MOVEMENTS AND SEASONAL HOME RANGES OF BULL MOOSE IN A PIONEERING ADIRONDACK POPULATION

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ABSTRACT: Seasonal movements and home range size of 4 adult male moose in a pioneering population in northern New York State were examined. Average rate of movements varied significantly ($P < 0.001$) among years, seasons within years, and individuals. Mean rate of movement during summer was 0.4 km/day, while mean rate of movement during winter was 0.2 km/day. Movements increased tenfold during fall as compared to other seasons. Summer home ranges were significantly ($P < 0.10$) larger than winter home ranges. Extensive movements by males in the fall may have important behavioral, physiological, and demographic implications, particularly in small populations.

ALCES VOL. 26 (1990) pp. 80-85

There is increasing interest in designing more effective translocation or restoration programs for large vertebrates(Nielsen and Brown 1988). In the United States, moose have recently garnered considerable attention in the Lake States and the Northeast. Efforts to restore moose populations are underway in Michigan (Schmitt and Aho 1988) and New York is considering an active translocation program to enhance its population.

Moose began immigrating into northern New York in 1980 from expanding populations in New England, southern Quebec and southeastern Ontario. At present, the population is guessed to number about 20 animals with males outnumbering females approximately 3:1. The bias towards males is typical of pioneering populations since males generally disperse at higher rates than females in the majority of mammals (Greenwood 1980). Little is known on the behavior of moose comprising this population. The objective of this study was to examine seasonal movements and home range size of this pioneering moose population in northern New York State.

Funding was provided by a grant from the New York State Legislature under the auspices of the Adirondack Wildlife Program. The New York State Department of Environmental Conservation helped in many facets of the study. We acknowledge H. R. and T. J. Helms of Helms Aero for their flying expertise. We are indebted to Dr. J. L. Manning, D.V.M., for professional assistance during capture operations. We are grateful to R. D. Masters and the staff and students at the Adirondack Ecological Center for assistance throughout all phases of the project. H. B. Underwood reviewed earlier drafts of the manuscript.

STUDY AREA

Field work was concentrated in a 47,000 km² region of northern New York referred to as The Greater Adirondack Ecosystem (GAE) (Garner, 1989) (Fig. 1). The GAE lies near the southern limits of historical moose range in eastern North America (Peterson 1955). It

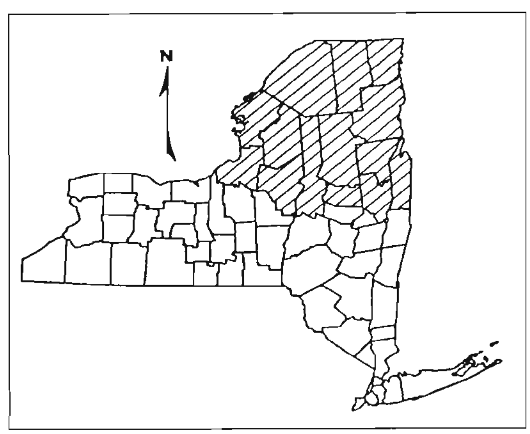

Fig. 1. The Greater Adirondack Ecosystem of New York as defined in this study.

consists of a forested, central mountainous region surrounded by relatively level mixed agricultrual and forested lands on the periphery. Elevations range from 1600 m in the central Adirondack Mountains to 30 m along the periphery. Forests are transitional between the Coniferous and Deciduous Biomes (Allee *et al.* 1949, Stout 1958, Leopold *et al.* 1988). Hardwood species are predominantly beech (*Fagus grandifolia*), sugar maple (*Acer saccharum*), and yellow birch (*Betual alleghiensis*), with some aspen (*Populus tremuloides*) (Stout 1958). Conifers are predominantly red spruce (*Picea rubens*), black spruce (*P. mariana*), and balsam fir (*Abies balsamea*), with some white spruce (*P. glauca*) and white pine (*Pinus strobus*) (Stout 1958).

Climate varies locally with topography and regionally with proximity to Lake Ontario. Mean maximum July temperatures range from 18 C in the central mountains to 21 C along the periphery (Mordoff 1949). Mean winter temperatures range from 5 C at the southern limits of the GAE to -1 C at the northern limits (Davis and Huber 1971). Average annual snowfall ranges from 102 cm along the eastern border to 356 cm in the southwestern portion of the GAE (Mordoff 1949).

METHODS

Fieldwork was conducted from January 1986 to April 1989. Moose were immobilized for radio-tagging using Carfentanil citrate (Wildnil; Janssen Pharmaceutica, Wildlife Laboratories Inc., Fort Collins, CO). All moose were immobilized from the ground using a Palmer extra-long-range Cap-Chur gun (Palmer Chemical and Equipment Company, Douglasville, GA). Diprenorphine hydrochloride (M50/50; Lemmon Co., Sellersville, PA) was used as the antagonist.

Once immobilized, age was estimated from toothwear (Passmore *et al.* 1955). Metal ear tags (Size 49, National Band and Tag Co., Newport, KY) and mortality sensing radio-transmitters (Advanced Telemetry Systems, Inc., Isanti, MN) with visual identification numbers were affixed to each individual. Radio-tagged moose were located with scanning receivers using both ground and aerial tracking techniques (Mech 1983).

Moose locations were plotted on 7.5 minute USGS topographic maps. Universal Transverse Mercator coordinates were determined using a tablet digitizer. Seasonal movements were determined by moose behavior for spring-summer (April-August), fall (including rut) (September-December), and winter (January-March). Home range analysis followed methods outlined by Gustafson and Fox (1983) and were described using harmonic mean (Dixon and Chapman 1980) and irregular convex polygon (Mohr 1947) methods. Seasonal home ranges were pooled for all animals and years to increase sample size. All movement data were analyzed using a computer program written in STSC APL (1987). Statistical Analysis System (SAS Institute, 1985) computer software was used for quantitative analyses using the general linear model procedure's F-test.

RESULTS

Four of the estimated 20 moose in the GAE were captured during the study. The 4 adult males (ages 2.5, 2.5, 3.5, 8.5 years) were located 462 times. The number of locations per individual per season varied from 5 to 79. One moose was located for 3 consecutive years and another for 2 consecutive years. The other 2 moose were located for 1 year. These two moose died of natural causes in 1987 following extensive fall movements. One animal died as a result of complications from a comminuted fracture of the right metatarsal and the other died apparently as a result of a systemic bacterial infection.

Mean rate of movement varied significantly ($P < 0.001$) among seasons within years, among years, and between individuals (Table 1). Mean rate of movement during summer

Table 1. The effect of year, season within year, and individuals on mean rate of movement (km/day) of male moose in the GAE, 1986 to 1989.

Source	df	*F* Value	*P* > *F*
Year	3	8.97	0.001
Season (Year)[1]	5	19.10	0.001
Individual	3	10.89	0.001

[1]Season nested within year.

was 0.4 km/day, while mean rate of movement during winter was 0.2 km/day (Table 2). Movements increased tenfold during fall as compared to other seasons. Minimum (straight line) distance travelled during fall, for all individuals, ranged from 96.0 km to 576.9 km (Table 3). Individual rate of movement during fall ranged from 2.5 to 9.7 km/day.

Home range size within seasonal home ranges varied with the method of home range calculation used. Summer home ranges were significantly ($P < 0.10$) larger than winter home ranges regardless of the method of home range calculation (Table 4). Only 1 moose showed seasonal fidelity to his summer and winter home range.

DISCUSSION

Moose in the population pioneering the GAE displayed two behavioral differences from those in established populations. First, adult males in the GAE display exceptionally large fall movements. Increased movement and expansion of home ranges by moose during the fall are well known (Houston 1968, Van Ballenberghe and Peek 1971, Phillips *et*

Table 2. Mean rate of movement (km/day) by season of male moose in the GAE, 1986 to 1989.

Season	Year								Mean Seasonal Movement
	(*n*)	1986	(*n*)	1987	(*n*)	1988	(*n*)	1989	
Fall	(2)	4.6	(3)	5.2	(2)	3.4	-	-	4.4
Winter	-	-	(3)	0.3	(2)	0.1	(2)	0.1	0.2
Summer	(2)	0.4	(3)	0.5	(2)	0.3	-	-	0.4

Table 3. Total distance (km) travelled (TDT) and rate (km/day) of movement (ROM)[1] by male moose during fall season in the GAE, 1986 to 1988.

Moose	Year					
	1986		1987		1988	
ID. No.	TDT	ROM	TDT	ROM	TDT	ROM
1	576.9	5.1	-	-	-	-
2	159.8	4.0	290.7	3.4	380.6	3.0
3	-	-	204.4	9.7	-	-
4	-	-	243.6	2.5	96.0	3.8

[1]Rate of movement = TDT/time period (days).

Table 4. Mean summer and winter home range sizes (km^2) of male moose in the GAE, 1986 to 1989[1].

Method	Summer	Winter	F-ratio	$P > F$
Irregular Convex Polygon	36.3	7.5	3.686	0.079
95% Harmonic Mean	56.5	17.3	3.634	0.081
75% Harmonic Mean	16.2	4.6	5.467	0.038

[1]n = 7 for home range calculations.

al. 1973, Lynch and Morgantini 1984). However, none of these studies show the order of magnitude increases in movement observed in the GAE. This difference could be attributed to the scarcity of females within the GAE and consequently results in extensive movements by males in search of females.

If this hypothesis is true, non-breeding movement behavior observed in the GAE would be similar to that observed elsewhere. Investigations elsewhere have shown that home range sizes and movements are highly variable. Average summer home ranges vary from 2.2 km^2 in Montana (Knowlton 1960) to 56 km^2 in south-central Alaska (Taylor and Ballard 1979). Estimates of winter home range sizes vary from 2 km^2 in northwestern Ontario (Addison et al. 1980) to 49 km^2 in north-central Alberta (Lynch and Morgantini 1984). Seasonal non-breeding movements in the GAE are within the ranges reported for moose in these established populations.

The second behavioral pattern displayed by moose in the GAE is a general lack of fidelity to home ranges from one year to the next. Yearly home range fidelity is typical for most established moose populations (Knowlton 1960, Houston 1968, LeResche 1972, Phillips *et al.* 1973, Pulliainen 1974, Van Ballenberghe 1977, Sandegren *et al.* 1982, Cederlund *et al.* 1987). In the GAE, only 1 of 4 moose showed any tendency to use the same area two years, consecutively.

There are two possible explanations for this pattern. First, it may be that moose entering the GAE are uncharacteristically nomadic due to low intraspecific competition for resources. Moose have entered the GAE from several directions and are scattered across the region, the probability of encountering conspecifics is low, therefore, an abundance of available resources exists. Thus, fidelity may not be as important as in established populations where resources may be limited.

Alternatively, we suggest that the non-breeding season movements of adult males were dictated largely by breeding season movements. During the fall, male moose in the GAE travelled extensive distances. Since male moose lose up to 19% of their body weight during the breeding season (Schwartz *et al.* 1987), the energetic cost of male moose in the GAE returning to their previous winter range was probably greater than the cost associated with establishing a new winter home range. The location of a male at the end of the breeding season determined where it began to search for suitable winter habitat, and subsequently, suitable summer habitat.

MANAGEMENT IMPLICATIONS

The movement patterns observed in moose pioneering into the GAE have two important implications for management. First, the highly scattered distribution of moose in the GAE and extensive movements displayed by males suggests cause for concern that not all females are being bred. Second, home range familiarity is important to the survival of most mammals (Ewer 1968, Baker 1978, Vaughan 1986). In this study, 2 moose died after travelling extensive distances through unfamiliar habitat during the fall. Thus management planning should pay close attention to techniques that could minimize extensive movement. The extensive movements of male moose during fall in the GAE may be attributable to the apparent scarcity of females in the population. Therefore, translocation of additional females may reduce these long range movements.

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