MOVEMENT PATTERNS OF TAGGED MOOSE FROM AN UNHUNTED AREA TO A HEAVILY HUNTED AREA

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ABSTRACT: Thirty one of 386 (8.0%) moose (*Alces alces*) which were ear tagged within Algonquin Provincial Park, Ontario, were recovered over a five year period from outside the Park. Young bulls represented the highest percentage returns and emigrated the greatest distances. Inferences regarding direction of travel and optimal refuge size are discussed.

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Aerial population surveys indicate that the moose (*Alces alces*) population in unhunted Algonquin Park, Ontario, numbered between 3324 (0.4/km^2) and 5147 (0.7/km^2) in 1983 and is remaining relatively stationary (Wilton, 1987).

Heavily hunted areas adjacent to Algonquin Park have moose populations with lower densities approaching 0.1/km^2 and hunter densities up to 2/km^2 (OMNR file reports). The objective of this study is to establish the importance of moose emigration from unhunted Algonquin Park since this may have management implications on the adjacent hunted areas outside the Park.

METHODS

Algonquin Provincial Park is located in south central Ontario between Georgian Bay (Lake Huron) and the Ottawa River (45° 39'N, 78° 39'W) and is approximately 7314 km^2 in area. Moose tagging for this study was confined to the western half of Algonquin Park (Fig. 1).

Between 1981 and 1985, 357 swimming moose were marked by methods described briefly by Simkin (1963). Swimming moose were marked either by attaching a numbered metal tag to the ear, or by placing a radio transmitting neck collar on the animal. A float equipped helicopter was utilized for this phase of the program, during the May-July period. An additional 10 cows and 9 calves were marked between 1981 and 1983 during a spring cow-calf research study (Addison *et al.* 1985). A further 10 animals were ear tagged during a mid-winter program to transfer moose to Michigan, U.S.A. in 1985 and 1987. Since these animals escaped into dense cover they could not be air lifted and were released (Schmitt and Dalton, 1987). All moose were sexed and classified at time of tagging as young (calf or yearling) or adult (Goddard, 1970).

Weatherproof signs were placed adjacent to roadways in the vicinity of Algonquin Park alerting hunters to the fact that they may encounter and harvest an ear tagged moose. Hunters who turned in an ear tag with appropriate data received a special crest for their cooperation.

Tag return data included cause of death and location. From information collected at time of tagging it was possible to calculate time (in months) from tagging to death, linear distance and direction travelled and average rate of travel. Only animals recovered outside the Park were included in this analysis and no interim observations were made on the location of animals between tagging and mortality.

The 1987 and 1988 moose harvests from Wildlife Management Unit 50 were considered representative of the proportions of moose taken in the harvest.

Chi-square analysis was used to compare return rates to the tagged population and to

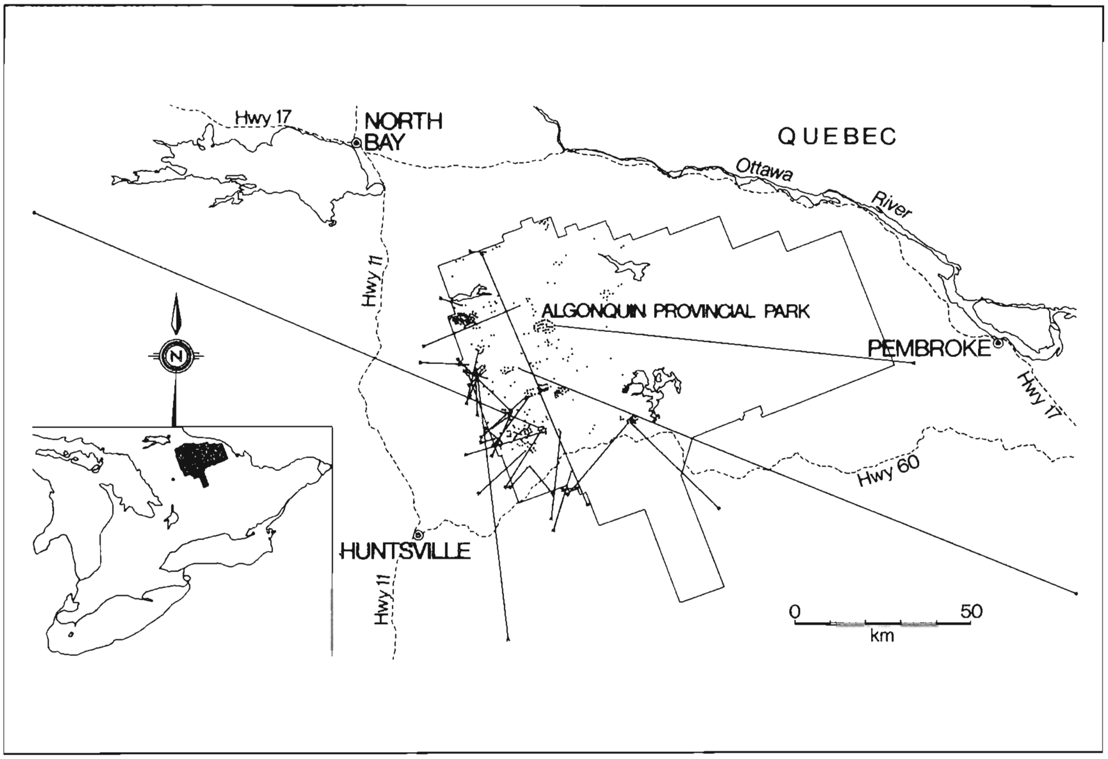

Figure 1. Location of Algonquin Provincial Park in Ontario showing moose tagging locations and subsequent recovery locations for all tag returns.

normal harvest estimates outside the Park. Since distance travelled could not be assumed to be normally distributed, Wilcoxon's Rank Sum test was used to compare these estimates. Computation was done on a computer using SAS/STAT™ (SAS Institute, 1987). Median, rather than mean, values were used as the measure of central tendency. Therefore we are talking about 'distances moved by average moose', not 'average distances moved by moose'.

The level of confidence was set at alpha = 0.05.

RESULTS

A total of 386 moose consisting of 209 (54.1%) males and 177 (45.9%) females were tagged within Algonquin Park during the period 1981-87 (Table 1). Returns from 2 animals which died within Algonquin Park (Appendix 1) are not included in calculations.

Table 1. Number of moose tagged within Algonquin Park 1981-87 and recovered outside the Park boundary to 31 December, 1988.

Sex	Age	Number Tagged	Recovered Number	Recovered %	Hunter Harvest WMU 50 1987
Male	Young[1]	79	13	(16.5)	
	Adult	130	12	(9.2)	192
Female	Young[1]	54	2	(3.7)	
	Adult	123	4	(3.3)	62
Total Moose		386	31	(8.0)	254

[1]Calves and Yearlings

Thirty one tags (8.0%) were recovered from moose killed outside the Park boundary up to 31 December, 1988 (Fig. 1). At the time of harvest all moose were adults. The largest proportion of recoveries (81%) were bulls, especially those tagged as young bulls (eg. 13 of 25).

The proportion of each of the four groups in the harvest differed from the tagged sample. When compared separately there were significant differences between young and old males and between all males and females. Ontario has a selective harvest program which differentially regulates the numbers of adult bulls and cows harvested. The proportions of adults returned are not different from the overall harvest in the area adjacent to the Park.

The median distance that moose were tagged inside the Park boundary was 10.4 km. There were differences among years, however. In 1981, for example, 50 moose were tagged 25.9 km inside the Park, while 67 moose were tagged 1.6 km inside the Park in 1984.

In a comparison of distances travelled between age groups, there was a significant difference between young and old animals in the total distance travelled and distance travelled inside the Park, but not in distance travelled outside the Park (Table 2). These differences are attributed in part to a significant difference between young and old males in total distance travelled. No differences were detected between female age groups.

Significant differences between sexes were detected in the total distance and distance travelled outside the Park when age groups were pooled. This is in part the result of significantly greater distances travelled by young males outside the Park.

There were no differences in distance travelled per month among any of the age or sex classes.

Cause of death of all moose (33) for which tag returns were received (Table 3 and Appendix 1) indicates that legal hunting was the major mortality factor, followed by poaching, unknown, and vehicle collisions.

Table 3. Cause of death of all moose for which tag returns were received, including 2 animals which died inside Algonquin Park

Cause of death	Number of moose	Percent of tag returns
Hunters	27	81.8
Poachers	3	9.1
Unknown (carcass scavenged)	2	6.1
Vehicle Collisions	1	3.0
Total	33	100.0

Emigration direction from tagging to recovery as designated through one of the eight

Table 2. Median emigration distance (km.) of moose tagged in Algonquin Park (1981-87) and recovered outside Algonquin Park to 31 December, 1988.

	Bulls			Cows			All
	Young[1]	Adult	All	Young[1]	Adult	All	Moose
Total Distance (km)	28.0	15.2	19.5	15.2	8.6	10.7	15.9
Distance from Park (km)	6.7	5.5	6.7	1.8	2.1	1.8	4.9
Sample	13	12	25	2	4	6	31

[1]Calves and Yearlings

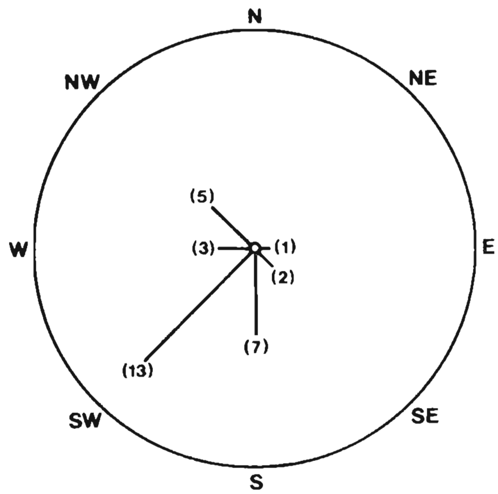

Figure 2. Moose emigration vectors out of Algonquin Park by compass point - (number of animals).

compass points (N, NE, E, SE, S, SW, W, NW) was plotted (Fig. 2) utilizing vectors to indicate the number of animals recovered outside Algonquin Park and direction of travel. The majority of tags (i.e. 23 of 31) were recovered from animals which had emigrated toward the southwest quadrant.

DISCUSSION

Results suggest that emigration out of Algonquin Park by bulls tagged as young animals is significantly greater than emigration by bulls or cows tagged as adults. Although a significantly greater proportion of males was returned than females, it is not possible to distinguish whether this is due to differential emigration or the intended differential harvest rates used in Ontario. Of the four sex-age classes considered, young moose exhibited significantly greater emigration distances than adults, and young bulls exhibited greater distances than young cows at least outside the Park. Saunders and Williamson (1972) found that there were no significant differences between the movements of males and females or between young and old moose of the same sex. Lynch (1976) found that distances moved by subadult males and adult females were significantly greater than those moved by adult males and subadult females respectively. Since moose in our study had to leave Algonquin Park to be harvested there was a greater likelihood of discerning movement patterns between the four major sex-age groups than in studies where tagging occurred in huntable areas.

Emigration distances from studies in Alberta, Minnesota and Northwestern Ontario vary from approximately 14 to 34 km (Van Ballenberghe and Peek 1971, Phillips *et al.* 1973, Addison *et al.* 1980, Hauge and Keith 1981). In our study an average moose emigrated a distance of 15.9 km from an unhunted area to adjacent hunted areas outside Algonquin Park. Of this total distance moved, 11.0 km were within the safety of the Park and 4.9 km were in the hunted area outside the Park.

These measures of moose movement are biased to the extent that animals had to move beyond the Park boundary before there was much probability of recovery and only harvested animals are used. Some 353 tags not yet recovered may be on animals which are alive or dead, and either inside or outside the Park. None of the 50 moose tagged nearly 26 km inside the Park in 1981 have been recovered.

There is a second form of bias because no hunting season occurred during 1983. Moose tagged in that year, or alive after the 1982 hunting season had a 'free year' in which to disperse. The two moose with the longest distances outside the Park were in this group. Movements of these moose, in combination with differential distances travelled by age classes suggest that colonization of areas with low moose density is likely to be by young animals, and that colonization might occur relatively rapidly in the absence of hunting.

If the returned moose are representative of moose in the immediate area outside the Park, then hunting appears to be a major influence on those populations. The average density of moose outside the Park ($0.1/km^2$) is much lower than in the Park (0.4- $0.7/km^2$). Most moose (61%) leaving the Park are killed within two seasons, and an average moose only moved 4.9 km from the Park before it was killed.

Nearly 20% of mortality among all tagged moose was due to causes other than legal hunting (Table 3). The 9.1% (3 of 33) attributed to poachers, as a result of Conservation Officer investigations, indicates only those occurrences which were uncovered. We believe this to be an underestimate, since most poachers would not turn in an ear tag.

Our results indicate that the majority of recovered animals emigrated in a southwesterly direction (Fig. 2). This movement is obviously influenced by the fact that tagging only occurred in the western half of Algonquin Park (Fig. 1) and animals would have had to travel much further to reach the eastern Park boundary. Due to the orientation of the Park boundary, south-west represents the shortest distance out of the Park for most tagged moose. Goddard (1970) found no evidence of a directional tendency from unhunted to hunted areas in North Central Ontario.

What size area is required to protect a population of moose? The answer depends on the size of the population, their density, and the objective for protection relative to the sex or age class in the population. If it may be assumed that distances travelled by recovered moose are representative of the population from which they were tagged, then a frequency distribution curve will predict area required to protect a specified proportion of that population. Barring directional tendencies, the protection (relative to area protected) would be derived from a circular area with a radius equal to the distance travelled.

Consequently an area of 800 km^2 (radius 15.9 km, from Table 2) would protect 50% of the population and an area of 2400 km^2 (radius 27.5 km, based on ranked distances travelled) would protect 75% of the total population. If the objective was to protect only adult moose (the breeding population), areas could be considerably smaller; 590 km^2 for 75% protection.

The median distance from point of tagging to the Park boundary for all moose was 10.4 km, and eight percent of the tagged sample was returned. This distance appears to offer a high level of protection to the moose tagged. It is not informative to use the distance to the Park boundary for all moose tagged as a measure of protection because a tagged animal could move longer distances in any other direction and still be protected. However, the distance to the boundary travelled by an average moose killed outside the Park (11.0 km) is a reasonable measure of the effective distance of protection which the Park has provided. Those moose travelling less than this distance were protected by the Park. Using this estimate, an area of approximately 380 km^2 (i.e. a circle with a radius of 11.0 km) has protected 92% of the moose in this population of 386 animals, without consideration for age or sex. The assumption in this calculation that all moose are located at the centre of the circle is not realistic. Therefore it is necessary to enlarge the circle by the area required to house 386 moose at the Algonquin Park density level (0.4 - $0.7/km^2$). Three hundred and eighty six moose at an assumed density level of $0.55/km^2$ require an area of approximately 702 km^2. Total reserve size could therefore be expressed as the sum of two concentric circles; the inner circle approximately 702 km^2 (radius 14.9 km) representing the moose population (386) at estimated density ($0.55/km^2$) and the outer circle (doughnut) with a radius of 11.0 km representing the area required to protect 92% of the population. Total reserve size therefore becomes two concentric circles with a combined radius of 25.9 km and an area of 2106.3 km^2.

If a refuge is smaller than the size required to meet the intended objective, then a smaller proportion of the population will be protected. If it is larger, then other objectives for resource

Appendix 1 - Data on Tag Returns

Tag No.	Sex	Date Tagged	Age When Tagged	Death Date	Death Cause	Time Span (months)	Interim Distance (Total km)	Net Direction
1846	F	83/06/23	Adult	84/10/22	Hunter	16	15.2	SW
1879	M	83/06/24	Adult	84/10/23	Hunter	16	24.4	SW
1356	M	82/07/13	Young[1]	84/10/23	Hunter	27.5	176.9	SE
15&16	M	83/05/25	Young	84/10/25	Hunter	17	22.6	S
1832	M	83/06/23	Adult	84/10/22	Hunter	16	19.5	SW
1852	M	86/06/23	Young	84/10/06	Hunter	15.5	153.7	NW
1379	M	82/07/16	Young	84/10/23	Hunter	27.5	47.6	S
1977	M	84/06/30	Adult	84/10/22	Hunter	4	12.2	S
56	M	82/06/04	Young	84/10/23	Hunter	28.5	28.1	NW
69	M	82/06/08	Young	84/10/23	Hunter	28.5	15.9	W
1878[2]	F	83/06/24	Adult	84/03/04	Unknown scavenged	8.5	10.4	NE
1823	M	83/06/21	Young	85/10/21	Hunter	28	27.5	NW
1877	M	83/06/24	Adult	85/10/25	Hunter	28	15.2	SW
1891	M	83/06/26	Young	85/10/25	Hunter	28	79.9	S
1501	F	85/10/28	Adult	85/10/26	Hunter	9	4.9	SW
1951	M	84/06/26	Adult	85/10/25	Hunter	16	15.2	W
1930	M	83/06/28	Young	85/10/21	Hunter	28	104.9	E
1902	M	83/06/26	Adult	86/10/26	Poacher	40	5.5	NW
1535	F	85/07/03	Adult	86/10/20	Hunter	15.5	9.2	SW
1359	F	82/06/04	Young	86/10/20	Hunter	52.5	18.3	SW
58	M	82/06/08	Adult	86/10/23	Hunter	52.5	3.7	W
1513	M	85/07/01	Young	86/10/22	Hunter	15.5	14.0	SW
1613	M	84/07/03	Young	86/10/21	Hunter	27.5	75.0	S
19	M	82/06/04	Adult	86/10/30	Poacher	53	26.8	SW
M8203[2]	F	83/05/20	Adult	86/10/16	Vehicle	41	8.5	S
1390	M	82/07/16	Adult	87/10/19	Unknown Decomposed	63	42.1	SE
1603	M	84/07/01	Young	87/10/24	Hunter	40	6.1	S
1922	M	83/06/28	Young	87/10/20	Poacher	52	12.8	NW
1616	F	84/07/03	Young	87/10/23	Hunter	40	12.2	SW
1561	M	87/02/05	Adult	87/10/21	Hunter	8.5	15.9	SW
1601	M	84/06/01	Adult	88/10/19	Hunter	52.5	10.0	SW
1530	M	85/07/03	Adult	88/10/17	Hunter	39.5	9.5	S
1546	F	85/07/04	Adult	88/10/20	Hunter	39.5	8.2	SW

[1]Calves and Yearlings
[2]Died Inside Algonquin Park

utilization (eg. harvesting) may be negatively impacted. Optimal refuge size, especially where differential movements occur between immature and breeding age classes could provide protection for breeding animals and prevent over population by the removal of juveniles.

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