and I.R. METHVEN. 1995. Moose browsing on regenerating tree species on early seral sites in Gros Morne National Park, Newfoundland *in*: Proc. of the 2nd Int. Conf. on Science and the Manage. of Protected Areas, Dalhousie Univ., Halifax, N. S. 1994. Science and Manage. of Protected Areas Association, Acadia Univ., Wolfville, N. S., Canada.

McKAY, K. 1982. White-tailed deer (*Odocoileus virginianus*) roadside count. Tech. Rep., Kejimkujik Nat. Park, Nova Scotia, Canada.

McLAREN, B.E. and R.O. PETERSON, 1994. Wolves, moose and tree rings on Isle Royale, Science 266: 1555-1558.

MESSIER, F. 1994. Ungulate population models with predation: a case study with North American moose. Ecol. 75: 478-488.

MORTON, L.D. and M. SAVOIE, 1983. The mammals of Kouchibouguac National Park. Can. Wildl. Serv. Rep. for Parks Canada. 4 vol.

OOSENBURG, S.M. 1990. Analysis of moose habitat conditions in Terra Nova National Park. Unpub. Rep. to Parks Canada.

PASTOR, J. and R.J. NAIMAN. 1992. Selective foraging and ecosystem processes in boreal forests. The Amer. Nat. 139(4).

PATEY, J.R. 1973. Moose census. Tech. Rep. Terra Nova Nat. Park, Newfoundland.

PETERSON, R.O. 1988. The pit or the pendulum: issues in large carnivore management in natural ecosystems. Pages 105-117 *in* J.K. Agee and D.R. Johnson, eds. Ecosystems management for parks and wilderness. Univ. of Washington Press, Seattle. USA.

PIMLOTT, D.H. 1953. Newfoundland moose. Trans N.A. Wildl. Conf. 18: 563-581.

PORTER, W.F. 1992. Burgeoning ungulate populations in national parks: is intervention warranted? Pages 304-312 *in* McCullough D.R. ed. Wildlife 2001 populations. Elsevier Applied Science ISBN 1851668764N.

PRESCOTT, W.H. and M.C. BATEMAN, 1978. The mammals of Fundy National Park. Can. Wildl. Serv. Rep. for Parks Canada, 3 vols.

_____. 1980. The mammals of Cape Breton Highlands National Park. Can. Wildl. Serv. Rep. for Parks Canada, 3 vols.

RICHARD, B. 1995. Aerial ungulate survey. Tech. Rep. Kouchibouguac National Park, (In prep.)

ROBINSON, K. 1989. Aerial random block moose survey. Tech. Rep. Terra Nova Nat. Park, Newfoundland, Canada.

ROSCOE, B. 1980. Aerial moose censuses, 1969-1978. Preliminary Rep. Terra Nova Nat. Park, Newfoundland, Canada.

ROWE, J.S. 1972. Forest regions of Canada. Dep. of Environ., Can. For. Serv. Pub. No. 1300.

SHELDON, C. 1936. The mammals of Lake Kedgemakooge and vicinity, Nova Scotia J. of Mammal. 17:207-215.

SQUIRES, A.W. 1968. The mammals of New Brunswick. Publ. the New Brunswick Museum, St. John. Canada 57 pp.

TAYLOR, E. 1991. Gros Morne National Park aerial moose survey, March 1990. Unpub. Tech. Rep. Parks Canada 24 pp.

THOMPSON, I.D. and W.J. CURRAN. 1993. A re-examination of moose damage to balsam fir-white birch forests in central Newfoundland: 27 years later. Can. J.of For. Res. 23: 1388-1395.

UNDERWOOD, H.B. and W.F. PORTER. 1991. Values and science: white-tailed deer management in eastern national parks. Trans 56th N. Am. Wildl. and Nat. Resour.Conf. (1991).

VAN BALLENBERGHE, V. and W.B. BALLARD 1994. Limitation and regulation of moose populations: the role of predation. Can. J. Zool. 72:12.

WARREN, R.J. 1991. Ecological justification for controlling deer populations in eastern national parks. Trans. 56th N. Am. Wildl. and Nat. Resour. Conf. (1991).

WENTZELL, N. 1975. Moose census. Tech. Rep. Fundy Nat. Park, 4 pp.

_____. 1985. Aerial moose census. Tech. Rep. Cape Breton Highlands Nat. Park.

WHITLAW, H.A. and M.W. LANKESTER 1994. A retrospective evaluation of the effects of parelaphostronglylosis on moose populations. Can. J. Zool 72:1-7.

WOOD, T.J., J.W. MAXWELL and B.C. ROSCOE. 1971. Moose survey, Fundy Nat. Park, Fredericton, N. B., 9 pp.

_____. 1973. The mammals of Kejimkujik National Park. Can. Parks Serv. Rep. prepared for Parks Canada.

WRIGHT, B.S. 1956. The moose of New Brunswick. Northeast Wildl. Sta., Univ. of New Brunswick, Fredericton, N.B. 66 pp.