REVIEWING ONTARIO'S MOOSE MANAGEMENT POLICY - 1980-2000 - TARGETS ACHIEVED, LESSONS LEARNED

H.R. Timmermann[1], R. Gollat[2], and H. A. Whitlaw[3]

[1]R.R. # 2 Nolalu, ON, Canada POT 2KO; e-mail: TTimoose@aol.com; [2]Ontario Ministry of Natural Resources, Thunder Bay, ON, Canada P7C 5G6; [3]9305 Winston Ave., Lubbock, TX 79424, USA

ABSTRACT: We examine progress made in meeting the 1980, 20- year Ontario Moose Management Policy (MMP) directive. Specific interim (1985, 1995) and final (year 2000) provincial program targets, including population, harvest, hunting, and viewing opportunities, particularly those in the NW Region, are reported. In addition to MMP guidelines, other management policy achievements and shortfalls pertaining to harvest control, population management, enforcement, habitat management, inventory and assessment, research, and hunter education are discussed. Provincially, moose numbers have increased only 7-20% throughout the 1990s plateauing at 100,000- 120,000 while the number of adult tags has almost been halved. Hunter numbers during this period have increased by about 4% and total harvest has remained fairly constant. Adult tag draw success has declined and success in filling a tag has increased while harvest remained similar in absolute numbers. This suggests that factors other than hunting pressure are limiting further population growth. Knowledge gained since 1980 suggests overall population and harvest targets are unattainable and should be revised using adaptive management principles, to more closely reflect land capability and societal demands. Reduced hunter reporting rates in recent years have jeopardized the quality of harvest estimates and diminished overall hunter confidence. Recommendations for policy changes, including revisions to program direction and targets, are made based on lessons learned.

ALCES VOL. 38: 11-45 (2002)

Key words: enforcement, habitat management, harvest targets, hunter education, inventory and assessment, management policy, population targets, predator control, program targets

---

Specific goals and objectives to guide the development of management plans are employed by most jurisdictions that manage moose in North America (Timmermann and Buss 1995). Policy objectives generally relate to maintaining or increasing moose populations and the recreational, social, and economic benefits associated with a harvest, as well as gaining new knowledge about moose ecology. Management policies with specific goals and objectives typically guide moose management plans over a 5 - year period (Timmermann and Buss 1998).

Ontario introduced a comprehensive moose management policy in 1980 following a series of public meetings (OMNR 1980a) and in response to declining moose populations and related recreational and economic benefits (OMNR 1980b). The Cabinet - approved policy included a broad program objective, 4 program targets, 14 policy guidelines, and 15 management goals spanning a 20 - year horizon (OMNR 1980b). Specific program targets included: (1) increase the herd from 80,000 to 100,000 by 1985, 140,000 by 1995, and 160,000 by the year 2000; (2) harvest 10,000 moose per year after 1985, 18,000 per year by 1995, and 25,000 per year by 2000; (3) provide for

750,000- 875,000 hunter days annually by 2000; and (4) create sites by the year 2000 where more than 1 million people annually have the opportunity to observe moose. The new policy prompted many changes in moose management including the requirement of sharing a moose during1980-82 (Timmermann and Gollat 1984) and establishing parameters for selective harvesting of moose beginning in 1983 (Euler 1983, Gollat and Timmermann 1983, Timmermann and Gollat 1986, Smith 1990, Heydon et al.1992, Timmermann and Whitlaw 1992). The selective harvest system introduced in 1983 proportioned the allowable harvest among the tourist industry on a 90/10 percent (non tourist / tourist industry) basis provincially (Bisset and Timmermann 1983). This allocation was based on historic use and capacity of individual outfitters and may vary (above or below 10%) by Wildlife Management Unit (WMU).

Year 2000 moose population density targets for each WMU were originally set out in the Northwestern Ontario Strategic Land Use Plan (OMNR 1982). Three population densities were targeted; 0.05-0.11/ km^2 (WMUs 1C and 17), 0.15-0.35/km^2 (WMUs 16A, 16B, 16C, 18A, 18B), and 0.39/km^2 for the remaining 21 WMUs (Fig.1). These population targets were based on the belief that moose populations with good habitat (i.e., Quetico Provincial Park and the Chapleau Crown Game Reserve) supported densities of about 0.40/km^2 (Bisset 1992). Likewise, year 2000 sport harvest rates were established at 17.5% per year for all but 4 northern WMUs, where they varied between 12.3 and 15.0%

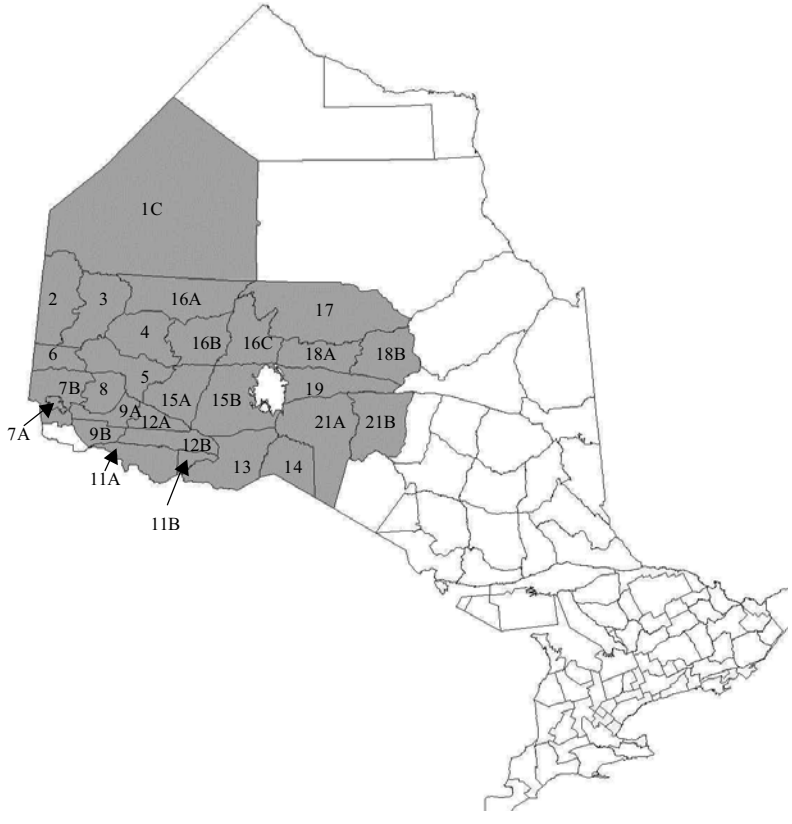


Fig. 1. Location of 28 Wildlife Management Units (WMUs) in Ontario's Northwest Region (shaded), in relation to Provincial WMUs used to manage moose in Ontario.

(OMNR 1982). This provincial policy guided field offices, which developed more specific approaches that were appropriate for their area. Some regions targeted a faster rate of population increase by limiting adult hunting opportunities (number of Adult Validation Tags — AVTs), while others, opted for a stable, or slower rate of increase, and provided more AVTs.

Each WMU harvest quota was apportioned into a specific number of bulls, cows, and calves beginning in 1983. The applied 1983 ratio of 50:20:30 was refined to a baseline 60:20:20 in 1984, based on a computer simulation population model (OMNR 1984, Gollat et al. 1985). Annual harvest quotas were set for each WMU based on the number of adult bulls and cows that could be taken and still allow the herd to increase or remain stable, depending on population status relative to year 2000 targets. These were calculated based either on a percentage of adult cows in the population or a harvest rate applied to the total pre-hunt population estimate (i.e., 10-15%; Greenwood et al. 1984).

Adult bull and cow harvest opportunities, governed by the number of AVTs, were restricted during most of the 18 - year period. A 3 - year moving average of hunter success rates was used initially to govern the number of bull and cow AVTs. A regression-based success rate projection was used more recently to calculate the number of AVTs. Managers also targeted 67 bulls /100 cows as a minimum post-hunt adult bull/cow sex ratio in an attempt to increase populations and optimize harvests to year 2000 targets (Crête et al. 1981).

The objective of this paper is to examine progress made towards meeting the 1980 Moose Management Policy (MMP) (OMNR 1980b). It is not a detailed analysis of MMP objectives. Our intent is to provide an overview of accomplishments and shortfalls that hopefully will lead to a comprehensive program review. We report on specific targets achieved and lessons learned, particularly in Ontario's Northwest Region (NWR); an area that contains more than one half of the provincial moose population and annual harvest (Whitlaw et al. 1993). In addition, we chronicle a partial list of published material relating to meeting the 20-year (1980-2000) provincial moose management policy objectives.

METHODS

Population and harvest estimates were compiled from a variety of published and unpublished Ontario Ministry of Natural Resources (OMNR) sources, generally spanning the period 1980-2000. Detailed data for 28 of 67 provincial WMUs from the current NWR (Fig. 1) were examined. Moose population density estimates were obtained from aerial inventories conducted approximately every 3 years in most WMUs and compared to targeted densities (Timmermann and Whitlaw 1992; Bisset and McLaren 1995,1999; Bisset 1996; Bisset et al. 1997, 1998, 2000). Estimated densities were derived from moose observed plus those not sighted but believed to have been missed, based on a track aggregate method described by Bergerud and Manuel (1969), or a resurvey of random plots at a higher search intensity (Bisset and Rempel 1991). Harvests were largely determined from annual (1980-96) District post-hunt mail surveys (DMS) as described by Gollat and Timmermann (1987) as well as those conducted centrally beginning in 1997 (Bisset et al.1999, 2001). Trends in overall provincial hunter numbers and total harvests were obtained from the annual centrally - conducted provincial mail survey (Barbowski 1972, Cumming 1974). The number of AVTs and harvest quotas assigned to each WMU were retrieved from regional files in Kenora and Thunder Bay (Whitlaw et al. 1993), annual OMNR Moose

Hunter Fact Sheets, and Wildlife Branch files. We had difficulty in readily obtaining population and harvest information for some WMUs and not all databases were similar.

Achievement of population targets was assessed using WMU mean trend estimates and/or applying a ± 20 % at the 90% confidence interval (C.I.) minimum level of precision (Bisset and McLaren 1995) where the pattern is questionable. In reality C.I.s were higher and averaged ± 28.4% (range ±15-73%) based on 107 surveys (1980 - 93) conducted in NWR's 28 WMUs (Whitlaw et al. 1993). Based on these criteria, we then categorized each WMU as to: (1) target achieved; (2) unclear; and (3) target not achieved. Likewise, we compared planned harvests to estimated harvests using DMS data, realizing that calf harvests were underestimated, as "few districts attempt to sample calf-only licenced hunters" (Timmermann and Rempel 1998:25). Our review follows the 1980 MMP outline structure, respecting headings and subheadings (OMNR 1980a).

PROGRAM TARGETS

Population Trends

Historical provincial post-hunt moose population estimates peaked at 125,000 in 1958 and this estimate was used until the early 1970s when densities in some areas were thought to have declined due to indications of over-hunting (Cumming 1974). No comparable published estimates of NWR densities are available for this period. Bisset (1993:abstract) believed that provincial populations "hit a low point" about 1978 at an estimated 75,000 (Table 1). Reduced harvests following MMP restrictions

Table 1. Ontario provincial moose population estimates and targets, 1953-2000.

Year	Population Estimate	Source	Comments
1953	42,000	Lumsden (1953)	First province-wide estimate
1956-57	70,548	Lumsden (1958)	Based on 21 District areas
1957-58	80,325	Lumsden (1958)	Based on 21 District areas
1958	125,000	Lumsden (1959)	Based on 21 District areas
1978	75,000	Bisset (1993)	
1982	80,000	Timmermann (1987)	Stefanski, personal communication, 1984
1990-91	120,000	Timmermann & Buss (1995)	Bisset, personal communication, 1994
1990	92,883	Whitlaw et al. (1993)	
1991	91,100	Euler (1994)	E.A. decision
1992	104,500	Bisset (1993)	Review of survey data - 1975-92
1993	120,000	Bisset (1993)	"in the order of"
1994	120,000	Simmons (1997)	Province-wide independent review
1997	120,000	Simmons (1997)	Province-wide independent review
1997	100,000	Provincial Auditor (1998)	Audit report for F&W Program
1999	120,000	Bisset & McLaren 1999	Aerial inventory plan 1999-2002
Targets			
1985	100,000	OMNR (1980a)	Year 1985 province-wide target
1995	140,000	OMNR (1980a)	Year 1995 province-wide target
2000	160,000	OMNR (1980a)	Year 2000 province-wide target

begining in 1980 were thought largely responsible for population recovery to near previous levels by the 1990s. The most currently used population estimate (1999), derived from aerial inventories, places the NWR population at 51,047. This is slightly higher than the 1975 estimate of 49,806 but far short (59%) of the 2000 MMP target of 86,483 (Table 2). Population targets were achieved in only 8 of 28 WMUs, 5 were unclear, and 15 were judged to have failed to have met expected target densities. Similarly, the "official" provincal population estimate (1997) of 120,000 fell short (25%) of the year 2000 target of 160,000 (Table 1).

The accuracy of the 120,000 (1993-97) estimate is suspect, particularly when actual estimates (including missed moose) were nearly 15,000 less in 1992 (Bisset 1993) and 20,000 lower in 1997 (Provincial Auditor 1998). "A 1996 Ministry study found that 93% of all WMUs within core range were below their population target levels" (Provincial Auditor 1998:6). Incomplete or poor quality aerial surveys carried out by untrained and inexperienced survey crews during mild, low snow winters, may have contributed to lower density estimates (see Timmermann1993). Population swings of about 20% or more are required before changes can be detected (Gasaway and Dubois 1987). Further, most WMU survey estimates for NWR reported by Whitlaw et al. (1993) were higher than the "minimum acceptable level" of ± 20% at the 90% C.I. suggested by Bisset and McLaren (1995:6) "to provide reliable trend - through - time information". Sightability estimators are used to calculate estimates of actual numbers. Those used in Ontario have varied from a low of 1.04-1.06 (Novak and Gardner 1975) to a high of 1.75 - 2.60 reported by Thompson (1979). WMU densities are assumed to remain unchanged between survey years. Hence, provincial population estimates are based on the cumulative total of all WMUs, even though most are only sampled every 3 or more years.

Several explanations are plausible as to why MMP population targets (Table 1) were not achieved. Overhunting resulting from ineffective harvest control may be the single most likely cause of density shortfall (A. Bisset, Ontario Ministry of Natural Resources, personal communication). We believe factors affecting population growth are complex, variable, and poorly understood. Additional factors that may have impacted carrying capacity and density response include: parasites and diseases, predation, subsistence harvest by Native people under treaty, poaching losses, winter severity, green period length, summer heat, and lower than expected land capability (Timmermann and Whitlaw 1992; G. Lynch, Alberta Wildlife Consultant, personal communication 2001). Increased road access resulting from accelerated timber harvests has raised success rates in many WMUs. Unfortunately, few solid data exist on levels of subsistence hunting or predation losses, even though they undoubtedly play a role (see predator control section). Parasite and disease studies suggest a plausible link to population declines in some areas (see Research section).Winter ticks (*Dermacentor albipictus*) have been implicated as a mortality factor in high- density moose areas (Samuel and Barker 1979, Lankester 1987). Recently (1998-99) a major winter moose dieoff was reported in Algonquin Park (N. Quinn, Park Biologist, Ontario Ministry of Natural Resources, personal communication 2001). Interspecific competition with white-tailed deer (*Odocoileus virginianus*) and transmission of the brain-worm (*Parelaphostrongylus tenuis*) from deer may impact local populations (Whitlaw and Lankester 1994a). In addition, E. Addison, (Ontario Ministry of Natural Resources, personal communication 2001) suggested a possible

Table 2. Year 2000 moose population density targets and population estimates (1975-99) for 28 WMUs in Ontario's Northwest Region.

	Year 2000 Targets[1]		Population Estimates						Target Achievement
WMU	Density (/km^2)	Population	1975[2]	1980[2]	1985	1990	1995	1999	
1C[3]	0.10	13,228	7,000	7,000	7,000	7,000	7,000	7,000	No
2	0.39	4,575	1,230	1,130	1,050	1,600	3,203	1,562	No
3	0.39	4,536	3,360	1,640	1,900	1,500	1,700	1,408	No
4	0.39	3,825	2,360	1,250	1,600	1,900	1,550	2,031	No
5	0.39	3,340	2,130	1,459	3,050	3,050	2,601	3,521	Yes? [4]
6	0.39	1,393	720	490	330	1,100	1,300	1,740	Yes
7A	0.39	285	612	116	200	660	977	660	Yes
7B	0.39	2,370		468	800	1,350	1,600	1,751	No
8	0.39	1,748	1,133	1,040	1,700	1,950	2,485	2,819	Yes
9A	0.39	1,425	1,756	952	750	1,000	1,450	1,525	Yes
9B	0.39	1,230			200	500	940	1,100	No? [5]
11A	0.39	1,010	2,520	2,886	541	638	1,097	550	Unclear
11B	0.39	581			414	529	775	600	Yes
12A	0.39	1,340	3,232	2,750	1,207	1,209	1,100	1,400	Unclear
12B	0.39	2,088			2,042	2,188	2,463	2,450	Yes
13	0.39	4,373	2,889	2,129	3,385	4,966	4,013	3,894	Unclear
14	0.39	463	160	203	585	721	325	319	No
15A	0.39	3,701	5,980	6,600	1,200	2,800	2,500	3,600	No? [5]
15B	0.39	5,844			4,091	4,091	5,440	6,120	Yes? [4]
16A	0.33	4,837	3,090	745	769	950	825	825	No
16B	0.15	1,325		388	550	800	847	1,615	Unclear
16C	0.15	1,447		590	1,480	1,480	1,134	1,000	Unclear
17	0.11	2,965	1,000	1,000	1,914	1,914	1,914	1,332	No
18A	0.33	2,580	1,510	1,360	845	615	657	657	No
18B	0.15	1,649			666	770	770	528	No
19	0.39	4,015	1,210	1,154	1,602	1,485	1,349	1,690	No
21A	0.39	5,320	7,914	6,180	6,347	3,895	2,976	3,205	No
21B	0.39	4,990			3,942 [6]	2,474	3,105 [6]	3,105 [6]	No
Total NWR		86,483	49,806	41,530	43,160	43,661	49,096	51,047	No

[1] OMNR (1982).

[2] Bisset (1991).

[3] Bisset (1992).

[4] Not clear; pattern suggests target achieved.

[5] Not clear; pattern suggests target likely not achieved.

[6] Virginia Thompson, Ministry of Natural Resources, personal communication, 2001.

link between canine parvovirus that swept through domestic canids and apparently also wolf populations in the late 1970s and early 1980s and hence may have increased survival of moose. Illegal hunting or poaching losses appear to be significant in some areas of Ontario (D. Harnish, Ontario Ministry of Natural Resources, personal communication 2000). Additionally, above average winter severity and lower than expected land capability where density targets in some WMUs may have been unrealistically high, could help explain some target shortfalls (Peterson and Allen 1974, Timmermann and Whitlaw 1992, Rempel et al. 1997b). Elevated calf harvests in some WMUs due to an unlimited calf harvest strategy may be impacting growth potential (Timmermann and Rempel 1998). Drought and warmer summer temperatures that lead to reduced net energy intake may result in lower fertility levels and pregnancy rates as recently suggested for Isle Royale moose by R.O. Peterson (Michigan Tech University, personal communication 2000). Conversely, an extended summer green period may have extended the period of positive energy balance in some years to enhance production as reported by Stewart et al. (1977). Ferguson et al. (2000) studied the influence of density on growth and reproduction in northwestern Ontario moose and concluded that populations living in areas of low primary productivity and low natural predation show less persistence and require greater conservation efforts. Recently McKenney et al. (1998) developed a spatially explicit moose population model to help increase understanding of the myriad of factors regulating Ontario moose populations.

Bisset (1992) proposed revisions to some of the 14 "original" NWR population targets downwards in 3 , no change in 2, and upwards in 9 WMUs, while retaining the original total population target. He believed where targets were excessive, they should be reduced, and raised in most areas in core range to a population density of at least 0.70 moose/km^2, similiar to those acheived on the Aulneau Peninsula (WMU 7A). Unfortunately no similiar province-wide exercise was undertaken, and hence "official"year 2000 population targets for the Province (Table 1) remained as those generated in the Northwestern Ontario Strategic Land Use Plan in 1982 (Table 2). A new set of draft population targets was recently generated, following an internal province-wide review (OMNR 2001). A further public review of these targets including a full review of the MMP is intended in the near future (E.R. Armstrong, Ontario Ministry of Natural Resources, personal communication 2001).

We conclude that moose populations are regulated by a host of factors, and not necessarily by any single factor such as overhunting. Targeting a specific moose density and attempting to manage at that density level over time may be unrealistic. Witness the dramatic reductions of Swedish moose populations from 1982-92 that demonstrate the difficulties involved in managing wild populations at a predetermined density (Sylvén 1995). Moose shot by hunters declined from 175,000 to 99,000 during this 10 - year period. Sizeable, but unquantified effects of global warming, if occurring, may also negatively influence population growth.

We agree with Morris (1959), that often the major, common mortality factors may not be as important in influencing population fluctuations as those variable factors that operate inconsistently and over which managers have no control. We support the current target review exercise in re-examining population and harvest targets, to determine their relevance and achievability. Further reducing AVTs and hunting opportunities is, in our opinion not necessarily

the answer in all cases. We suggest the overall population target of 160,000 be reduced. Lower moose densities can provide proportionately more recreation per kill than higher densities (Crête 1987,1989). Lower densities (e.g., half of *K*) also provide a greater sustained yield if hunting is assumed to be the major mortality factor. The question then arises whether it is really necessary to increase populations in all WMUs by actively restricting participation to socially unacceptable levels. Timmermann and Gollat (1986) suggested managers consider offering a mix of hunting qualities - high but limited in some WMUs and lower and more liberal in others, coupled with reducing hunter efficiency.

Harvest Trends

Provincial harvests increased incrementally from 1,456 in 1953, 2 years after seasons were re-opened (Cumming 1974), to around 12,000 in 1962 (Table 3). They averaged 12-13,000 for the next decade, peaking at 14,610 in 1965, following a period of long, liberal non- selective hunting seasons. Substantial harvest reductions occured 1980-81 when seasons were shortened, and opening dates were delayed and hunters were required to share a moose (Timmermann and Gollat 1984). Harvests were lowest (7,971) in 1983, following introduction of the current selective harvest program. They rebounded and varied little (10,000- 11,000) from 1984 - 98 (Table 3), even though hunter numbers (1980 - 98) increased by 20,000 (Table 4). NWR harvests however increased from 39.2% (4,188) of provincial harvest in 1982, to 51.3 % (5,611), in 1998, while hunter numbers increased by about 7,000 (Table 5).

Table 3. Total estimated Ontario provincial moose harvests, 1953-1998.

Year	Estimated Harvest[1]	Year	Estimated Harvest[1]	Year	Estimated Harvest	Year	Estimated Harvest
1953	1,456	1965	14,610	1977		1989	10,771[2]
1954	1,781	1966	14,517	1978		1990	
1955	2,867	1967	13,207	1979		1991	11,000[3]
1956	4,540	1968	12,050	1980	8,361[2]	1992	
1957	5,943	1969	12,332	1981	8,092[2]	1993	
1958	6,787	1970	11,918	1982	10,691[2]	1994	10,000[4]
1959	8,925	1971	13,072	1983	7,971[2]	1995	
1960	10,048	1972	13,114	1984	10,346[2]	1996	
1961	11,830	1973		1985	10,162[2]	1997	9,813[5] (10,500)
1962	12,147	1974		1986	10,790[2]	1998	10,929[6]
1963	13,113	1975		1987	10,763[2]		
1964	11,924	1976		1988			

[1] Cumming (1974) for the period 1953-1972.

[2] OMNR Moose Hunter Fact Sheets, Ontario Ministry of Natural Resources, Wildlife Branch, Toronto, Ontario, Canada.

[3] Timmermann and Buss (1995).

[4] Simmons (1997).

[5] Bisset et al. (1999); 10,500 estimate includes hunters who did not apply for AVTs.

[6] Bisset et al. (2001).

Table 4. Ontario provincial moose hunter numbers and harvests.

	Resident		Tourist Industry		All Hunters	
Year	Number of Hunters	Harvest	Number of Hunters	Harvest	Number of Hunters	Harvest
1980[1]	71,666	7,669	3,927	692	75,593	8,361
1981	66,852	7,626	3,105	466	69,957	8,092
1982	82,678	9,747	5,841	944	88,519	10,691
1983	65,062	7,971	6,794	1,082	65,062	7,971
1984	72,194	6,828	6,949	1,143	79,143	10,346
1985	71,408	8,781	7,191	1,381	78,599	10,162
1986	72,959	9,378	7,217	1,412	80,176	10,790
1987	76,918	9,438	7,971	1,325	84,889	10,763
1989	82,600	9,104	8,091	1,667	90,691	10,771
1997[2]					95,004	9,813
1998[3]					89,006	10,929

[1] 1980-89 data from OMNR Hunter Fact Sheets, Ontario Ministry of Natural Resources, Wildlife Branch, Toronto, Ontario, Canada.

[2] Bisset et al. (1999).

[3] Bisset et al. (2001).

Higher harvests for tourist industry based hunters in the 1990s have contributed to increased overall NWR harvests (Table 5). Planned harvests (# of bulls, cows, and calves) in the NWR 1984-99 remained reasonably constant during the 16 year period (4,629- 5,372; Fig. 2). They were highest in 1988-90 when populations were thought to have increased (Timmermann and Whitlaw 1992) and returned to around 5,000 thereafter.

Estimated NWR bull harvests exceeded planned harvests in 9 of 15 years, but were generally within10% of planned harvests whereas cow harvests were almost always higher (up to 36%) (Fig. 3). Hence the impact of heavy cow harvests may have curtailed herd increase in some areas. Estimated total harvests ranged from 3,711 in 1984 to a high of 5,587 in 1998. However, an increased effort in assessing the calf kill beginning in 1997 is believed responsible for elevated estimates in recent years (Fig. 4). If only the adult harvest estimates are examined, data suggest peak harvests of bulls and cows occurred in 1988-90.

A provincial harvest target of 10,000 moose was achieved by 1985. However, harvests stalled at 10,000-11,000 per year thereafter (Table 3), hence the higher harvest targets of 18,000 and 25,000 by 1995 and 2000, respectively, were grossly underachieved. Likewise NWR harvests (48.8% of Provincial harvests in 1985, rising to about 55% by 1997) fell far short of MMP harvest target expectations, even though no specific interim NWR WMU - specific harvests were defined.

Hunting Opportunities

The MMP targeted an increase in hunting opportunities from 350,000 - 400,000 user-days after 1985 to 750,000-875,000 by the year 2000 (OMNR 1980a). Published data suggest that these user-day targets were largely met (713,000 in 1993 and 817,000

Table 5. Ontario NW Region (28 WMUs – WMU 1C through 21B) hunter numbers and harvests.

	Resident		Tourist Industry		All Hunters		Percent of Provincial Harvest
Year	Number of Hunters	Harvest	Number of Hunters	Harvest	Number of Hunters	Harvest	
1982[1]	22,286	3,643	2,688	545	24,974	4,188	39.2
1983	20,896	3,875	3,041	649	23,937	4,524	56.8
1984	19,995	3,902	2,967	726	27,590	5,354	51.7
1985	22,368	4,166	3,527	798	25,895	4,964	48.8
1986	22,238	4,473	3,565	786	25,803	5,259	48.7
1987	23,773	4,483	4,169	937	27,942	5,420	50.4
1989	26,942	4,636	4,215	1,089	31,157	5,725	53.2
1997[2]					32,319	5,422	55.3
1998[3]					31,957	5,611	51.3

[1] 1980-89 data from OMNR Hunter Fact Sheets, Ontario Ministry of Natural Resources, Wildlife Branch, Toronto, Ontario, Canada.

[2] Bisset et al. (1999).

[3] Bisset et al. (2001).

Fig. 2. Planned and estimated harvests for bulls, cows, and calves combined in 28 WMUs of the Northwest Region of Ontario, 1984-1999 (source: District Mail Surveys).

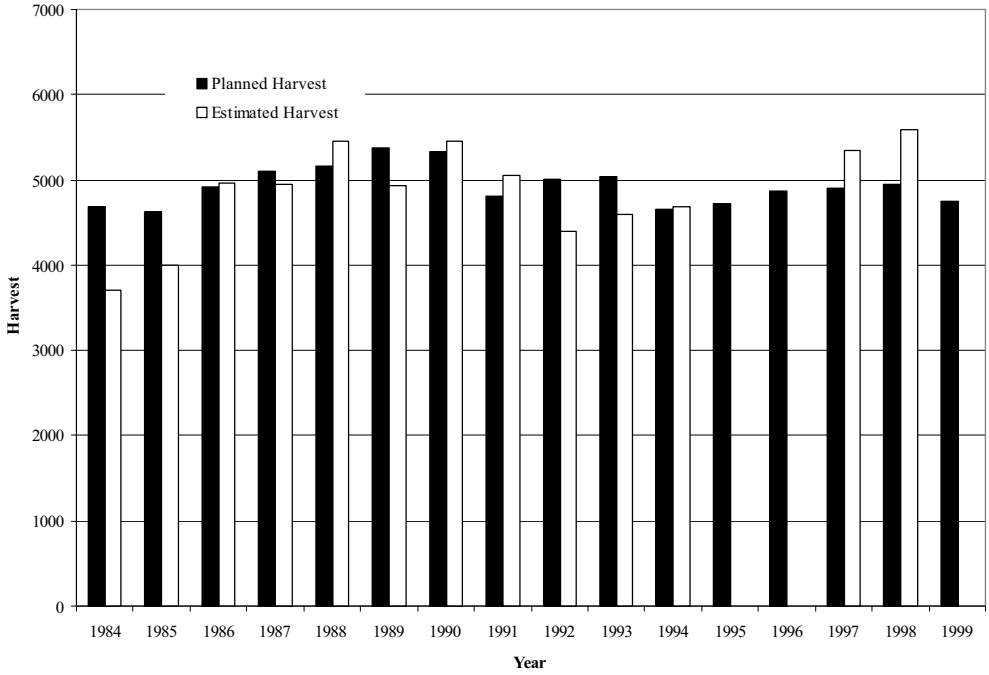
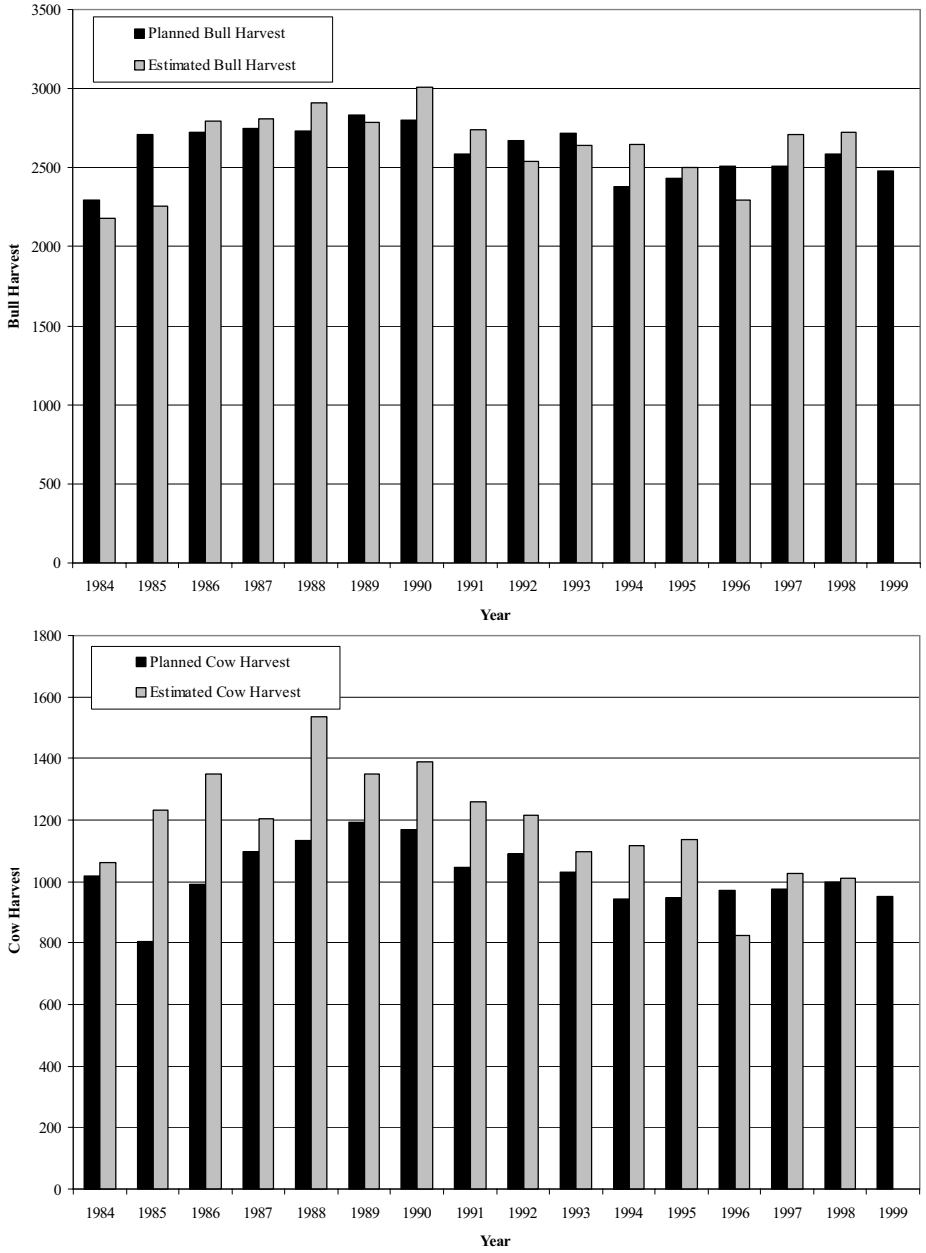


Fig. 3. Planned and estimated bull and cow harvests in 28 WMUs of the Northwest Region of Ontario, 1984-99 (source: District Mail Surveys).



in 1997; Table 6). The large provincial and regional increase in hunter numbers (Tables 4 and 5), and relatively long seasons, combined with the introduction of legal party hunting in 1988, the introduction of a group application for an adult moose tag in 1992 (OMNR 1991), and unlimited calf hunting opportunities for all licenced hunters, are believed largely responsible. Archery seasons were also introduced to provide additional hunting opportunities in 6 WMUs in 1984 and increased to 25 WMUs by 2000. The NWR offers the majority (60-70%) of Provincial adult archery tags in 20

Fig. 4. Planned and estimated calf harvests in 28 WMUs of the Northwest Region of Ontario, 1984-1999 (source: District Mail Surveys).

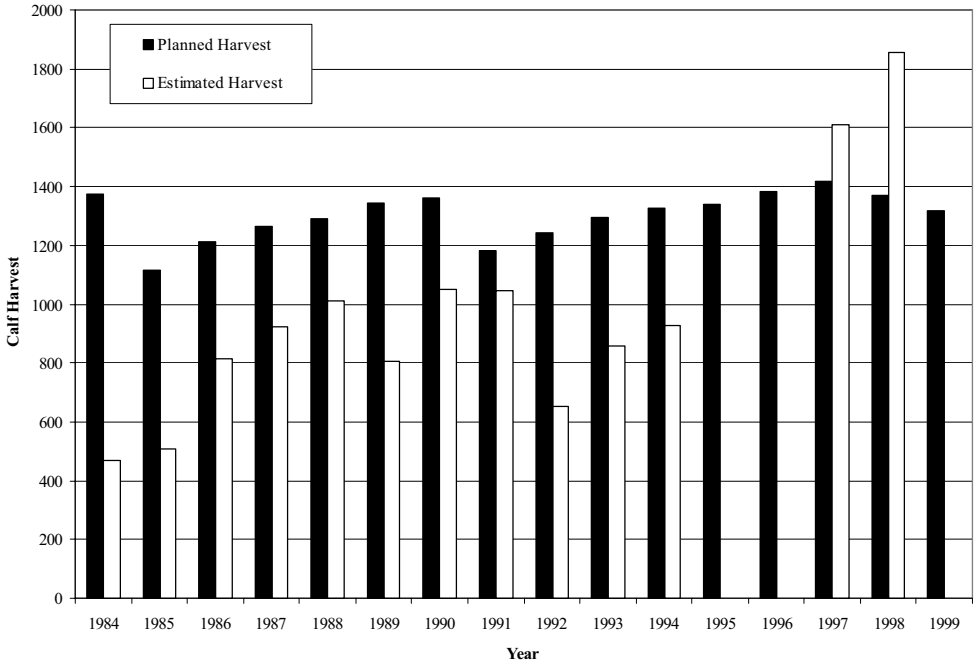


Table 6. Ontario provincial moose hunting opportunities and targets, 1973-1997.

Year	Number of user days	Source	Comments
1973	460,000	Cumming (1974)	Economic impact of $13M per year
1993	713,000	Legg (1995)	Economic impact of $134.7M per year
1997	817,000	Bisset et al. (1999)	Average of 8.6 days per hunter
Targets			
1985	350,000-400,000	OMNR (1980a)	Year 1985 target
1995	630,000-720,000	OMNR (1980a)	Year 1995 target
2000	750,000-875,000	OMNR (1980a)	Year 2000 target

of 25 WMUs (Figs. 5 and 6).

On the other hand a significant reduction in resident gun AVTs occurred (Fig. 7). Combined Provincial bull and cow AVTs fell stepwise from 55,886 in 1983 to 15,994 in 2000, 29% of the original allocation. Likewise tag numbers in the NWR in 2000 represented about 35% of those available in 1983 (i.e., from 22,291 [39.9% of total provincial tags] in 1983 to 7,894 [64.4 % of the provincial total] in 2000; Fig. 8).

Area closures following logging operations were suggested as a management strategy to protect vulnerable moose populations and limit hunting opportunities in some areas. (Timmermann and Gollat 1984). Racey et al. (2000) reported hunting opportunities were likely reduced in these areas but that quality viewing opportunities were provided in areas with good access and relatively high moose densities in a closed area case study.

Fig. 5. Number of available Ontario Provincial archery resident Adult Validation Tags (AVTs), 1983-2000.

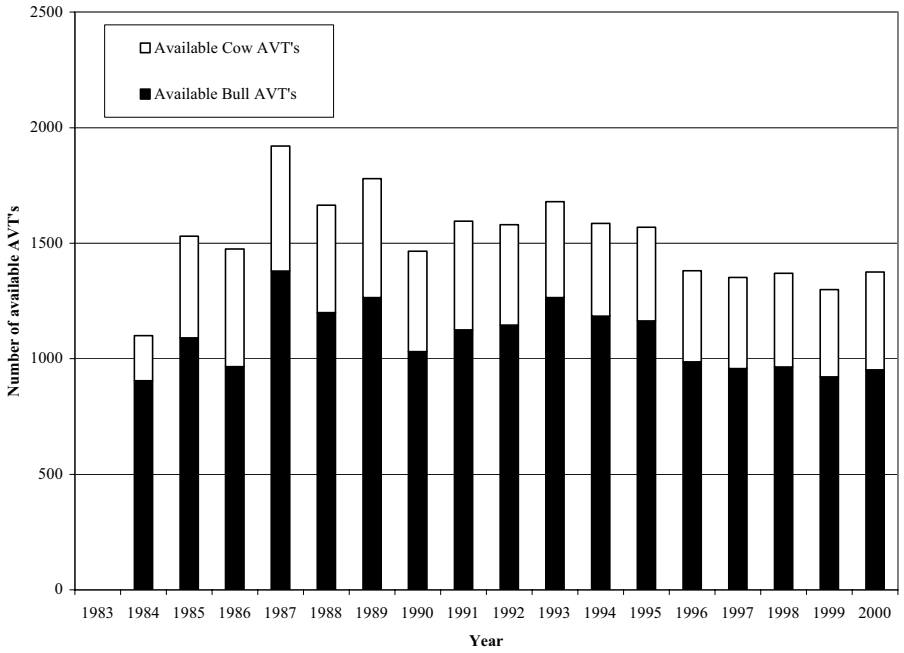
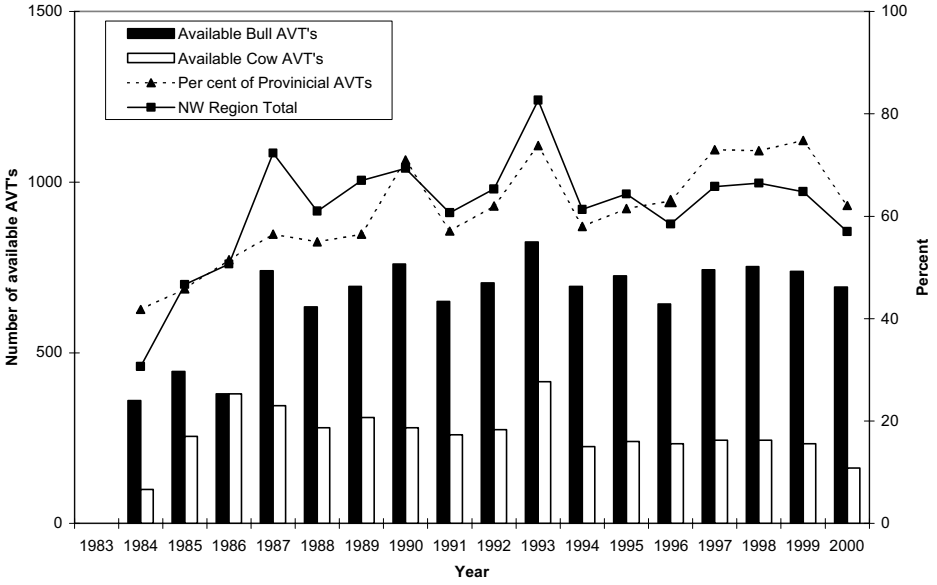


Fig. 6. Number of available Ontario resident archery Adult Validation Tags (AVTs) for the Northwest Region (1983-2000) and percent of total available Provincial archery AVTs.



Viewing Opportunities

The MMP targeted the development of specific interim (1985, 1995) and year 2000 moose viewing opportunities (OMNR 1980a). Little or no effort was made to identify moose viewing sites, hence it remains unclear how much progress was made in reaching this goal. Currently the best viewing opportunities appear to be in lightly

Fig. 7. Number of available Ontario Provincial resident gun Adult Validation Tags (AVTs), 1983-2000.

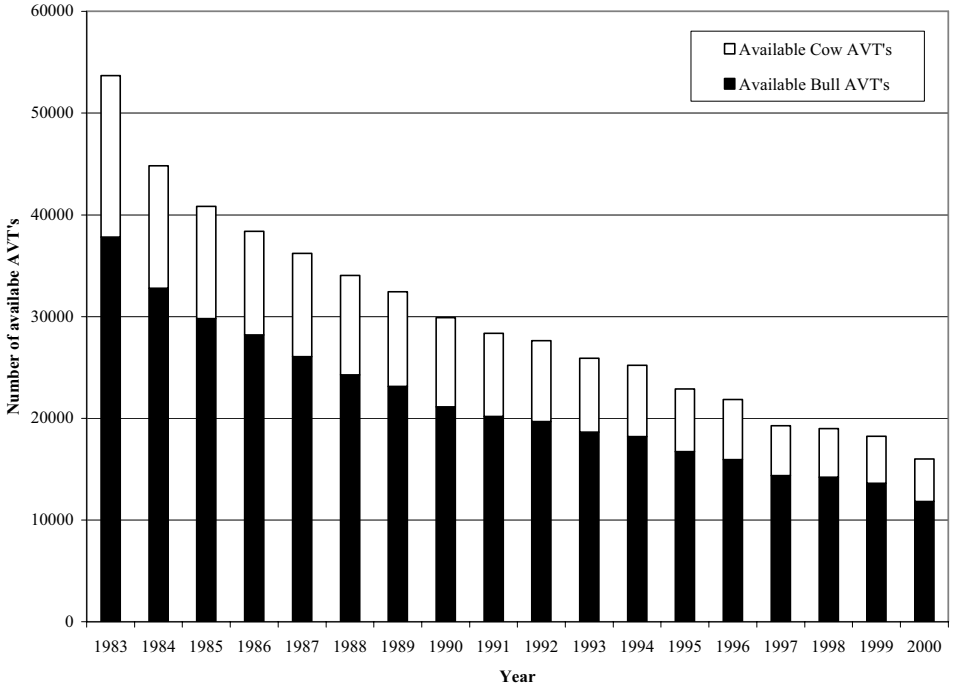
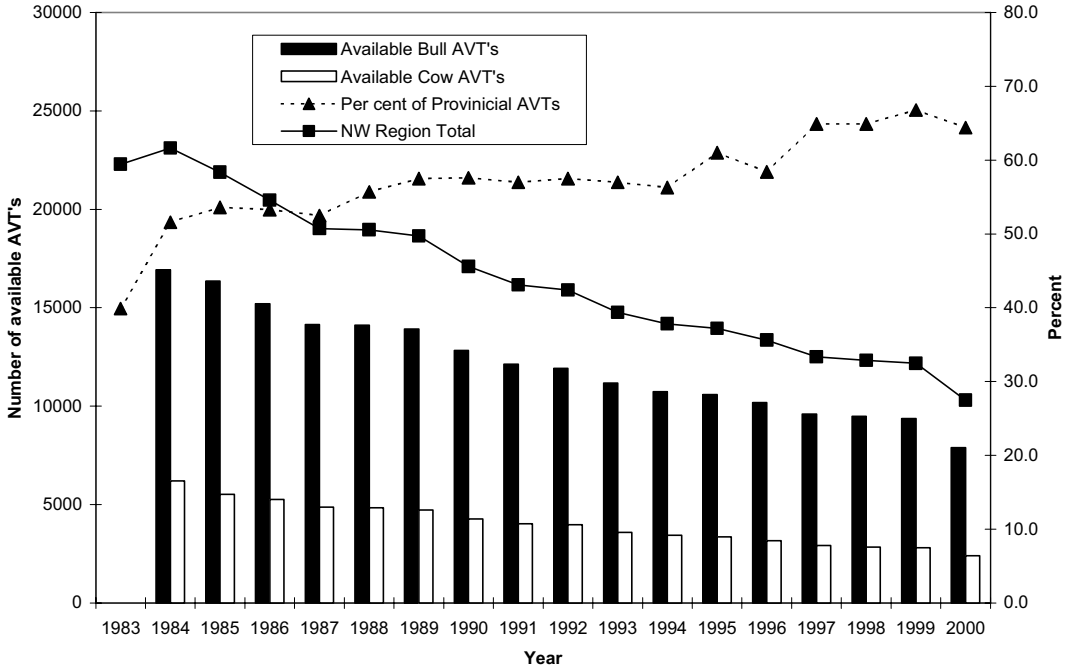


Fig. 8. Number of available Ontario resident gun Adult Validation Tags (AVTs) for the Northwest Region (1983-2000) and percent of total available Provincial AVTs.



hunted or non-hunted areas with high land capability such as portions of Algonquin Park, Lake Superior Park, Quetico Provincial Park, Chapleau Crown Game Preserve, and several local closures near Thunder Bay (Timmermann and Whitlaw 1992) where population densities approach or exceed 1.0/ km^2.

POLICY GUIDELINES

The MMP listed 14 policy guidelines to provide a framework for planning and management towards development of more specific program policies (OMNR 1980a). These included, the development of harvest plans to meet targets, use of WMUs as the basic unit for planning and management, close coordination of habitat management with forest management, and public participation in management planning. Most, if not all, of these policy guidelines were followed during the 20-year MMP period. Public reviews of the program included consultations held across Ontario in 1987 using a consultant - organized mail questionaire (OMNR 1987, Wedeles et al. 1989), a public review conducted by the Ministry of Natural Resources in 1991 (OMNR 1991), and an independent review conducted by George Simmons, December 1996-March 1997 (Simmons 1997). All 3 reviews added new components to the original MMP. Included were the introduction of legal party hunting in 1988, development of an extensive moose hunter education manual (OMNR 1990), development of a group application system begining in 1992 (OMNR 1991), introduction of a Sportsman's Card to reduce draw application errors in 1992 (HHHF 2000), introduction of a special mobility-impaired hunt for disabled hunters in 1992 (OMNR 1991, Armstrong and Simons 1999), and in 2000, the first review of moose population targets since their inception in 1980 (HHHF 2000).

Population assessment (Policy item #12) was identified in the MMP, along with the need to consider harvest and habitat management. However, no further policy details concerning how and when population assessments were to be made have been provided since the inception of the MMP. Standards and guidelines for moose aerial inventory in Ontario were drafted in 1980 (OMNR 1980c). A survey schedule of once every 3 years (OMNR 1993) was suggested for core WMUs and Bisset and McLaren (1995) provided criteria for establishing survey priority. Oswald (1982, 1997) produced a detailed moose aerial observation manual. Inventory surveys were carried out in most core WMUs during the 1980s (Timmermann and Whitlaw 1992, Bisset 1993; Fig. 1). In the early to mid 1990s, population assessments were not conducted "frequently enough to enable managers to make informed decisions"(Provincial Auditor 1998:7). Standards and guidelines for moose aerial inventory were revised in 1991 and again in 1996 (Bisset 1991, 1996). A plan to restore the 3-year inventory cycle across moose range was first implemented in the winter of 1995-96 and later updated to cover the period 1999-2001 (Bisset and McLaren 1995, 1999). Bisset et al. (1997, 2000) published a comprehensive report on province-wide population surveys for 1995-96, 1996-97, and 1998-99. A pilots' manual aimed at helping pilots to better understand the survey process and increase consistency was issued in 1998 (Bisset et al.1998). As a result of all these measures, "a more regular schedule of aerial moose surveys is being carried out across the province and allowable harvests are being recalculated to reflect new information" (Provincial Auditor 1998:9). Survey crew experience, training, and adherence to survey guidelines will remain a challenge to managers in future years.

MANAGEMENT POLICY

Harvest Control

The MMP directed a limit on harvest using age and sex specific licencing (OMNR 1980a). The selective harvest system introduced in 1983 accommodated this policy by limiting the number of bull and cow AVTs issued by WMU (OMNR 1984), yet allowing all unvalidated licence holders the opportunity to hunt for calf moose.The number of AVTs issued was directly related to the WMU allowable harvest, past hunter success rates, and overall herd status (Euler 1983). The MMP further proposed regulating harvests by influencing hunter access to moose by controlling use of aircraft, snowmobiles, and all-terrain vehicles. This policy was not implemented; currently there are relatively few restrictions on firearm use and no specific regulations that limit or control the use of all-terrain vehicles (McMillan et al. 1993). The harvest control policy included season closures for short periods in specific local areas such as recently logged areas where moose are especially vulnerable to harvest (Timmermann and Gollat 1982). One such area in the NWR was closed for a period 1977-89 and then re-opened to hunting (Racey et al. 2000). Results of a monitoring study suggested that closures not be considered an alternative to Moose Habitat Guideline application even though such closures may enhance moose densities to meet population targets or provide alternate recreational opportunities. Despite the former, social pressures make support for closures very difficult. Access and hunting pressure are probably more significant than the Moose Habitat Guidelines in regulating moose densities (Racey et al. 2000:21). Hunting pressure was distributed according to the MMP (OMNR 1980a), beginning in 1983 by WMU - specific licences for AVT holders (OMNR 1984). However, all unvalidated licence holders were able to hunt calves in any WMU, as well as legally party hunt (since 1988) for adult moose with an AVT holder (Wedeles et al. 1989). Finally, the harvest control policy recommended increasing recreation from moose hunting by requiring hunters to hunt in groups. This policy was implemented for 3 years beginning in 1980, but abandoned because it failed to include a mechanism for predictable area specific control of the harvest (Timmermann and Gollat 1984). A voluntary Group Application System for adult moose tags was introduced in 1992 (OMNR 1991). This system allowed a fairer allocation of AVTs and spread tags amongst more hunters. In 1999, for example, 37.7% of hunters applied in groups of 2 or more. The average group size was 4.23 hunters per group and 64.7% of groups received an AVT compared to only 19% of individual applicants (OMNR 2000:36).

Predator Control

The MMP targeted a limited predator control program to allow moose numbers to increase where gray wolves (*Canis lupus*) are significantly depressing moose populations (OMNR 1980a). No efforts were made to implement this policy, nor were studies implemented to assess the impact of black bear (*Ursus americanus*) predation on moose, even when other jurisdictions identified both predators as capable of limiting or regulating moose populations (Gasaway et al. 1983, Wilton 1983, Schwartz and Franzmann 1991, Ballard 1992, Van Ballenberghe and Ballard 1994, Ballard and Van Ballenberghe 1998). Kolenosky (1981) reviewed the status and management of wolves in Ontario, while Bergerud (1981) and Bergerud et al. (1983) suggested wolf predation limited moose populations particularly in the Pukaskwa National Park area of northcentral Ontario. Thompson and Peterson (1988) argued that wolf predation alone did not

limit moose populations in the Park, while Bergerud and Snider (1988) provided additional arguments supporting their position. Closure of the Ontario spring black bear season in 1999 (HHHF 2000) potentially may increase moose calf losses to this predator, assuming bear populations increase (see Ballard 1992). Newfoundland, on the other hand, has bears which predate some moose calves but no wolves, white-tailed deer, or moose ticks, and currently has an estimated pre-hunt population of 150,000 moose despite liberal hunting regulations. The 1999 legal hunter kill was estimated at 19,500 by Mercer and McLaren (2002).

Enforcement

Hunters commonly believe there are insufficient conservation officers afield to enforce moose hunting regulations (Bottan 1999). The Provincial auditor reported a decrease in the amount of time spent on general deterrent patrols by conservation officers and in the number of charges laid under the Game and Fish Act 1996-98 (Provincial Auditor 1998:3). The MMP proposed increased enforcement of legislation and regulations to control illegal hunting and to suppress poaching (OMNR 1980a). Few moose enforcement data concerning hunter compliance have been analysed or published. Timmermann and Gollat (1986) provided the only known published information for the former Northcentral Region, which contained 14 of the current 28 NWR WMUs. They indicated that moose - related charges increased from 358 (1980-82) to 511 during the first three years of the selective harvest (1983-85), averaging about 171 per year.

C.J.W. Todesco, (Ontario Ministry of Natural Resources, personal communication 2001) reported 549 illegally killed moose in the Northeastern Region of Ontario during the period 1997-2000 of which 224 were related to abandoned animals. Northeastern region managers identified a growing problem of illegal moose hunting with 472 moose-hunting related charges laid in 1999. Consequently they launched a high profile enforcement campaign prior to the 2000 fall season. "Moose Watch 2000" was designed prior to the 2000 fall season to combat a perceived increase in illegal moose hunting, including those shot and abandoned. By November 30th 2000, almost 500 charges relating to illegal moose hunting were laid and a further 170 charges were pending with 65 investigations under way. MNR officers seized 82 illegally killed moose, and investigators found 53 moose shot and abandoned, based on 126 tips received.

Bob Stewart, an experienced Thunder Bay District Ontario Ministry of Natural Resources conservation officer, reported more hunters were charged and more moose seized in 2000 than ever before (personal communication 2001). He believed several factors contributed, including better enforcement tools, use of DNA analysis, improved officer training, and better communications. Hunter dissatisfaction with recent federal firearm legislation and AVT reductions are believed by Stewart and others to have contributed to increased illegal activities. AVT manipulation is considered to be common (i.e., hunters using other family member's tags and abusing party hunting regulations). Moose tag transfers and new tags issued provincially totaled 841(5.5% of total tags) with the majority (568 or 68%) occurring in the NWR (Table 7). The number of hunters applying in a group ($\geq$2) fluctuated from a high of 45,447 in 1992 when the program was introduced to a low of 32,884 in 1997 (Table 8). Approximately 61-65% of groups applying receive an AVT, compared to 18-20% of individual applicants. Large hunting parties of 8 or 10 who have one adult tag issued between them, may shoot more moose than

Table 7. Ontario moose tag transfers and new tags issued in the Northwest Region and Province-wide, 2000.

Number of WMUs	Area	Number of Tags Transferred	Total Number of Tags	Percent of Total
26	NW Region	568	9,722	5.8
33	Other Regions	273	5,488	5.0
59	Province	841	15,210	5.5

they are licenced for without the knowledge of all party members (Dave Harnish, Ontario Ministry of Natural Resources, personal communication 2001).

Habitat Management

The MMP directed maintenance of moose habitat, by recommending wildlife and forest managers work closely to modify cutovers, especially around aquatic feeding areas, mineral licks, and winter concentration areas (OMNR 1980a). Production of irregularly shaped cuts, scattered shelter patches, and high age class diversity among species was the prime objective. Significant progress in meeting this target has been made beginning with the release of Timber Management Guidelines for the Provision of Moose Habitat (OMNR 1988a), which provided direction regarding forest access, harvest operations, site preparation, regeneration, and maintenance. Racey et al. (1989a) studied the application of the moose guidelines and their impact on forest industry investment. A review of habitat planning was provided by Payne et al. (1988), while management tools regarding habitat interpretation were provided by Racey et al. (1989b), Jackson et al. (1991), and Timmermann (1998). An inventory manual for use in timber management planning was recently issued (Ranta 1998). In addition to identification of habitat, McNicol and Baker (1998) devised a "ranking" for both early and late winter habitat from 1 (low potential) to 4 (very high potential).W.B. Ranta (Ontario Ministry of Natural Resources, personal communication 2001) is currently updating the "Forest Management Guidelines for the Provision of Moose Habitat" originally issued in 1988. (OMNR 1988a). Inventory funding is currently provided to districts who are involved in preparing Forest Management Plans (M. Sobchuck, Ontario Ministry of Natural Resources, personal communication 2001).

Inventory and Assessment

The effectiveness of a harvest control system depends on a reasonably accurate assessment of hunter kill (Timmermann 1987, Timmermann and Buss 1998). In the early 1990s, 16 of 21 North American jurisdictions that actively manage moose practiced compulsory harvest registration (Timmermann and Buss 1995). The MMP directed an improved program of voluntary reporting by hunters and a phased-in mandatory registration and reporting system. This policy failed to deliver as Ontario hunters are currently neither required to register their kill nor provide data to managers, except on a voluntary basis.

In our opinion, current assessment techniques are ineffective in providing managers with a timely and accurate assessment of the annual moose harvest. This program currently relies on a centralized mail survey of licenced hunters to assess harvest (Barbowski 1972; OMNR 1997; Bisset et

Table 8. Ontario adult moose validation tag (AVT) draw – Provincial summary (Source: Ontario Annual Hunting Regulations Summary, 1992-2001).

Year	No. of AVTs	Total No. of Applicants	No. of Groups	Average Group Size	% of Hunters Applying in Groups	Total number of Hunters in Groups	% of Group Receiving Tags	Total Number of Hunters Applying as Individuals	% of Individuals Receiving Tags
1992	28,792	98,026	11,751	3.9	46.4	45,447		52,579	
1993	27,726								
1994	26,402	103,244	10,896	3.9	40.8	42,160		61,084	
1995	24,047	106,013	9,954	4.2	39.1	41,439		64,574	
1996	22,802								
1997	20,592	100,731	7,341	4.5	32.6	32,884	61.1	69,032	17.7
1998	20,351	102,443	9,141	4.4	38.8	39,701	62.0	69,732	20.0
1999	19,520	103,499	9,073	4.2	37.7	38,425	64.7	65,074	19.0
2000	17,540	103,835	9,852	4.4	42.0	43,651	63.0	60,184	18.0

al. 1999, 2001) replacing the system of post-card surveys previously conducted by field districts 1984-96 (Gollat and Timmermann 1987). Response rates from those former district-conducted mail surveys were considered high (80+%) when prepaid return postage and a follow-up mailing to non-respondents was included. Response rates to centralized mailed questionnaires has declined noticeably since introduction in1997, thus lowering confidence in WMU harvest estimates (G.Eason, B. Ranta, and R.Hartley, Ontario Ministry of Natural Resources, personal communication 2001). Factors believed responsible include lack of return postage, no second follow-up mailings, and reduced hunter support. The Provincial Auditor (1998:2) indicated "the Ministry did not have adequate procedures in place to provide the information necessary for measuring and reporting on the program's effectiveness in sustaining fish and wildlife resources".

Timmermann and Rempel (1998) examined moose age and sex structure from 38,870 hunter submitted samples from northcentral Ontario over the period 1972-91. Their analysis demonstrated the value of hunter-submitted kill records to help evaluate changes in population structure and assess the effectiveness of management strategies. Findings suggest a significant change in age and sex structure and an elevated calf harvest that may have impacted growth potential since introduction of a selective harvest strategy in 1983. The voluntary jaw collection program was eliminated in the early 1990s when government downsizing occured and hunters were informed that managers no longer needed this information for management purposes. Hence, hunters are not responsible for providing data and appear more skeptical than ever in supporting the program even though repeated program reviews and published reports have recommended mandatory reporting (Timmermann and Whitlaw 1992, Timmermann et al. 1993, Hansen 1995, Hansen et al. 1995, Timmermann and Rempel 1998, Bottan 1999).

Stewart (2000) in a discussion document towards a hunting management strategy for Ontario recommended that the required knowledge for effective big game management includes a measure of licenced hunter and aboriginal harvest (sex, age, numbers). Simmons (1997:33) recommended MNR develop a harvest reporting system that would account for all moose harvests including those by "Natives who hold Treaty and Aboriginal Rights." Bisset (1999) provided an overview of mandatory reporting, including cost estimates of quality information and relative importance. He argued that assessing and improving systems designed to manage the current voluntarily provided data should be completed before introducing a more expensive mandatory reporting program. Simmons (1997:56) recommended "an accurate data base" be established to monitor populations and harvest numbers. The Ontario Ministry of Natural Resources has stated that enhanced data management is a Ministry priority (OMNR 1999).

Research

Research on habitat management was a major focus of the MMP. Early efforts focused on gaining basic knowledge. McNicol and Gilbert (1980) studied late winter use of upland cutovers by moose north of Lake Superior. McNicol et al. (1980) reported the effects of heavy browsing pressure while McNicol and Timmermann (1981) reviewed the effects of forestry practices on moose populations in the boreal mixedwood forest. Thompson et al. (1981) studied the traditional use of early-winter concentration areas in northeastern Ontario, while Thompson and Vukelich (1981) described the use of logged habitat in winter by moose

cows with calves in northeastern Ontario. Cumming (1980) related moose track counts to cover types in northcentral Ontario. Euler (1981) proposed a moose habitat strategy and Thompson and Euler (1987) discussed the changing perception of moose habitat in Ontario. Eason (1985,1989) reported on hunting vulnerability in recently logged areas. Effects of hunting closures and timber harvest on local moose densities and hunting opportunities were examined by Racey et al. (2000).

Several related habitat studies originated from Lakehead University in Thunder Bay. They included those on the impact of glyphosate on moose by Cumming (1985), Connor (1986), Connor and McMillian (1988), and Kelly and Cumming (1994). Moose vegetative preferences resulting from 16 years of browse surveys were detailed by Cumming (1987). Winter use by moose of modified strip cuts compared to clearcut use were reported by Todesco et al. (1985) and Todesco (1988). Mastenbrook and Cumming (1989) examined moose use of residual strips of timber left within cutovers, while Dalton (1989) detailed moose use of partially and totally logged clearcuts. Timmermann and McNicol (1988) provided a literature review of overall moose habitat needs and Timmermann (1991), completed a review of ungulate and aspen management. Descriptive studies of moose access routes to an aquatic feeding area and moose cratering for *Equisetum* sp. were provided by Timmermann and Racey (1989) and Timmermann et al. (1990). Moose use of aquatic plants, road salt, and natural mineral springs was reported by Fraser and Reardon (1980), Fraser and Thomas (1982), Fraser and Hristienko (1983), and Fraser et al. (1980, 1982, 1984).

The MMP recommended an increased effort to research the effectiveness of management policies, moose productivity, and diseases of moose. The effectiveness of the 1980-82 2- tag harvest system was examined in the former Northcentral Region (Timmermann and Gollat 1984). Effectiveness of the selective harvest system was reported by Timmermann and Gollat (1986, 1994), Timmermann and Whitlaw (1992), Bisset (1992, 1993), Heydon et al. (1992), Timmermann et al. (1993), and Timmermann and Rempel (1998). Research on moose diseases and parasites included reports on pathological anomalies by Lankester and Bellhouse (1982); studies on the moose fly by Lankester and Sein (1986), on gastro-intestinal helminths by Kennedy et al. (1985), Snider and Lankester (1986) and Fruetel and Lankester (1988), on the brainworm (*P. tenuis*) by Whitlaw (1993), Whitlaw and Lankester (1994a, b), and on the moose tick (*D. albipictus*) by Timmermann and Lankester (1980), Addison and McLaughlin (1988, 1993), Addison and Smith (1981), Addison et al. (1998a, 1998b), and Wilton and Garner (1993). Cadmium levels in Ontario moose and potential sources of contamination were investigated by Glooschenko et al. (1988) and Kronberg and Glooschenko (1994). Studies on the structure and composition of calving sites in Algonquin Park were reported by Addison et al.(1990) and Wilton and Garner (1991).

In 1994, under Term and Condition 80 of the Environmental Assessment Board decision (OEAB 1994), Ontario was directed to undertake long-term scientific studies to assess the efficacy of the Timber Management Guidelines for the Provision of Moose Habitat. The Moose Guidelines Evaluation Program (MGEP), originally established after the introduction of guidelines in 1988, was modified and expanded to comply with Term and Condition 80 (OEAB 1994, Rodgers et al. 2000). The MGEP was designed to study Ontario moose population dynamics, habitat use, condi-

tion and productivity, characterization of moose calving sites and aquatic feeding areas, and to delineate moose morphometrics and genetics (Rodgers et al. 2000). MGEP publications to date include those on: ecosystem management (Hénault et al. 1999); home range size (Lawson and Rodgers 1997, Rodgers and Carr 1998); Global Positioning System (GPS) (Rodgers and Anson 1994; Rempel et al. 1995; Rodgers et al. 1995, 1996, 1997, 1998; Rempel and Rodgers 1997); timber management and natural disturbance effects on moose habitat (Rempel et al. 1997a); moose browse production (Rempel et al.1997b); sensitivity of harvest data to changes in aerial population estimates (Timmermann et al. 1993); and calving site fidelity (Welch et al. 2000).

Hunter Education

The MMP targeted the introduction of a voluntary moose hunter education course and firearm proficiency test, and a phased-in mandatory course and test for new moose hunters (OMNR 1980a). This policy was supported by 79% of hunters who attended 72 public meetings that attracted 7,350 hunters across the province in 1979 (OMNR 1980b).

A great deal of information was prepared and circulated to hunters. Included were a moose hunter handbook (OMNR 1984), instructional magazine articles, annual moose hunter fact sheets distributed at all licence sales locations and government offices, and a moose identification quiz (Timmermann 1992). In addition, an extensive 78 - page moose hunter educational manual (OMNR 1990) along with a draft instructor's manual were published as the core curriculum for a mandatory moose hunter education course. Two videos entitled "Moose Hunt, a Guide to Success" (Interesting Services Inc., Emsdale, Ontario, Canada, 1989) and "Firearms for the Moose Hunter" (Interesting Services Inc., Emsdale, Ontario, Canada, 1988) were circulated to hunter education instructors. In addition, a standardized shooting skill scoring sheet along with a life-sized target, shooting instructions, and an illustrated moose anatomy pamphlet were prepared to test shooting skills (OMNR 1988c, Buss et al. 1989, Timmermann and Buss 1998).

Repeated studies by Rollins (1987), Romano (1988), Rollins and Romano (1988,1989), and Wedeles et al. (1989) recommended an expanded hunter education effort to strengthen hunter understanding and compliance. Hansen et al. (1995) reported only a third (597 of 2,007) of hunters responding to a survey of satisfaction with the Ontario moose management system had reported attending a voluntary moose hunter seminar. Stewart (2000) identified hunter education as a critical component toward development of an effective hunting management strategy for Ontario. The strategy made 26 recommendations, the majority dealing with various aspects of hunter education. Recommendations included that new hunters be encouraged to take advanced species - specific courses (waterfowl, moose, etc.) and that voluntary training does not result in significant advances in the knowledge, skill, and conduct of new hunters. They concluded advanced courses should continue to be voluntary for existing licenced hunters.

Resource Allocation

The MMP gives primary consideration to subsistence use by First Nations people in recognition of obligations made under historical treaties. This policy has been largely honored. However, little effort has been made to measure the magnitude of this harvest. Otherwise, the allocation policy which provides for all residents to be treated equally, and favours residents over non-residents, and resident Canadians over non

- resident aliens, has largely been followed. In addition, a process was estabished that required non - residents of Ontario to use established tourist facilities that were issued a special quota of licences (10% of total allocation) (Bisset and Timermann 1983). Licence allocation to the tourist industry must be made a year in advance of up-to-date data, hence a lag in quota adjustment occurs. In 1998, the policy restricting non - residents from hunting in resident - only WMUs was relaxed. They now may hunt in those WMUs as long as they both obtain their AVT from and use designated tourist outfitting facilities. Resident hunter resentment over this change is believed to stem from misconceptions derived from lack of information such as hunting as a group on only one adult tag (Bottan 1999).

MANAGEMENT IMPLICATIONS AND RECOMMENDATIONS

Targets Achieved, Lessons Learned

A significant number of year 2000 population targets proposed in 1980 for many WMUs were not achieved. We believe the 20 - year policy timeframe lacked a feedback mechanism to allow periodic program review and target adjustment (i.e., Adaptive Management) as added information and experience was gained. Why, for example were targets not adjusted when it became apparent that those set for1995 (140,000) would not be met?

In future, we suggest WMU-specific population targets be tailored to more closely reflect land productivity as well as a host of mortality factors which managers are unable to control, or in most cases measure, as reported by McKenney et al. (1998). We suggest a 5 - year policy time-frame in which population status is reviewed and targets are adjusted if necessary. Further consideration should be made to target a population range for each WMU, reflecting a minimum density, below which hunter harvest would be curtailed. Such a target range would reduce the frequency of downward AVT adjustments and work toward increasing hunter confidence in the program. Decision support tools, including the use of models, need to be employed to ensure integration of all factors affecting populations. Finally, managers need to remember that aerial surveys used to generate density estimates, nearly always underestimate the number of animals present and that population data thus obtained are best treated as trend indicators and not as absolute numbers (Gasaway et al. 1986; Timmermann 1974,1993). Hence, we suggest managing for a density range, not a specific density. In addition, managers need to recognize the time-lag in quota adjustments as population targets are directly influenced by annual allocation decisions.

Annual provincial harvest targets of 10,000 moose by 1985 were met, however they levelled out thereafter at 10-11,000 per year (Table 3). Projected harvest targets of 18,000 by 1995 and 25,000 per year by 2000 were grossly underachieved. These targets were not translated to various regions or WMUs, hence there is no way of judging achievement. We do know, however, that the proportion of hunter-killed moose taken in the NWR increased from about 40% of Provincial total in 1982 to over 50% beginning in1987 (Table 5). Failure to increase overall provincial harvests suggests that other mortality factors play a more important but ill-defined role than previously realized. Timmermann and Rempel (1998) also suggested changes in harvest structure and a growing calf harvest resulting from the selective harvest system may be impacting future growth potential in some WMUs.

Harvest assessment was centralized in 1997 and subsequent lower response rates to mailed questionnaires is believed to have affected quality of data. In addition, an

accurate assessment of calf harvest remains an elusive challenge. We suggest a hunter-supported harvest assessment program be given a high priority and that hunters be encouraged to provide harvest information and become responsible partners in the moose management program. Serious consideration should be given to returning to a provincially - coordinated DMS harvest assessment system including return postage, and a second reminder mailing. Alternatively, consideration should be given to requiring all hunters to complete and remit a simple questionnaire, attached to each licence as is required by many jurisdictions (Timmermann and Buss 1995). Failure to comply would trigger a penalty or default on a predescribed reward. Consideration could also be given to using a telephone questionnaire carried out by resource user groups to assess moose harvest as has been employed successfully in Alberta since 1985 (Lynch and Birkholz 2000). Without such support, the program cannot properly function.

Data collected over the past 20 + years suggest that a provincial population target of 100-120,000 and an annual harvest of 10-12,000 moose per year is a sustainable target (Tables 1 and 3). Population estimates have never exceeded 125,000, and harvests (13-14,000) were only exceeded for a short period of liberal any - sex hunting in the 1960s and early 1970s. Controlling adult cow harvests is considered essential in maintaining huntable populations. Long-term data sets should be consulted to guide realistic future WMU population and harvest targets. The economic impact of moose hunting and the annual number of user days is substantial. Legg (1995) estimated a total sales impact (gross output) of $134.7 million in 1993, while Bisset et al. (1999) reported 817,000 user days in 1997 (Table 6).

Recent efforts to increase the emphasis on regional enforcement suggest the level of illegal hunting has been underestimated and may be significantly impacting population densities in some WMUs. Extending the "Moose Watch" enforcement effort to all regions in the fall of 2001 is a positive step in controlling illegal moose hunting activities. We suggest a full analysis of past charges be made to help identify areas in which hunter education is deficient and target additional education efforts where needed. We further recommend a review of the guaranteed group size option be conducted to determine if large groups licenced for 1 or 2 adult moose contribute significantly to the number of moose found shot and abandoned.

Much progress has been made towards meeting the MMP targets regarding habitat management and research. Continued support for ongoing habitat research projects and sufficient funding to complete ongoing studies is essential. Consistent funding to evaluate connectivity between habitats prior to forest management planning is essential. We suggest further research is needed to help determine the magnitude of non-hunting mortality factors especially predation as well as the role of parasites and diseases, removal of moose by poaching losses, and First Nation harvest. In addition, managers need to more closely examine changes in harvest sex/age composition, especially the magnitude of calf harvests. The value of periodic season closures and access control mechanisms to reduce hunter efficiency should be re-examined. All regions should closely examine moose-related enforcement charges to determine trends and motivating causes.

Hunter Education was a major component of the MMP, and results 20 years later suggest the OMNR failed to deliver on this component of the policy. Voluntary moose hunter education courses were few

and far between and generally poorly attended. No mandatory course for new moose hunters was phased-in, nor was a firearm proficiency test initiated. Evidence from hunter opinion surveys indicated a majority of hunters initially supported the selective harvest program (Rollins 1987, Rollins and Romano 1989), but more recently they have "lost faith in the system"(Simmons 1997:56). We believe lack of hunter support and understanding can be partly traced to a failure to effectively communicate the program and better educate new hunters. Voluntary courses simply did not attract enough hunters to make a difference. Current communications efforts directed to hunters should be reviewed and re-evaluated. Hunt quality, including realistic hunter expectations, needs to be re-examined and recognized as an essential component in overall hunter satisfaction when a new policy is drafted. Managers must improve hunter communications related to setting and acheiving realistic population targets.

We fully support the major emphasis placed on hunter education in the recent discussion document toward a hunting management strategy for Ontario (Stewart 2000). We recommend a mandatory course for all new moose hunters, similiar to that offered by the Ontario Federation of Anglers and Hunters for all new turkey hunters since 1987 (HHHF 2000). Until hunters become more involved, knowledgeable, and responsible, their understanding and support will be lacking. Further, results of population and harvest surveys should be published in the annual Hunting Regulations Summary.

Viewing opportunities remain an under utilized component of the 1980 MMP who's full potential remains unrealized. The majestic moose is a wilderness symbol and a much sought after species, especially for tourists to view and photograph. In future, moose viewing opportunities need to be better identified and funding made available to develop specific sites in a variety of WMUs across moose range.

The MMP has generated a host of numerical data which need to be carefully assessed and interpreted to evaluate the level of target achievement. Some values are suspect, especially when they deviate from long-term patterns. Hence, managers need to recognize their inherent limitations when recommending management action. Such a process should be reflected in a revised set of standards and guidelines that provide a unified approach to data interpretation and away from the past focus on chasing numbers. The importance of testing management policies and strategies in the field while monitoring their effects on WMU populations is emphasized. Hunters, hunting organizations, and non-hunters all must be directly involved and support the soundness of recommended strategies. Current target review exercises should involve all user groups and social interests. In the absence of such support, it is doubtful that any regulated harvesting concept would survive long enough to allow a clear response and evaluation of that response.

We recommend a "basic program", which includes linked population and harvest evaluation components. Such a program needs to be properly staffed, funded, and coordinated. Data collection, compilation, assessment, and central reporting should become a district/provincial priority. Prompt data analysis and development of a simple user-friendly computer - based reporting and data access program is essential to rebuilding program confidence. We believe the current Québec moose management system which adopted a multi-harvest scenario in close cooperation with hunters has merit (Courtois and Lamontagne 1997). Harvest control in Québec varies

from a liberal approach (any sex / age) in hunting zones with few problems, to very restrictive strategies including complete protection of cows for 5 years in zones where moose are scarce or where hunters wanted a rapid increase. Such a varied, hunter-supported approach, if closely monitored, lends itself to Adaptive Management policies which retain the best, and reject strategies that prove ineffective or unsuccessful.

Finally we strongly recommend that all past and current WMU - specific population and harvest data be compiled and published. Consideration should also be given to carrying-out an independent biological evaluation of the current selective harvest program, before major changes are considered. Such a review should compare Ontario's management policies with those of other jurisdictions to ensure moose continue to provide sustained benefits based on a sound biological rationale, consistent with recreational and economic objectives and program targets.

ACKNOWLEDGEMENTS

We would like to thank the following for providing unpublished population, harvest, and enforcement data: Ted Armstrong, Northwest Regional Wildlife Biologist, Thunder Bay; Art Rodgers Ungulate Research Scientist, Thunder Bay; Howard Smith, Senior Biologist, Large Mammals, Wildlife Section, Fish & Wildlife Branch, Peterborough; Al Bisset, retired Leader, Big Game Management Information System, Provincial Assessment Unit, Kenora; Bruce Ranta, Area Biologist, Kenora; Charlie Todesco, Wawa Distirct Enforcement Supervisor; and Bob Stewart, Conservation Officer, Thunder Bay District. We thank: Mike Buss, retired Wildlife Specialist, Dorset; Gord Eason, Area Biologist, Wawa; John McNicol, retired Wildlife Specialist, Forest Policy Section, Thunder Bay; Harold Cumming, retired Lakehead University, Forestry Faculty, Thunder Bay; Murray Lankester, Lakehead Biology Department, Thunder Bay; Rosemary Hartley, Area Biologist, Nipigon; Mark Sobchuk, NW Region Fisheries Biologist, Thunder Bay; Dave Euler, retired Lakehead University, Forestry Faculty, Thunder Bay; Ed Addison, retired Wildlife Researcher, Ontario Ministry of Natural Resources, Maple Ontario; and Gerry Lynch, Wildlife Consultant, Sherwood Park, Alberta, for suggestions on an earlier draft of this paper.

REFERENCES

ADDISON, E.M., D.G. JOACHIM, R.F. MCLAUGHLIN, and D.J.H. FRASER. 1998a. Ovipositional development and fecundity of *Dermacentor albipictus* (Acari:axodidae) from moose. Alces 34: 165-172.

_____, and R.F. MCLAUGHLIN. 1988. Growth and development of winter tick, *Dermacentor albipictus*, on moose, *Alces alces*. Journal of Parasitology 74: 670-678.

_____, and _____. 1993. Seasonal variation and effects of winter ticks (*Dermacentor albipictus*) on consumption of food by captive moose (*Alces alces*) calves. Alces 29: 219-224.

_____, _____, and J.D. BROADFOOT. 1998b. Effects of winter ticks (*Dermacentor albipictus*) on blood characteristics of captive moose (*Alces alces*). Alces 34: 189-199.

_____, 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.

_____, and L.M. SMITH. 1981. Productivity of winter ticks (*Dermacentor albipictus*) collected from moose killed on Ontario roads. Alces 17: 136-146.

ARMSTRONG, E.R., and R. SIMONS. 1999.

Moose hunting opportunities for physically- challenged hunters in Ontario: a pilot study. Alces 35: 125-134.

BALLARD, W.B. 1992. Bear predation on moose: a review of recent North American studies and their management implications. Alces Supplement 1:1-15.

_____, and V. VAN BALLENBERGHE. 1998. Predator/prey relationships. Pages 247-273 *in* A.W. Franzmann and C.C. Schwartz, editors. Ecology and management of the North American moose. Smithsonian Institution Press, Washington, D.C, USA.

BARBOWSKI, J. 1972. Mail surveys of moose hunters in Ontario. Proceedings of the North American Moose Conference and Workshop 8:326-339.

BERGERUD, A.T. 1981. The decline of moose in Ontario - a different view. Alces 17: 30- 43.

_____, and F. MANUEL. 1969. Aerial census of moose in central Newfoundland. Journal of Wildlife Management 33: 910-916.

_____, and J.B. SNIDER. 1988.Predation in the dynamics of moose populations: a reply. Journal of Wildlife Management 52:559-564.

_____, W. WYETT, and J.B. SNIDER. 1983. The role of wolf predation in limiting a moose population. Journal of Wildllife Management 47: 977-988.

BISSET, A.R. 1991. Standards and guidelines for moose population inventory in Ontario. Ontario Ministry of Natural Resources, Wildlife Branch, Toronto, Ontario, Canada.

_____. 1992. Moose management in the Northwestern Region: towards a new strategy. Ontario Ministry of Natural Resources, Kenora, Ontario. Unpublished Report, May 5, 1992.

_____. 1993. The moose population of Ontario revisited— a review of survey data, 1975-1992. Ontario Ministry of Natural Resources, Kenora, Ontario, Canada. Unpublished Report.

_____. 1996. Standards and guidelines for moose population inventory in Ontario. Ontario Ministry of Natural Resources, Fish and Wildlife Branch, Peterborough, Ontario, Canada.

_____. 1999. Mandatory reporting: an implementation strategy. Northwest Science and Technology Unit, Thunder Bay, Ontario, Canada. Information Report IR-003.

_____, B. CROWELL, and C. HANSSON. 1998. Moose aerial inventory pilot's manual. Ontario Ministry of Natural Resources, Northwest Science and Technology Unit, Thunder Bay, Ontario, Canada. Technical Report TM-001.

_____, L. DIX-GIBSON, and M.A. MCLAREN. 2001. 1998 deer and moose harvest in Ontario. Ontario Ministry of Natural Resources, Northwest Science and Technology Unit, Thunder Bay, Ontario, Canada. Technical Report TR-128.

_____, _____, _____, J.MELLOR, and C. DAVIES. 1999. 1997 deer and moose harvest in Ontario. Ontario Ministry of Natural Resources, Northwest Science and Technology Unit, Thunder Bay, Ontario, Canada. Technical Report TR-117.

_____, and M.A. MCLAREN. 1995. Moose population inventory plan for Ontario, 1996-1998. Ontario Ministry of Natural Resources, Northwest Science and Technology Unit, Thunder Bay, Ontario, Canada. Information Report IR-002.

_____, and _____. 1999. Moose population aerial inventory plan for Ontario: 1999- 2002. Ontario Ministry of Natural Resources, Northwest Science and Technology Unit, Thunder

Bay, Ontario, Canada. Information Report IR-004.

_____, _____, C.L. EDMONDS, W.SAWYER , W. GLUHUSHKIN, K. MORRISON, and C. DAVIES. 1997. Report on the 1995-96 and 1996-97 moose population surveys: with considerations for future surveys. Ontario Ministry of Natural Resources, Northwest Science and Technology Unit, Thunder Bay, Ontario, Canada. Technical Report TR-113.

_____, _____, _____, and _____. 2000. Report on the 1998- 1999 moose population surveys. Ontario Ministry of Natural Resources, Northwest Science and Technology Unit, Thunder Bay, Ontario, Canada. Technical Report TR-127.

_____, and R.S. REMPEL. 1991. Linear analysis of factors affecting the accuracy of moose aerial inventories. Alces 27: 127-139.

_____, and H.R. TIMMERMANN. 1983. Resource allocation: an Ontario solution. Alces 19: 178-190.

BOTTAN, B J. 1999. Exploring the human dimension of Thunder Bay moose hunters with focus on choice behaviour and environmental preferences. M.A. Thesis, Faculty of Forestry and Forest Environment, Lakehead University, Thunder Bay, Ontario, Canada.

BUSS, M., R. GOLLAT and H.R. TIMMERMANN. 1989. Moose hunter shooting proficiency in Ontario. Alces 25: 98-103.

CONNOR, J. 1986. Early winter utilization by moose of glyphosate-treated cutovers. B.Sc.F. Thesis, Lakehead University, Thunder Bay, Ontario, Canada.

_____, and L. MCMILLAN. 1988. Winter utilization by moose of Glyphosate treated cutovers- an interm report. Alces 24: 133-142.

COURTOIS, R., and G. LAMONTAGE. 1997. Management system and current status of moose in Quebec. Alces 33: 97-114.

CRÊTE, M. 1987. The impact of sport hunting on North American moose. Swedish Wildlife Research Supplement 1: 553-563.

_____. 1989. Approximation of K carrying capacity for moose in eastern Quebec. Canadian Journal of Zoology 67: 373-380.

_____, R.J. TAYLOR, and P.A. JORDAN. 1981. Optimization of moose harvests in southwestern Québec. Journal of Wildlife Management 45:598-611.

CUMMING, H.G. 1974. Moose management in Ontario from 1948 to 1973. Naturaliste Canadien 101: 673-687.

_____. 1980. Relation of moose track counts to cover types in north-central Ontario. Proceedings of the North American Moose Conference and Workshop 16: 444-462.

_____. 1985. First year effects on moose browse from two silvicultual applications of glyphosate in Ontario.Alces 25:118-132.

_____. 1987. Sixteen years of moose browse surveys in Ontario. Alces 23: 125-156.

DALTON, W.J. 1989. Use by moose (Alces alces) of clearcut habitat where 100% or 50% of the production forest was logged. COFRDA Project 32001, Ontario Ministry of Natural Resources, Toronto, Ontario, Canada.

EASON, G. 1985. Overharvest and recovery of moose in a recently logged area. Alces 21: 55-75.

_____. 1989. Moose response to hunting and one km^2 block cutting. Alces 25: 63-74.

EULER, D. 1981. A moose habitat strategy for Ontario. Alces 17:180-192.

_____. 1983. Selective harvest, compensatory mortality and moose in Ontario.

Alces 19: 148-161.

_____. 1994. Page 179 *in* Environmental Assessment Board, reasons for decision and decision. Class environmental assessment by the Ministry of Natural Resources for timber management on crown lands in Ontario. Queen's Printer for Ontario, Toronto, Ontario, Canada.

FERGUSON, S.H., A.R. BISSET, and F. MESSIER. 2000. The influence of density on growth and reproduction in moose Alces alces. Wildlife Biology 6: 31-39.

FRASER, D.J. , D. ARTHUR, J.K. MORTON, and B.K. THOMPSON. 1980. Aquatic feeding by moose *Alces alces* in a Canadian lake. Holarctic Ecology 3: 218-223.

_____, E.R. CHAVEZ, and J.E. PALOHEIMO. 1984. Aquatic feeding by moose: selection of plant species and feeding areas in relation to plant chemical composition and characteristics of lakes. Canadian Journal of Zoology 62: 80-87.

_____, AND H. HRISTIENKO. 1983. Effects of moose *Alces alces*, on aquatic vegetation in Sibley Provincial Park, Ontario, Canada. Canadian Field-Naturalist 7: 57-61.

_____, and E. REARDON. 1980. Attraction of wild ungulates to mineral-rich springs in central Canada. Holarctic Ecology 3: 36-40.

_____, and E.R. THOMAS. 1982. Moose-vehicle accidents in Ontario: relation to highway salt. Wildlife Society Bulletin 10: 261-265.

_____, B.K. THOMPSON, and D. ARTHUR. 1982. Aquatic feeding by moose: seasonal variation in relation to plant chemical composition and use of mineral licks. Canadian Journal of Zoology 60: 3121-3126.

FRUETEL, M., and M.W. LANKESTER. 1988. *Nematodirella alcidis* (Nematoda: Trichostrongyloidea) in moose of Northwestern Ontario. Alces 24: 159-163.

GASAWAY, W.C., and S.D. DUBOIS. 1987. Estimating moose population parameters. Swedish Wildlife Research Supplement 1: 603-617.

_____, _____, D.J. REED, and S.J. HARBO. 1986. Estimating moose population parameters from aeial surveys. Biological Papers of the University of Alaska, Number 22. Fairbanks, Alaska, USA.

_____, R.O. STEPHENSON, J.L. DAVIS, P.E.K. SHEPHERD, and O.E. BURRIS. 1983. Interrelationships of wolves, prey, and man in interior Alaska.Wildlife Monographs 84.

GLOOSHENKO, V., C. DOWNES, R. FRANK, H.E. BRAUN, E.M. ADDISON, and J. HICKIE. 1988. Cadmium levels in Ontario moose and deer in relation to soil sensitivity to acid precipitation. Science of the Total Environment 71: 173-186.

GOLLAT, R., and H.R. TIMMERMANN. 1983. Determining quotas for a moose selective harvest in North Central Ontario. Alces 19: 191-203.

_____, and _____.1987. Evaluating Ontario moose harvests using a postcard questionnaire. Alces 23: 157-180.

_____, _____, AND J.MCNICOL. 1985. A review of methodology used to formulate moose quotas, Northcentral Region. Ontario Ministry of Natural Resources, Thunder Bay, Ontario, Canada.

GREENWOOD, C., D. EULER, and K. MORRISON. 1984. Standards and guidelines for the determination of allowable moose harvest in Ontario. Ontario Ministry of Natural Resources, Toronto, Ontario, Canada. Unpublished Report.

HANSEN, S. 1995. Moose hunter opinion survey:perceived satisfaction with the Ontario moose management system. Un-

published dissertation, Department of Outdoor Recreation, Parks and Tourism, Lakehead University, Thunder Bay, Ontario, Canada.

_____, W.J. DALTON, AND T. STEVENS. 1995. An overview of a hunter opinion survey of satisfaction with the Ontario moose management system. Alces 31: 247-254.

HÉNAULT, M., L. BELANGER, A.R. RODGERS, G. REDMOND, K. MORRIS, F. POTVIN, R. COURTOIS, S. MOREL, and M. MONGEON. 1999. Moose and forest ecosystem management: the biggest beast but not the best. Alces 35: 213-225.

HEYDON, C., D. EULER, H. SMITH, and A. BISSET. 1992. Modelling the selective moose harvest program in Ontario. Alces 28:111-121.

(HHHF) HUNTING HERITAGE, HUNTING FUTURES. 2000. Wildlife Chronicle — a history of Ontario's wildlife legacy. Hunting Heritage, Hunting Futures. Huntsville, Ontario, Canada.

JACKSON, G.L., G.D. RACEY, J.G. MCNICOL, and L.A. GODWIN. 1991. Moose habitat interpretation in Ontario. Ontario Ministry of Natural Resources, Northwest Ontario Forest Technology Development Unit, Thunder Bay, Ontario, Canada. Technical Report 52.

KELLY, C.P., and H.G. CUMMING. 1994. Effects of Vision application on moose winter browsing and hardwood vegetation. Alces 30: 173-188.

KENNEDY, M.J., M.W. LANKESTER, and J.B. SNIDER. 1985. *Paramphistomum cervi* and *Paramphistomum liorchis* (Digenea: Paramphistomatidae) in moose, *Alces alces*, from Ontario. Canadian Journal of Zoology 63:1207-1210.

KOLENOSKY, G.B. 1981. Status and management of wolves in Ontario. Pages 35-40 *in* L. Carbyn, editor. Wolves in Canada and Alaska. Canadian Wildlife Service, Ottawa, Ontario, Canada. Report Series No. 5.

KRONBERG, B.I., and V. GLOOSCHENKO. 1994. Investigating cadmium bioavailability in NW Ontario using boreal forest plants. Alces 30: 71-80.

LANKESTER, M.W. 1987. Pests, parasites, and diseases of moose (*Alces alces*) in North America. Swedish Wildllife Research Supplement 1:461-489.

_____, and T.J. BELLHOUSE. 1982. Pathological anomalies in moose of Northwestern Ontario. Alces 18: 17-24.

_____, and R.D. SEIN. 1986. The moose fly *Haematobosca alcis* (Muscidae) and skin lesions on *Alces alces*. Alces 22: 361-376.

LAWSON, E.J.G., AND A.R. RODGERS. 1997. Differences in home-range size computed in commonly used software programs. Wildlife Society Bulletin 25: 721-729.

LEGG, D. 1995. The economic impact of moose hunting in Ontario, 1993. Ontario Ministry of Natural Resources, Wildlife Branch, Toronto, Ontario, Canada.

LUMSDEN, H.G. 1958. Ontario moose inventory 1958. Department of Lands and Forests, Wildlife Branch, Toronto, Ontario, Canada. Unpublished Report.

_____. 1959. Ontario moose inventory winter, 1958-59. Ontario Department of Lands and Forests, Wildlife Branch, Toronto, Ontario, Canada. Unpublished Report.

LYNCH, G.M., and S. BIRKHOLZ. 2000. A telephone questionnaire to assess moose harvest. Alces 36: 105-109.

MASTENBROOK, B., and H. CUMMING. 1989. Use of residual strips of timber by moose within cutovers in northwestern Ontario. Alces 25: 146-155.

MCKENNEY, D.W., R.S. REMPEL, L.A. VENIER, YONGHE WANG, and A.R. BISSET. 1998. Development and application of

a spatially explicit moose population model. Canadian Journal of Zoology 76: 1922-1931.

McMillian, L.M., H.R. Timmermann, and M.E. Buss. 1993. Access management relative to the vulnerability of moose to recreational harvest - a discussion paper. Ontario Ministry of Natural Resources, North Central Region, Thunder Bay, Ontario, Canada.

McNicol, J.G , and J. Baker. 1998. Identification of early winter and late winter moose habitat.Pages 1 to 9 *in* W. B. Ranta, editor. Selected wildlife and habitat features: inventory manual for use in forest management planning. Version 1.0. Queen's Printer, Toronto, Ontario, Canada.

_____, and F.F. Gilbert. 1980. Late winter use of upland cutovers by moose. Journal of Wildlife Management 44: 363-371.

_____, and H.R. Timmermann. 1981. Effects of forestry practices on ungulate populations in Boreal mixed forest. Pages 141-154 *in* Proceedings of the Boreal Mixedwood Symposium. Canadian Forestry Service, Ottawa, Ontario, Canada.

_____, _____, and R. Gollat. 1980. The effects of heavy browsing pressure over eight years on a cutover in Quetico Park. Proceedings of the North American Moose Conference and Workshop 16:360-373.

Mercer, W.B. and B.E. McLaren. 2002. Evidence of carrying capacity effects in Newfoundland moose.Alces 38:123-141.

Morris, R.F. 1959. Single factor analysis in population dynamics. Ecology 40: 580-588.

Novak, M., and J. Gardner. 1975. Accuracy of moose aerial surveys. Proceedings of the North American Moose Conference and Workshop 11: 154-180.

(OEAB) Ontario Environmental Assessment Board. 1994. Class environmental assessment by the Ministry of Natural Resources for timber management on Crown lands in Ontario. Queen's Printer for Ontario, Toronto, Ontario, Canada.

(OMNR) Ontario Ministry of Natural Resources. 1980a. Moose management in Ontario: a report of open house public meetings. Queen's Printer for Ontario, Toronto, Ontario, Canada.

_____. 1980b. Moose management policy. Queen's Printer for Ontario, Toronto, Ontario, Canada.

_____. 1980c. Standards and guidelines for moose aerial inventory in Ontario. Ontario Ministry of Natural Resources, Toronto, Ontario, Canada.

_____. 1982. Northwestern Ontario strategic land use plan. Ontario Ministry of Natural Resources,Toronto Ontario, Canada.

_____. 1984. Moose hunter's handbook 1984. Ontario Ministry of Natural Resources, Wildlife Branch, Toronto, Ontario, Canada.

_____. 1987. Improving the quality and enjoyment of moose hunting in Ontario: background report. Wildlife Branch, Ontario Ministry of Natural Resources, Toronto, Ontario, Canada.

_____. 1988a. Timber management guidelines for the provision of moose habitat. Ontario Ministry of Natural Resources, Toronto, Ontario, Canada.

_____. 1988b. Moose anatomy for the hunter. Ontario Ministry of Natural Resources, Wildlife Branch, Toronto Ontario, Canada.

_____. 1990. The moose in Ontario. Book #1- moose biology, ecology and management, Chapters 1- 7, Book 2 - moose hunting techniques, hunting ethics and the law, Chapters 8-14. On-

tario Federation of Anglers and Hunters, Peterborough, Ontario, Canada.

_____. 1991. Review of adult moose validation draw. Final Report. June 1991. Queeen's Printer for Ontario, Toronto Ontario, Canada.

_____. 1993. A minimum wildlife program. Ontario Ministry of Natural Resources, Wildlife Branch, Toronto, Ontario, Canada.

_____. 1997. 1996 Moose hunt summary. Queen's Printer for Ontario, Toronto, Ontario, Canada.

_____. 1999. Ontario Government Response to the Consolidated Recommendations of the Boreal West, Boreal East and Great Lakes-St. Lawrence Round Tables. Queen's Printer for Ontario, Toronto, Ontario, Canada.

_____. 2000. 2000 Hunting Regulations Summary. Fall 2000 - Spring 2001. Ontario Ministry of Natural Resources, Toronto, Ontario, Canada.

_____. 2001. 2000 review of moose population objectives in Ontario. Draft Report of 3 regional workshops. Ontario Ministry of Natural Resources, Wildlife Branch, Toronto, Ontario, Canada.

OSWALD, K. 1982. Moose aerial observation manual. Ontario Ministry of Natural Resources, Wildlife Branch, Toronto, Ontario, Canada.

_____. 1997. Moose aerial observation manual. Ontario Ministry of Natural Resources, Northeast Science and Technology Unit, Timmins, Ontario, Canada. Technical Manual TM- 008.

PAYNE, D., J.G. MCNICOL, G. EASON, and D. ABRAHAM. 1988. Moose habitat management planning: three case studies. Forestry Chronicle 64: 270-276.

PETERSON, R.O. and D.L. ALLEN. 1974. Snow conditions as a parameter in moose-wolf relationships. Naturaliste Canadien 101: 481-492.

PROVINCIAL AUDITOR. 1998. Audit of the Ministry of Natural Resources, Fish and Wildlife Program. Toronto, Ontario, Canada.(http://www.gov.on.ca/opa/english/e98/309.htm).

RACEY, G.D., L.M. MCMILLAN, H.R. TIMMERMANN, and R. GOLLAT. 2000. Effects of hunting closures and timber harvest on local moose densities and hunting opportunities in Northwestern Ontario: a case study. Ontario Ministry of Natural Resources, Northwest Science and Technology Unit, Thunder Bay, Ontario, Canada. Technical Report TR-85.

_____, J.D. MCNICOL, and H.R. TIMMERMANN. 1989a. Application of moose and deer habitat guidelines: impact on investment. Pages 119-131 *in* Forest Investment: a critical look. Canadian Forest Research Centre Symposium Proceedings. O-P-17.

_____, T.S. WHITFIELD and R.A. SIMS. 1989b. Moose habitat. Pages 4-3 – 4-4 *in* Northwestern Ontario forest ecosystem interpretations. Ontario Ministry of Natural Resources, Northwest Ontario Forest Technology Develoment Unit, Thunder Bay, Ontario, Canada. Technical Report 46.

RANTA, W.B., editor. 1998. Selected wildlife and habitat features: inventory manual, for use in forest management planning. Version 1.0. Queen's Printer, Toronto, Ontario, Canada.

REMPEL, R.S., P.C. ELKIE, A.R. RODGERS, and M.J. GLUCK. 1997a. Timber management and natural disturbance effects on moose habitat: landscape evaluation. Journal of Wildlife Management 61: 517-524.

_____, G.D. RACEY and K.A. CUMMING. 1997b . Predicting moose browse production using the northwestern Ontario forest ecosystem classification. Alces 33: 19-31.

_____, and A.R. RODGERS. 1997. Effects of differential correction on accuracy of a GPS animal location system. Journal of Wildlife Management 61: 525-530.

_____, _____, and K.F. ABRAHAM. 1995. Performance of a GPS animal location system under boreal forest canopy. Journal of Wildlife Management 59: 543-551.

RODGERS, A.R., and P. ANSON. 1994. Animal-borne GPS: tracking the habitat. GPS World 5: 20-32.

_____, and A.P. CARR. 1998. HRE: the home range extension for ArcView. Users Manual. Ontario Ministry of Natural Resources, Thunder Bay, Ontario, Canada.

_____, R.S. REMPEL, and K.F. ABRAHAM. 1995. Field trials of a new GPS-based telemetry system. Pages 173-178 *in* C. Cristalli, C.J. Amlaner, Jr., and M.R. Neuman, editors. Biotelemetry XIII, Proceedings of the 13th International Symposium on Biotelemetry, March 26-31,1995, Williamsburg, Virginia, USA.

_____, _____, and _____. 1996. A GPS-based telemetry system. Wildlife Society Bulletin 24: 559-566.

_____, _____, and B. ALLISON. 2000. Moose guidelines evaluation project. Centre for Northern Forest Ecosystem Research, Ontario Ministry of Natural Resources, Thunder Bay, Ontario, Canada.

_____, _____, R. MOEN, J. PACZKOWSKI, C.C. SCHWARTZ, E.J. LAWSON, and M.J. GLUCK. 1997. GPS collars for moose telemetry studies: a workshop. Alces 33: 203- 209.

_____, S.M. TOMKIEWICZ, E.J. LAWSON, T.R. STEPHENSON, K.J.HUNDERTMARK, P.J. WILSON, B.N. WHITE, and R.S. REMPEL. 1998. New technology for moose management: a workshop. Alces 34: 239-244.

ROLLINS, R. 1987. Hunter satisfaction with the selective harvest system for moose in northern Ontario. Alces 23: 181-193.

_____, and L. ROMANO. 1988. Hunter attitudes to the selective harvest system in northern Ontario: a longitudinal study. Unpublished dissertation, School of Outdoor Recreation, Lakehead University, Thunder Bay, Ontario, Canada.

_____, and _____. 1989. Hunter satisfaction with the selective harvest system for moose management in Ontario. Wildlife Society Bulletin 17: 470-475.

ROMANO, L.A. 1988. A comparative study: hunter's attitudes to the selective harvest system for wildlife management units in northern Ontario. Unpublished dissertation, School of Outdoor Recreation, Lakehead University, Thunder Bay, Ontario, Canada.

SAMUEL, W.M. and M.J. BARKER. 1979. The winter tick, *Dermacentor albipictus* (Packard, 1869) on moose, *Alces alces* (L.), of central Alberta. Proceedings of the North American Moose Conference and Workshop 15: 303-348.

SCHWARTZ, C.C., and A.W. FRANZMANN. 1991. Interrelationship of black bears to moose and forest succession in the northern coniferous forest. Wildlife Monographs 113.

SIMMONS, G. 1997. Independent review of the moose and deer tag allocation for Ontario. Recommendations from Ontario's hunters. Queen's Printer, Toronto, Ontario, Canada.

SMITH, H. 1990. Managing a moose population. Pages 25-39 *in* M. Buss and R. Truman, editors. The Moose In Ontario, Book 1. Ontario Ministry of Natural Resources, Wildlife Branch, Toronto, Ontario, Canada.

SNIDER, J.B., and M.W. LANKESTER. 1986.

Rumen flukes (*Paramphistomum* spp.) in moose of Northwestern Ontario. Alces 22: 323-344.

STEWART, A. 2000. Discussion document towards a hunting management strategy for Ontario. Hunting Heritage, Hunting Futures, Huntsville, Ontario, Canada.

STEWART, R.R., R.R. MACLENNAN, and J.D. KINNEAR. 1977. The relationship of plant phenology to moose. Saskatchewan Department of Tourism and Renewable Resources. Technical Bulletin Number 3.

SYLVÉN, S. 1995. Moose harvest strategy to maximize yield value for multiple goal management- a simulation study. Agricultural Systems 49: 277-298.

THOMPSON, I.D. 1979. A method of correcting population and sex and age estimates from aerial transect surveys for moose. Proceedings of the North American Moose Conference and Workshop 15: 148-168.

_____, and D.L. EULER. 1987. Moose habitat in Ontario: a decade of change in perception. Swedish Wildlife Research Supplement 1:181-193.

_____, and R.O. PETERSON. 1988. Does wolf predation alone limit the moose population in Pukaskwa Park? A comment. Journal of Wildlife Management 52: 556-559.

_____, and M.F. VUKELICH. 1981. Use of logged habitats in winter by moose cows with calves in northeastern Ontario. Canadian Journal of Zoology 59: 2103-2114.

_____, D.A. WELSH, and M.F. VUKELICH. 1981. Traditional use of early-winter concentration areas by moose in northeastern Ontario. Alces 17: 1-14.

TIMMERMANN, H.R. 1974. Moose inventory methods: a review. Naturaliste Canadien 101: 615- 629.

_____. 1987. Moose harvest strategies in North America. Swedish Wildlife Research Supplement 1 :565-579.

_____. 1991. Ungulates and aspen management. Pages 99-110 *in* S. Navratil and P.B. Chapman, editors. Aspen management for the 21st century. Forestry Canada, Edmonton, Alberta,Canada.

_____. 1992. Moose hunter education in North America. Alces Supplement 1: 65-76.

_____.1993. Use of aerial surveys for estimating and monitoring moose populations- a review. Alces 29: 35-46.

_____. 1998. Importance and use of mixedwood sites and forest cover for moose (*Alces alces*). Boreal Mixedwood Technical Note. Queen's Printer, Toronto, Ontario, Canada.

_____ , and M.E. BUSS. 1995. The status and management of moose in North America- early 1990s. Alces 31: 1-14.

_____ , and _____. 1998. Population and harvest management. Pages 559-615 *in* A.W. Franzmann and C.C. Schwartz, editors. Ecology and management of the North American moose. Smithsonian Institution Press, Washington, D.C., USA.

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

_____, and _____. 1984. Sharing a moose in North Central Ontario. Alces 20:161-185.

_____, and _____. 1986. Selective moose harvest in North Central Ontario- a progress report. Alces 22: 395-417.

_____ , and _____. 1994. Early winter social structure of hunted vs unhunted moose populations in N. Central Ontario. Alces 30: 117-126.

_____, and M.W. LANKESTER. 1980. Studies of winter tick, *Dermacentor albipictus*, on the bell of moose in North-

western Ontario. Proceedings of the North American Moose Conference and Workshop 16: 137-151.

_____, and J.G. McNicol. 1988. Moose habitat needs. Forestry Chronicle 64: 238-245.

_____, and G.D. Racey. 1989. Moose access routes to an aquatic feeding site. Alces 25: 104-111.

_____, _____, and R. Gollat. 1990. Moose cratering for *Equisetum* in early winter. Alces 26: 86-90.

_____, and R.S. Rempel. 1998. Age and sex structure of hunter harvested moose under two harvest strategies in northcentral Ontario Alces 34: 21-30.

_____, and H.A.Whitlaw. 1992. Selective moose harvest in North Central Ontario. Alces 28: 137-163.

_____ , _____, and A.R. Rodgers. 1993. Testing the sensitivity of moose harvest data to changes in aerial population estimates in Ontario. Alces 29: 47-53.

Todesco, C.J. 1988. Winter use of upland conifer alternate strip cuts and clearcuts by moose in the Thunder Bay District. M.Sc.F. Thesis, Lakehead University, Thunder Bay, Ontario, Canada.

_____, H.G. Cumming, and J.G. McNicol. 1985. Winter moose utilization of alternate strip cuts and clearcuts in northwestern Ontario: preliminary results. Alces 21: 447-474.

Van Ballenberghe, V., and W. Ballard. 1994. Limitation and regulation of moose populations: the role of predation. Canadian Jounal of Zoology 72: 2071-2077.

Wedeles, C.H.R., H. Smith, and R. Rollins. 1989. Opinions of Ontario moose hunters on changes to the selective harvest system. Alces 25: 15-24.

Welch, I.D., A.R. Rodgers, and R.S. McKinley. 2000. Timber harvest and calving site fidelity of moose in Northwestern Ontario. Alces 36: 93-103.

Whitlaw, H. A. 1993. An evaluation of the effects of Parelaphostrongylosis on moose populations. M.A. Thesis, Lakehead University, Thunder Bay, Ontario, Canada.

_____, and M.W. Lankester. 1994a. A retrospective evaluation of the effects of parelaphostongylosis on moose populations. Canadian Journal of Zoology 72: 1-7.

_____, and _____. 1994b. The co-occurrence of moose, white-tailed deer, and *Parelaphostrongylus tenuis* in Ontario. Canadian Journal of Zoology 72: 819-825.

_____, H.R. Timmermann, P. Pernsky, and A.R. Bisset. 1993. Northwest region moose population and harvest profile. Ontario Ministry of Natural Resources, Northwest Science and Technology Unit, Thunder Bay, Ontario, Canada. Report Number 75.

Wilton, M.L. 1983. Black bear predation on young cervids - a summary. Alces 19: 136-147.

_____, and D.L. Garner. 1991. Preliminary findings regarding elevation as a major factor in calving site selection in south central Ontario, Canada. Alces 27: 111-117.

_____, and _____. 1993. Preliminary observations regarding mean April temperature as a possible predictor of tick-induced hair- loss on moose in south central Ontario, Canada. Alces 29: 197-200.