THE STATUS AND MANAGEMENT OF MOOSE IN NORTH AMERICA - EARLY 1990's

H.R. Timmermann[1] and M.E. Buss[2]

[1]Ontario Ministry of Natural Resources, N.W. Region Science and Technology Section, R.R. #1, 25th Side Road, Thunder Bay, Ontario, Canada, P7C 4T9; [2]Ontario Ministry of Natural Resources, Central Region, Huntsville, Ontario POA 1KO

ABSTRACT: In the early 1990's the North American moose population was estimated at about 1 million. Populations occurred in 11 Canadian provinces/ territories, and 11 U.S. states. Densities were believed to have been relatively stable or increasing in 17 jurisdictions, stable to decreasing in 3 and decreasing in only 2. In 1990-91 an estimated 436,240 licenced moose hunters harvested 88,630 moose in 22 jurisdictions, while a decade earlier 407,330 hunters cropped 70,390 in 19 jurisdictions. A wide variety of active and passive harvest strategies are used to manage the harvest of moose. Population estimates are presented for 23 National Parks where hunting is prohibited.

ALCES VOL. 31 (1995) pp.1-14

The status and management of North American moose populations was examined in the early 1990's to provide input to a Wildlife Management Institute book "Moose Ecology and Management". A comprehensive questionnaire similiar to that used by Timmermann (1987) was used to update population estimates as well as harvest and non harvest strategies used by 22 jurisdictions which actively manage moose. Tabulated data collected in the initial mailout was returned to all agencies for final perusal and changes/corrections were solicited. The objective of this paper is to report on strategies used to manage hunting harvest, non harvest management and the current (early 90's) population status. (Note: Vermont introduced a limited either-sex harvest system in 1993 just after this survey was completed, Alexander 1993).

MANAGING A HARVEST

Harvest control objectives

Two territories and nine provinces in Canada, and 11 states in the United States administered a moose hunt in 1990-91 (Fig.1). Collectively 436,619 moose hunters harvested an estimated 88,630 moose in 1991. A decade earlier, 408,330 hunters cropped 71,050 (Table 1). Harvest demands on moose populations have increased many-fold in the past two decades resulting in the need for more restrictive hunting regulations. Control of hunting is required to affect the desired allocation of moose harvest among recreational hunters, insure the sustainability of moose populations, and achieve other specified management objectives for a particular area.

Allocation of hunting opportunities

Like most wildlife in North America moose are essentially publically owned and held in trust by the government of the day. In allocating a harvest, at least 10 of 22 jurisdictions give prime consideration to subsistence use by native people as provided under treaty or other legal agreements (Franzmann and Schwartz 1983). Residents, non-residents and non-resident aliens are most often considered in allocation decisions in decreasing priority by most agencies. During the 1970's, when many jurisdictions sought to reduce the moose harvest, added controls were commonly placed on non-resident hunters, giving residents priority in the allocation of hunting opportunities. Increased licence fees, resident only seasons, guide requirements

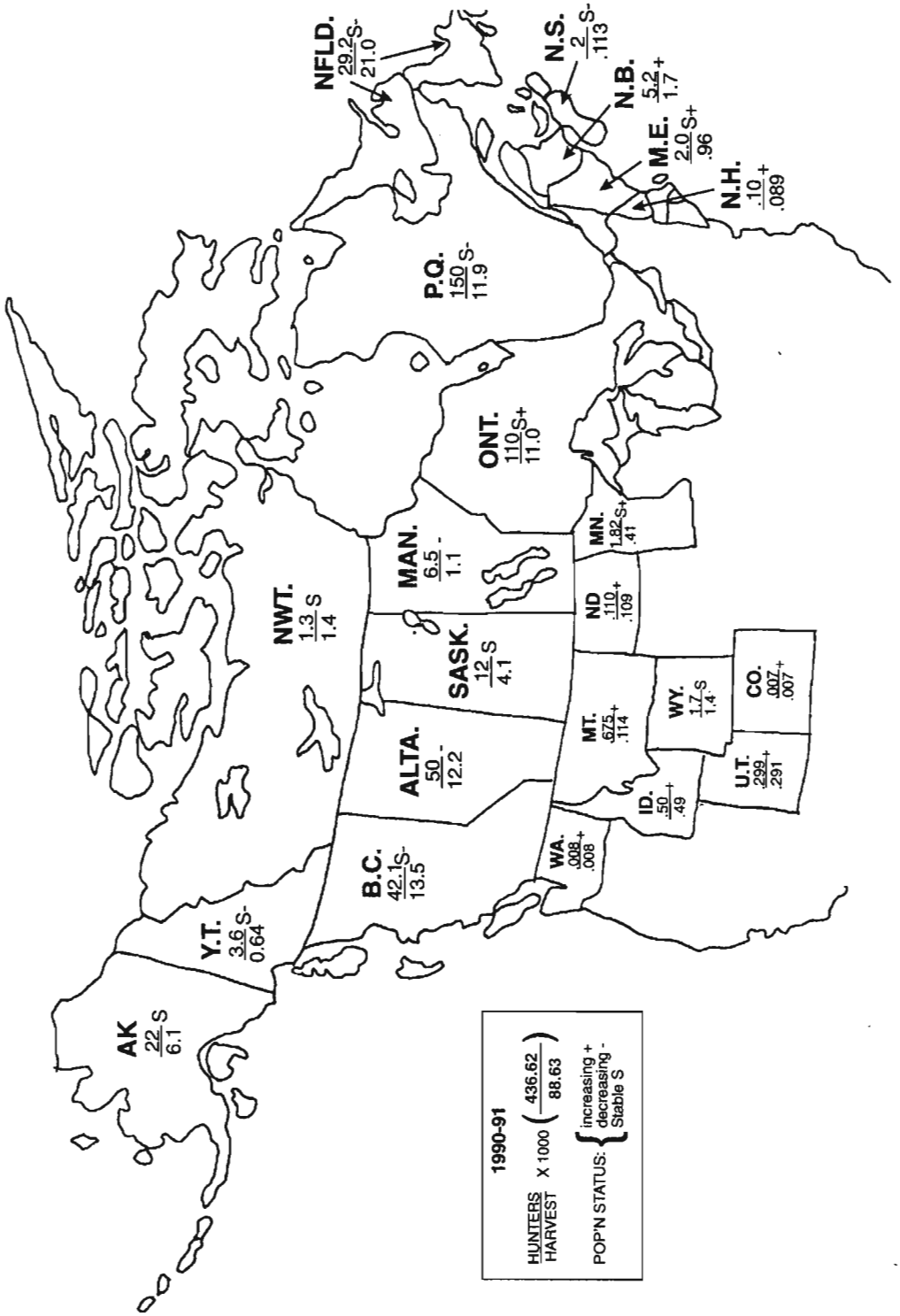

Fig. 1. Estimated 1990-91 licenced moose hunter numbers, harvest and population status for 22 North American jurisdictions.

Table 1. Numbers of sport hunters, harvest, and population estimates for 22 North American jurisdictions, 1972, 1982, 1990-91. N/A = not available.

	Total Hunters			Non Res. Hunters			Totel Est. Harvest			Est. Moose Pop.	
Agency	1972	1982	1991	1972	1982	1991	1972	1982	1991	1982	1990-91
Alaska	21,800	21,200	22,000	2,370	1,120	2,410	5,700	5,900	6,100	120,000[1]	155,000
Washington[2]	-	-	008	-	-	-	-	-	008	-	200
Idaho[2]	100	200	500	-	-	-	090	150	490	3,600	5,500
Utah	100	100	299	010	008	290	070	090	290	1,400	2,700
Wyoming	1,600	1,600	1,700	-	310	220	1,300	1,300	1,400	7,900	12,600
Montana	700	500	675	034	045	019	400	360	114	-	4,000
N Dakota[2]	-	030	110	-	-	-	-	020	109	300	550
Colorado	-	-	007	-	-	-	-	-	007	-	425
Minnesota	1,600	3,500	1,820	-	-	-	370	760	410	9,000	6,700
Maine	-	2,000	2,000	-	200	200	-	880	960	20,000	23,000
New Hampshire	-	-	100	-	-	020	-	-	089	-	4,000
Yukon[4]	N/A	4,400	3,600	N/A	300	460	N/A	1,000	640	3,500[1]	50,000
NW Territories	N/A	1,000	1,300	N/A	025	060	N/A	130	1,400	3,300[1]	9,000
British Columbia	55,000	45,800	39,400	5,600	1,940	1,860	14,300	12,800	13,500	240,000	175,000
Alberta	44,700	65,000	50,000	4,110	1,230	1,150	9,400	12,400	12,200	118,000	100,700
Saskatchewaan	13,000	12,700	12,000	1,000	300	1,170	4,100	2,600	4,100	45,000	50,000
Manitoba	10,200	10,200	6,500	1,990	230	100	2,100	1,700	1,100	28,000	27,000
Ontario	73,100	88,700	110,000	12,500	3,100	3,000	13,800	10,700	11,000	80,000	120,000
Quebec	62,000	126,000	150,000	3,000	1,000	2,500	6,800	11,800	11,900	75,000	67,500
New Brunswick[2]	2,400	5,000	5,200	-	-	-	1,000	1,300	1,700	12,000	20,000
Nova Scotia[2,3]	1,000	400	200	-	-	-	400	160	113	4,000	3,000
Newfoundland	19,100	20,000	29,200	4,310	980	1,400	11,000	7,000	21,000	70,000	140,000
TOTAL	306,400	408,330	436,619	34,924	10,671	14,580	70,830	71,050	88,630	841,000	976,875

1. Kelsell (1987)
2. No Non Resident Season
3. 1981 Data
4. Exclusive of Native hunters and harvest

and limited permits reduced 1982 non-resident hunter numbers to one third of 1972 levels (Table 1). In 1991, non-residents were still eligible to hunt in all but seven jurisdictions. A guide was required by eight of 15 agencies and several required registration with a licenced tourist outfitter to help stimulate additional local economic benefits.

Control concepts

Both passive and active strategies are used to regulate harvests and distribute hunting pressure (Timmermann 1987:569). During 1991, for example, nine agencies did not limit hunter numbers or total harvests over the majority of their areas. All but one, however, employed a limited hunter participation strategy in some management areas (Fig.2). Five combined unlimited non-selective with an unlimited selective antlered strategy while five jurisdictions used five or more selective or non-selective strategies to control harvests. For example in 1991 Quebec had 150,000 hunters, allowed hunting of either sex, and "encouraged" the shooting of calves. During the 1970's and 1980's there was no attempt to limit hunter numbers. In 1994 Quebec introduced limited antlerless quotas to reduce the number of breeding females harvested. Saskatchewan, Ontario, and British Columbia continue to use unlimited entry and specific sex or age specific licences to maximize hunting opportunities and limit hunter kill.

Licence qualifications and fees

In 1991 proof of hunting proficiency (either a previous licence or completing a hunter safety education course) was a basic requirement in nearly all jurisdictions. In addition both New Brunswick and Newfoundland required hunters to pass a shooting and written test before issuing a big game hunting licence. This requirement selects hunters on the basis of demonstrated marksmenship and requires increased commitment by applicants which resulted in a decrease in the number of hunters. Fee increases may also help reduce hunter numbers. Resident fees, however, are considered modest and have had little long-term effect in discouraging or re-distributing participation. In 1991 individual resident licence fees ranged from $5.00 in the Northwest Territories to $203.00 in Colorado with 12 agencies charging between $12.00 to $35.00 and four between $50.00 and $79.00. Non-resident fees varied from $10.00 in the Nortwest Territories to $1,003.00 in Colorado with most in the $150.00 to $500.00 range in the same year. Some jurisdictions use different fees for non-resident citizens and non-resident aliens. Trophy fees or export permits are required in addition to the licence fee by some agencies.

Seasons

Season length controls the total amount of hunting opportunity available while season timing may control success because of seasonal vulnerability of moose to hunting mortality. A secondary effect of season timing may be its limitation on access to moose range where seasonally dependent methods such as float planes, all-terrain vehicles and snowmobiles are necessary. Seasons set during the rut or snow period generally result in higher harvests due to sex specific vulnerability (Timmermann and Gollat 1982, Crete 1987). The most liberal 1991 seasons (243 days in Alaska) extended from August to March in some Game Management Areas (Table 2). The majority of jurisdictions conduct open seasons between September and December. In a 1992 survey of 19 moose management jurisdictions, Wilton (1992) found 74 percent of 136 open seasons ran concurrent with the normal rutting period (16 Sept. - 15 Oct.). In this survey eight of 22 jurisdictions used split seasons to help distribute hunting pressure allowing both an early hunt during open water and a later hunt on snow. Most (17 of 22) agencies use a fixed

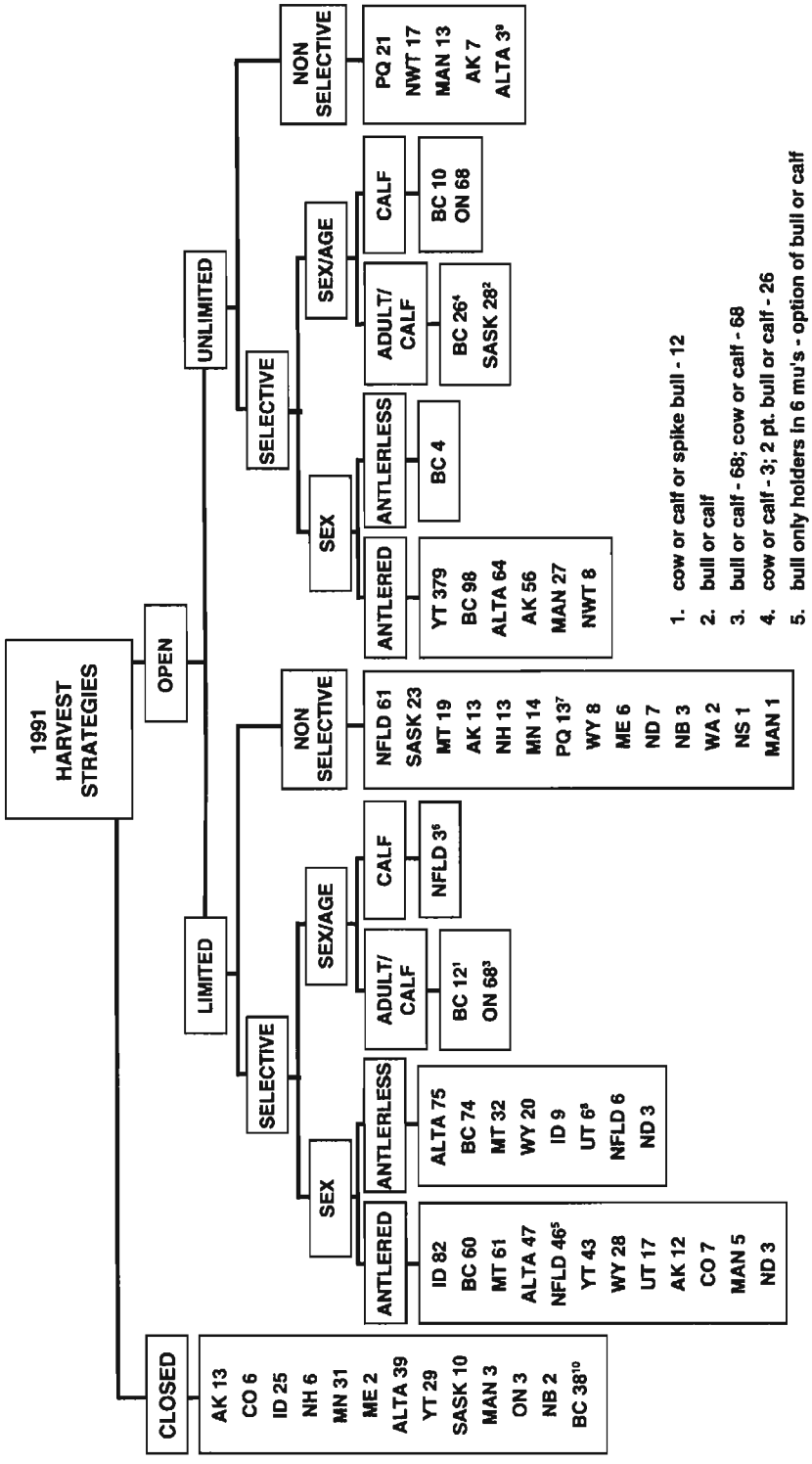

Fig. 2. Moose harvest strategies employed by 22 North American jurisdictions (circa 1990-91). Numerals designated numbers of Management areas or subdivisions thereof.

Table 2. Characteristics of moose hunting seasons in North America, 1990-91.

	Number of Management Areas				Season Length/Timing		
	With	Size (Km^2)		With Open			
Agency	Moose	Min.	Max.	Season	Max Days	Earliest	Latest
Alaska	94	290	5,300	83[1]	243[2]	Aug 01	Mar 21
Washington	4	680	700	4	16	Nov 10	Nov 25
Idaho	123	130	3,900	98[3]	86	Aug 30	Nov 23
Utah	13	800	2,000	10	16	Sep 07	Dec 01
Wyoming	40	450	4,100	37[1]	82	Sep 10	Nov 30
Montana	71	250	2,500	71	90	Sep 01	Nov 29
N Dakota	7	330	410	7[3]	30[2]	Sep 11	Dec 25
Colorado	10	130	1,540	4[3]	16	Nov 10	Nov 25
Minnesota	44	130	1,800	14[3,4]	16	Sep 28	Nov 30
Maine	8	4,000	13,800	6[6]	6	Oct 01	Oct 13[7]
New Hampshire	19	490	1,810	11	10	Oct 15	Oct 24
Yukon	451	060	2,800	427	90	Aug 01	Oct 31
NW Territories	18	7,500	2,000,000	18	153	Sep 01	Jan 31
British Columbia	189	520	19,600	154	118[2]	Aug 15	Dec 10
Alberta	122	210	30,000	83[1,6]	83[2]	Sep 09	Nov 30
Saskatchewan	40	2,000	120,000	30[1,6]	64[2]	Aug 26	Nov 30
Manitoba	38	200	131,000	35[1,6]	112[2]	Sep 01	Dec 21
Ontario	71	1,700	85,800	68[1,6]	88	Sep 19	Dec 15
Quebec	22	2,150	225,200	21[1]	92	Sep 01	Dec 01
New Brunswick	25	830	6,400	23[3,6]	3	Sep 22	Sep 24
Nova Scotia	11	540	7,400	1[3,5,6]	5	Oct 15	Oct 19
Newfoundland	67	116	4,500	67[1,6]	79[8]	Sep 14	Dec 28

1. Special archery seasons in some areas.
2. Split seasons (most are 20-30 days in duration).
3. Resident only.
4. NE region closed - normally 44 areas open.
5. 1981 Data - (most are 20-30 days in duration).
6. Closed Sundays in some or all areas.
7. 6 day season, opens 1st Monday in Oct.
8. Special winter season in one area Feb. 01-15.

or day of the week while the remaining provide aweekend opening. Sunday hunting is prohibited by at least six jurisdictions. (Table 2).

Management areas and harvest strategies

All agencies have developed a system of game management areas to enable area specific harvest control. Moose management areas vary in size from 23 to 770,000 mi^2 (60 - 2 million km^2) and number from 4 to 451 per jurisdiction (Table 2). This variation reflects the complexity of habitat and varying management objectives across North America's moose range. All jurisdictions except the Northwest Territories used either a selective or non selective limited hunter participation strategy, or a combination of both in 1991 (Fig. 2). Most jurisdictions limit the number of licences available for each management area (limited hunter participation). Alaska, however, employed registration hunts to control harvests in some areas. Hunters in these areas are required to report their kill at the

end of the hunt and when the prescribed number of moose are killed, the season is closed for the area.

Limited licence techniques usually require application for a pre-determined number of licences. Application is made on official forms sent to a central office. Applicants are generally allowed to indicate a choice of several areas and licences are awarded by random draw. In some jurisdictions where demand far exceeds supply, hunters successful in such a lottery are ineligible to re-apply for a period of years: in North Dakota - one year, Idaho and New Hampshire - three years, Wyoming, New Brunswick and Nova Scotia - five years, Montana - seven years. If a hunter claims a bull moose as in Idaho, Utah, Washington, Colorado and North Dakota no future application is accepted. Utah allows re-application after 10 years if a cow is shot and claimed. In other jurisdictions a preference pooling system gives unsuccessful applicants a priority of obtaining a permit in the following year's lottery.

Fourteen agencies limit the number of non-selective (of age or sex) area specific licences issued based on population estimates and historic hunter success rates (Fig.2). Seven employ this method exclusively whereas four combine it with limited selective control and four use it in conjuction with two or more forms of unlimited entry licencing.

Thirteen agencies offered a limited number of selective licences (Fig.2) designed to control the harvest of specific age or sex classes, maximize opportunities and increase herd productivity.

Saskatchewan introduced a sex and age selective hunt in 1977 followed by British Columbia, Ontario and Newfoundland between 1980 and 1991. Each has developed a selective harvest system to fit their own program objective as described by Timmermann (1987:573). In Ontario the key elements of the selective harvest program are area specific harvest quotas, adult validation tag quotas and the allocation of these tags to hunters through a computerized lottery draw (Smith 1990). Harvest limits are set annually for nearly 70 Ontario Wildlife Management Units (WMU) with moose seasons. Harvest quotas, a planned number of adult bulls and cows to be harvested, are set by using the most recent reliable moose population estimate for each WMU. Allowable harvests are calculated on the basis of a percentage of adult cows in the herd or a percentage of the total population. Ten percent of the annual province-wide planned harvest is set aside for the clients of tourist outfitter's to help stimulate economic activity in the tourist industry (Bisset and Timmermann 1983). All licenced hunters may hunt for a calf in any WMU. Adult validation tags (stickers) are distributed by lottery for either an adult bull or cow. Adult validation tag quotas combine the harvest quota for the year with the average hunter success rate in a WMU. For example, if the harvest quota for bulls in a WMU is 100 animals and the regular gun hunter success rate is 25 percent (.25), then the bull quota would be 100÷.25 and 400 bull tags could be issued for an expected harvest of about 100 bulls.

Traditionally, harvest strategies have been directed toward the male segment of the population. Twelve of 22 agencies limited the harvest of antlered animals in 1991, but only Utah and Colorado used it exclusively and most did not specify age (Fig. 2). Concern for declining bull to cow ratios (Timmermann 1992) and its potential effect on productivity lead British Columbia and Alaska to experiment with a selective bull harvest strategy based on antler architecture (Child 1983, Child and Aitken 1989, Schwartz *et al.* 1992). Regulations developed by both jurisdictions in the 1980's was designed to increase survival of prime breeding age bulls. These regulations allowed the legal harvest of bulls with spike or forked antlers (1 or 2 points on one side). In addition, Alaska in-

cluded bulls with antlers 50 inches (106 cm) in spread or larger or with three brow tines on one antler in some areas and four brow tines in others.

Results in Alaska have been positive according to Schwartz *et al.* (1992), and after five years the number of bulls in the population increased. Yearlings with large antlers were protected, as were about 80 percent of the two to three year olds, and almost 50 percent of four to five year olds. The increasing bull numbers generated a high public support and viewable bulls were common in many areas where it had been rare beforehand to see one after the hunting season. Schwartz *et al.* (1992) suggested that future adjustments to this strategy could include replacing the 50 inch regulation with a limited number of permits to harvest males surplus to the target bull to cow ratio. Such a system could provide for a general hunting season where everyone qualifying could participate and a special permit season with hunting success enhanced and bull harvest controlled.

In British Columbia, pre and post - rut hunting seasons are held to help protect mature bulls. After the rut unrestrictive hunting is permitted for immature bulls with two or fewer points on one antler. Mature bull and cow harvests are controlled by a limited draw (Child 1983, Child and Aitken 1989).

British Columbia, Ontario, Montana, Idaho, Utah, Newfoundland, North Dakota, Alberta, and Wyoming all utilize limited antlerless permits to harvest cows and calves in selective management areas (Fig. 2). The objective is to maintain specific sex ratios while providing additional harvest opportunities. British Columbia has developed the widest range of harvest strategies (both limited and unlimited -8) followed by Alberta, Manitoba and Alaska with four each (Fig. 2).

Harvest assessment

Hunter kill must be assessed to monitor the effectiveness of a harvest strategy. Hunters are required to report their hunting activity in eight of 22 jurisdictions (Table 3). Registration of kill is compulsory in 16, while 10 agencies apply a non-compliance penalty to hunters failing to report. Enforcement of these requirements vary among agencies. Compliance levels are considered high in States like Minnesota and Maine which have short seasons and limited hunter numbers (Timmermann 1987). Those with longer seasons and higher hunter numbers such as Quebec (Lacasse *et al.* 1984) and Newfoundland (Mercer and Strapp 1978) have measured compliance levels of 60 and 82 percent respectively using random mail survey checks. Voluntary responses from hunters surveyed by mail are used by 14 agencies in calculating the estimated kill while eight require a compulsory hunt activity report (Table 3). Voluntary reports are normally obtained by a random sample mail survey. Original questonnaires may be followed up by one or two reminders to achieve a compliance level varying from 70 percent in the Yukon (Kale 1982) to 70-80 percent in Ontario (Timmermann 1987). Results usually provide reliable information to assess harvests on a state, provincial or regional basis but often are imprecise on a management unit basis. Non-resident kill is monitored by an export permit or trophy fee in five jurisdictions (Table 3).

Population status

Continental moose populations are estimated to have increased up to 16 percent between 1982 and 1991 (Table 1). Population densities in the early 1990's are believed to be relatively stable or increasing in 17, stable to decreasing in three and decreasing in only two jurisdictions (Fig. 1, Table 1). Respecting the latter, both Alberta and Manitoba report moose were declining during the late 1980's. Alberta hunting seasons were generally long with liberal bull licence allo-

Table 3. Moose harvest assessment strategies used in North America, 1991.

	Hunt Activity Report		Kill Registration		Non-Compliance
Agency	Compulsory	Voluntary	Compulsory	Voluntary	Penalty[6]
Alaska	X[1]	-	X[1,2]	-	None
Washington	X	-	X	-	N/A
Idaho	X	-	X	-	Fine, Loss of Licence & Jail
Utah	-	X	-	X	N/A
Wyoming	-	X	-	X	None
Montana	-	X[3]	-	X	N/A
N. Dakota	-	X[3]	X	-	None
Colorado	-	X	X	-[5]	None
Minnesota	-	X	X	-	Fine & Loss of Licence
Maine	X	-	X	-	Fine & Jail
New Hampshire	X	-	X	-	Fine, Loss of Licence & Jail
Yukon	X	-	X[2,4]	-	Fine-non resident only
N.W. Territories	-	X	X[2,4]	-	Fine
British Columbia	-	X	X[1,2]	-	Fine
Alberta	-	X	X[2]	-	None
Saskatchewan	-	X	-	X	N/A
Manitoba	-	X	-	X	N/A
Ontario	-	X	X[2,4]	-	N/A
Quebec	-	X	X	-	Fine & Loss of Licence
New Brunswick	X[3]	-	X	-	Fine & Loss of Licence
Nova Scotia	X[3]	-	X	-	Fine & Jail
Newfoundland	-	X[3]	X[2]	-	None

1. Limited draw hunts only (BC - only late season anterless hunts)
2. Export permit/trophy fee
3. Unsuccessful hunters only
4. Non-resident hunter only
5. Voluntary kill registration in 1992
6. Variable enforcement

cations and restrictive cow regulations. Losses due to the effects of winter ticks, predation, and high harvest rates associated with increasing access and use of off-road vehicles are believed responsible for lower Alberta populations (Todd pers. comm. 1992). In Manitoba extensive, unregulated hunting by treaty Indians was suggested by Crichton (1981, pers. comm. 1992) as a principle cause of declining populations. Bulls-only seasons are used extensively in Manitoba to protect a declining herd estimated at 28,000 in 1982 and 27,000 in 1991 (Table 1).

British Columbia, Quebec and Nova Scotia report stable to declining moose populations (Fig. 1, Table 1). The results of a selective harvest system initiated in one area of British Columbia in the early 1980's helped to reduce the harvest of prime bulls (≥5yrs.) by 50% and increase the calf kill nearly 6-fold (Child 1983). However the reintroduction of post-rut bull seasons in some areas in 1986 resulted in more adult bulls than calves killed as hunters preferred taking adults over calves when given a choice (Child and Aitken 1989). The provincial population in 1991 is estimated at 175,000 down from 240,000 in 1982 (Table 1).

Quebec prefers to monitor populations and adjust harvest regulations to observed population trends. Limited permits are used in specific wildlife reserves (Desmeules 1966, Bouchard and Moisan 1974, Goudreault 1980) and not elsewhere due to the imprecision of census and harvest assessment. Between 1982 and 1991, hunter numbers in Quebec increased nearly 20 percent and overall moose populations declined about 10 percent from an estimated 75,000 to 67,500 (Table1). Begining in 1994 Quebec introduced a limited quota for antlerless moose in an attempt to increase productivity. The moose hunting season in Nova Scotia was closed in 1982 because of an apparent population reduction (Timmermann 1987). Both illegal kill and the effects of brainworm may have contributed to the decline, the legal harvest is believed to have had only minimal impact. One area in Cape Breton has since been re-opened.

Early 1990's populations were believed to be stable, stable to increasing or increasing in the majority (17) of jurisdictions (Fig. 1). Yukon and the Northwest Territories both report a substantially higher population in 1990-91 than in 1982, although there are no comprehensive population estimates over this hugh area (Table 1). Where hunter demand exceeds supply by ratios of up to 500 to 1, eleven agencies have limited permit numbers to regulate harvests and sustain populations (WA., MT., ID., WY., UT., CO., ND., MN., NH., ME., and NS., Fig. 2). Both Colorado and North Dakota strive to sustain or increase populations and offer a high success averaging 80 percent. Moose populations in Minnesota increased 33 percent between 1972 and 1982, declined slightly in the late 1980's and were considered stable to increasing in 1992 (Lenarz 1992). Both the Alaskian and Saskatchewan populations were considered stable in 1991 even though estimates given were higher than a decade earlier (Fig. 1, Table 1).

Ontario reported stable to increasing populations , and the overall population had grown from approximately 80, 000 in 1982 to 120, 000 by 1991. Populations in 69 WMU's were stable in 30, increasing in 17, decreasing in eight and unknown in 14 (Bisset pers. comm.1994). Newfoundland moose are reported to have increased 40 percent from 1973 to 1982 and again doubled by 1991 to a pre hunt population estimated at 140,000. A Province-wide harvest quota system initiated in the late 1970's, the absence of grey wolves (*Canis lupus*), and favourable habitat created by extensive logging is considered responsible for the increase. Densities in both New Brunswick and New Hampshire are increasing while those in Maine were considered stable to increasing in the early 90's (Fig. 1, Table 1). Increasing populations were also reported for the majority of western states including WA., MT., ND., ID., UT., and CO. while Wyoming populations were considered stable (Fig.1, Table1).

MANAGING A NON HARVEST

Parks, refuges and special areas

Most North American jurisdictions where moose occur provide for areas where hunting is not a primary management objective. These areas are found in game or wildlife reserves, national, state and provincial parks, or nature reserves. Although few agencies have policy statements regarding moose management in protected areas, the assumed common objective is the preservation of native fauna in representative natural habitats, with minimum human disturbance, for the education and enjoyment of current and future generations. This objective is in accord with the larger goal of maintenance of biodiversity and ecosystem function. The often stated benefit resulting from harvest protection in our experience is the provision or improvement of viewing opportunities which in itself is not a consequence of protection.

Only a third (8 of 22) responding juridictions indicated they have given spe-

cial management consideration or had developed special objectives for pro-active management of moose populations in protected areas. Nine of 22 commented that the provision of viewing opportunities and natural history interpretation were primary concerns in their park's programs.

Not all jurisdictions disallow hunting in parks and reserves. Manitoba and Saskatchewan for example report that controlled annual moose hunts are conducted in many of their provincial parks. Recreational hunting is regulated in Ontario provincial parks by the process of master planning and is thus specific to the park's classification and wildlife management objectives. Currently only two Ontario parks provide moose hunting opportunities that might be considered significant contributions to the province's total hunting opportunities. British Columbia allows moose hunting in provincial parks but has protected zones within some to promote viewing opportunities. The rational for allowing hunting in all these situations is to provde a mix of both hunting and viewing opportunities by managing the population to achieve a broader or alternative non-harvest objective.

More recently park managers have begun to realize the impacts of large herbivores on other natural features, such as vegetation and the presence and abundance of large predators within parks (Crichton 1977, Diamond 1992, U.S. Department of Interior 1992). In these circumstances issues are related to the restoration or maintenance of ecosystems where fluctuations in moose densities are impacted by human related interventions such as forest fire suppression, logging, disease related to the expansion of white-tailed deer range, extirpation of natural predators (Blood 1974) and the effects of forest and range succession. Additional complexities for managers are those of the animal rights and animal protection interests who largely promote non-intervention.

Protected moose populations in large state, provincial, and federal parks and reserves contribute much to our understanding of moose ecology by functioning as ecological laboratories. Both the U.S and Canadian federal governments recognize the research opportunities offered by such unhunted populations. In most, large scale habitat alterations have not taken place and "natural"ecosystem functions are allowed to proceed. Witness Isle Royale National Park with its long history (begining in the late 1950's) of basic ecological research on moose/wolf/habitat interactions (Peterson and Page 1983, Jordan *et al.* 1973). In addition Denali National Park and Reserve and the Kenai National Wildlife Refuge in Alaska have been sites for extensive monitoring of moose numbers and related moose research (Van Ballenberghe *et al.* 1989, Miquelle 1990, Van Ballenberghe 1992, Bailey 1978, Bailey and Bangs 1980). Larger provincial parks, like Algonquin in Ontario, also served as outdoor laboratories for moose research (Ontario Ministry of Narural Resources 1989, Addison *et al.* 1990, Wilton and Garner 1991, Forbes and Theberge 1992, Garner and Wilton 1993). In addition Algonquin Park has served as a source of moose for a successful reintroduction to Michigan (Aho and Hendrickson 1989). While ecological research and monitoring do not constitute management, the results of these activities do provide comparative benchmarks for management strategies applied to exploited populations and are indispensable in gauging management results with naturally regulated populations. Further, basic ecological research conducted in protected areas contributes to our overall knowledge about ecosystem functions in environments less affected by human disturbance.

Both the Canadian and U.S. national parks service state that "protection" and "preservation" of native processes of population regulation are foremost to their management

policies (Masyk 1975, Canadian Parks Service 1979, U.S. Department of Interior 1988, Ontario Ministry of Natural Resources 1989). Policies have been developed to deal with the maintenance of genetic diversity and consider culling or introductions of new genetic types to restore genetic diversity (U.S. Department of the Interior 1988). For example the Canadian Parks Service culled 1,130 moose from the totally enclosed and predator free Elk Island National Park in Alberta between 1959 and 1973 (Blood 1974).

Many large U.S. and Canadian national parks monitor moose populations using a variety of techniques. The necessity for these density estimates stems from the mandate to

Table 4. Moose population status in North American National Parks.

Jurisdiction/Park	Location State/Prov.	Current Population	Year of Survey	Estimated by:
Banff National Park	Alberta	no estimates ever made	-	-
Beringland Bridge Preserve	Alberta	200-400	1980s	-
Cape Breton Highlands N.P.	Nova Scotia	2052	1993-94	Aerial survey*
Denali National Park and Preserve	Alaska	2000	1990	Aerial survey
Forillion National Park	Prov. Of Quebec	75	1990	Aerial survey
Fundy National Park	New Brunsick	123	1993	Aerial survey*
Gates of the Arctic National Park and Preserve	Alaska	-	-	-
Glacier National Park	Montana	100	1985	-
Grand Teton National Park	Wyoming	120	1988	-
Gros Morne National Park	Newfoundland	7738	1995	Aerial survey*
Isle Royale National Park	Michigan	2400	1994-95	Aerial survey
Jasper National Park	Alberta	100-150	1992	Ground survey
Kenai National Park and Preserve	Alaska	-	-	-
Kejimkujik National Park	Nova Scotia	10-15	1992	Guess estimate
Kluane National Park	Yukon Territories	316	1991	Aerial survey
Kootenay National Park	British Columbia	<75	1985	CWS biologists
Kouchibouguac National Park	New Brunswick	110	1995	Aerial survey*
Lake Mauricie National Park	Prov. of Quebec	212 (3.9/10 km)	1989	-
Lake Clark National Park and Preserve	Alaska	-	-	-
Mt. Revelstoke and Glacier National Park	British Columbia	15-20	1991	Sightings and tracks
Nahanni National Park	Northwest Territories	-	-	-
Nootak Preserve	Alaska	-	-	-
Prince Albert National park	Alberta	975	1990	Aerial survey
Pukaskwa National Park	Ontario	379	1990	Aerial survey
Riding Mountain National Park	Manitoba	3066	1992	Aerial survey
Terra Nova National Park	Newfoundland	170	1993	Aerial survey*
Voyageurs National Park	Minnesota	25	1987	-
Watertown Lakes National Park	Alberta	50	1988	Aerial and ground surveys
Wood Buffalo National Park	Alberta	1300	1989	-
Wrangell St. Elias National Park and Preserve	Yukon Territories	-	-	-
Yellowstone National Park	Montana	200	1990	Aerial survey
Yukon Charleg Preserve	Yukon Territories	-	-	-

-Information not available
*Corbett (1995)

insure the maintainance of viable wildlife populations within national parks. In addition, research being conducted in these parks may necessitate population estimates. Table 4 presents the current population estimate for 23 national parks and indicates the method used to obtain each estimate.

ACKNOWLEDGEMENTS

The authors are grateful to Karen Punpur of the Northwest Region Science and Tecnology Section, Ontario Ministry of Natural Resources, Thunder Bay and Linda Siczkar of the City of Thunder Bay for preparing tables and figures and to moose managers across North America who provided unpublished information in response to our questionnaire survey.

REFERENCES

ADDISON, E.M., J.D. SMITH, R.F. McLAUGHLIN, D.J.H. FRASER and D.G. JOACHIM. 1990. Calving sites of moose in Central Ontario. Alces 26:142-153.

AHO, R.W. and J. HENDRICKSON. 1989. Reproduction and mortality of moose translocated from Ontario to Michigan. Alces 25:75-80.

ALEXANDER, C.E. 1993. The status and management of moose in Vermont. Alces 29:187- 195.

BAILEY, T.N. 1978. Moose populations on the Kenai National Moose Range.Proc. N. Am. Moose Conf. Workshop 14:1-20.

_____, and E.E. BANGS. 1980. Moose calving areas and use on the Kenai National Moose Range Alaska. Proc. N. Am. Moose Conf. Workshop. 16:289-313.

BISSET, A.R. and H.R. TIMMERMANN. 1983. Resource allocation: an Ontario solution. Alces 19:178-191.

BLOOD, D.A. 1974. Variation in reproduction and productivity of an enclosed herd of moose (*Alces alces*). Trans. Int. Congr. Game Biol. 11:59-66.

BOUCHARD, R. and G. MOISAN. 1974. Chasse controlee a l'orignal dans les parcs et reserves du Quebec (1962-1972). Naturaliste can. 101:689-704.

CANADIAN PARKS SERVICE. 1979. Parks Canada policy, Pages 31-32 *in* Ministr. of Environ., Can. Parks Serv., Ottawa.

CHILD, K.N. 1983. Selective harvest of moose in the Omineca: Some preliminary results. Alces 19:162-177.

_____, and D.A. AITKEN. 1989. Selective harvests, hunters, and moose in central British Coumbia. Alces 25:81-97.

CORBETT, G.N. 1995. Review of the history and present status of moose in the National Parks of the Atlantic Region: Management Implications? Alces 31:167-180.

CRÊTE, M. 1987. The impact of sport hunting on North American moose. Swedish Wild. Res. Suppl. 1:553-563.

CRICHTON, V.F. 1977. Hecla Island - Manitoba's answer to Isle Royale. Proc. N. Am. Moose Conf. Workshop. 13:191-199.

_____,1981. The impact of treaty Indian harvest on a Manitoba moose herd. Alces 17:56-63.

DESMEULES, P. 1966. Controlled moose hunts in Quebec's provincial parks. Proc. N.E. Sect. Wildl. Soc., Boston Massachusettes. 15pp.

DIAMOND, J. 1992. Must we shoot deer to save nature? Natural History, Aug :3,4,6,8.

FORBES, G.F. and J.B. THEBERGE. 1992. Importance of scavenging on moose by wolves in Algonquin park, Ontario. Alces 28:235-241.

FRANZMANN, A.W. and C.C. SCHWARTZ. 1983. Management of North American moose populations. Pages 517-522 *in* C.M. Wemmer, ed., Biology and management of the Cervidae. Smithsonian Institute Press, Washing-

ton.

GARNER, D.L. and M.L. WILTON. 1993. The potential role of winter tick (*DERMACENTOR ALBIPICTUS*) in the dynamics of a south central Ontario moose population. Alces 29:169-173.

GOUDREAULT, F. 1980. L'influence d'un parc de conservation et d'un reserve sur la recolte des orignaux dans les territoires adjacents intensement chasses dans le centre-sud du Quebec. Proc. N. Am. Moose Conf. Workshop. 16:527-548.

JORDAN, P.A., D.B. BOTKIN, A,S. DOMINSKI, H.S. LOWENDORF and G.E. BELOVSKY. 1973. Sodium as a critical nutrient for moose of Isle Royale. Proc. N. Am. Moose Conf. Workshop. 9:13-42.

KALE, W. 1982. Estimation of moose harvest for smaller management units in the Yukon. Alces 18: 116-141.

LACASSE, M., J.L. DUCHARME, J. PELLETIER, and G. PAMONTAQUE. 1984. Wildlife management and use in Quebec, development strategies. Loisir, Chasse et Peche, Quebec City. 43pp.

LENARZ, M.S. 1992. 1991-92 Aerial moose survey results. Upub. Rep. MN Dep. of Nat.Resour. Wildl. Res., Grand Rapids. 8pp.

MASYK, J. 1975. Wildlife management in national parks, past and future. Proc. N. Am. Moose Conf. Workshop. 11:264-276.

MERCER, W.E., and M. STRAPP. 1978. Moose management in Newfoundland 1972-1977. Proc. N. Am. Moose Conf. Workshop. 14:227-246.

MIQUELLE, D.G. 1990. Behavioral ecology of moose in Denali National Park and Preserve, Alaska. Thesis., Univ. Idaho, Moscow. 152pp.

ONTARIO MINISTRY OF NATURAL RESOURCES, 1989. Algonquin Park bibliography, rev. ed. Ont. Min. Nat. Resour., Whitney. 90pp.

PETERSON, R.O. and R.E. PAGE. 1983. Wolf-moose fluctuations at Isle Royale National Park, Michigan, U.S.A. Acta. Zool. Fennica. 174:251-253.

SCHWARTZ, C.C., K.J. HUNDERTMARK, and T.H. SPRAKER. 1992. An evaluation of selective bull moose harvest on the Kenai peninsula Alaska. Alces 28:1-14.

SMITH, H. 1990. Managing a moose population. Pages 25-29 *in* M. Buss and R. Truman, eds., The Moose in Ontario, Book 1. Ont. Min. Nat. Resour., Wildl. Branch, Toronto, 78pp.

TIMMERMANN, H.R. 1987. Moose harvest strategies in North America. Swedish Wildl. Res. Suppl. 1:565-579.

_____. 1992. Moose sociobiology and implications for harvest. Alces 28:59-78.

_____, and R. GOLLAT. 1982. Age and sex structure of harvested moose related to season manipulation and access. Alces 18:301-328.

VAN BALLENBERGHE. 1992. Behavioral adaptions of moose to treeline habitats in subarctic Alaska. Alces Suppl. 1:193-206.

_____, D.G. MIQUELLE and J.G. MacCRACKEN. 1989. Heavy utilization of woody plants by moose during summer at Denali National Park, Alaska. Alces 25:31-35.

U.S. DEPARTMENT OF INTERIOR, 1988. Management policies of the U.S. Department of Interior National Parks service. Chap. 4:5, 4:6, 4:7, and 4:10. U.S. Dep. Inter., Washington, D.C.

_____. 1992. Voyageurs National Park draft. sect. 11 (S) 21:1-20. *in* U.S. Dep. Inter., Nat. Park Serv. International Falls, MN.

WILTON, M.L. 1992. Implications of harvesting moose during pre-rut and rut activity. Alces 28:31-34.

_____, and D.L. GARNER. 1991. Calving site selection in south central Ontario, Canada. Alces 27:111-117.