IMPACT OF MOOSE ON AQUATIC VEGETATION IN NORTHERN MAINE

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ABSTRACT: Many ponds in northern Maine have a low abundance of aquatic vegetation. Five exclosures were built in 2 ponds with high moose use but little vegetation. All exclosures sustained ice damage each winter. One was damaged beyond repair after 3 years, 3 were lost during the fifth winter, and 1 lasted for 6 years. The number of plants rooted along a 20 m transect were counted in mid-August in the first, second, fourth, and fifth years of the study. All vegetation rooted in 24 1 m^2 plots (3 inside and 3 outside of each of the remaining exclosures) was pulled, dried, and weighed after the third growing season. Ten plots (5 inside and 5 outside) from the 1 remaining exclosure were clipped and weighed after 6 growing seasons. Plant biomass was greater in 3 of 4 protected than in unprotected areas after 3 years ($P < 0.05$) and in the 1 remaining exclosure after 6 years ($P < 0.05$). Biomass increased within the exclosures from the third to the sixth year ($P < 0.05$) but there was no change in the unprotected area.

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In the late-1970s, what seemed to be a low abundance of aquatic plants was observed in many of the shallow ponds in northern Maine. Sightings of moose and moose tracks in these ponds indicated that these ponds were heavily used by moose. Feeding by moose was suspected to be one possible cause for the near absence of aquatic plants in some ponds. However, no information is available on the condition of these ponds when moose were less abundant. Moose commonly use aquatic plants as a source of sodium when sodium levels are low on nearby terrestrial browse (Jordan et al. 1973; Fraser 1979; Fraser et al. 1982, 1984). Several studies have documented that moose can reduce the abundance of aquatic plants (Murie 1934, Jordan et al. 1973, Aho and Jordan 1979, Fraser and Hristienko 1983).

The objective of this study was to document the impact of moose browsing on the abundance of aquatic plants in 2 ponds in Maine, USA.

STUDY AREA

Two ponds in north central Maine that were included in Crossley's (1985) study of pond use by moose were selected for study. Sixteen species of aquatic plants in these ponds ranged from 0.08% to 1.28% Na (dry matter) compared to 0.0047-0.0098% in 10 species of commonly browsed terrestrial plants from the surrounding area (Crossley 1985). Aquatic plants seem to be the only source of concentrated sodium in the area. None of the radio collared moose in this area visited a recognizable mineral lick and none made the 35 km journey to the nearest salted highway (Crossley 1985, Leptich 1986, Thompson 1987, Maine Department of Inland Fisheries and Wildlife, unpublished data).

Leonard Pond (15 ha) and Bartlett Pond (31 ha) are shallow (60-100 cm) bog lakes surrounded by floating mats of *Sphagnum* spp. and associated plants. Plant life in the ponds is sparse. The bottoms of both ponds are loose muck, allowing moose to swim and become completely submerged in water less than 1 m in depth. The bottom is visible throughout both ponds, although the water in Leonard Pond is noticeably dark stained.

METHODS

Five moose exclosures, 3 in Bartlett Pond and 2 in Leonard Pond, were built in May 1983. An exclosure was placed in the center of each pond with the remainder spaced equally between the center of the pond and the shore farthest from the outlet. Average August water depths in the exclosures were 24, 30, and 50 cm for Bartlett Pond, and 60 and 75 cm for Leonard Pond. Each 4.9 m square (24 m^2) exclosure was made of 4 hogwire panels and wooden posts. Cedar fence posts (2 m) were pushed into the bottom at each corner and the middle of each side. When the muck bottom was exceptionally deep the corners of the exclosures were reinforced with posts up to 3.5 m long. The panels were 1.2 m high and set so that the top was near the water surface in May. The loose muck bottom made it impossible for moose to reach over the panels at water level or exert enough pressure to damage the exclosures.

The exclosures were checked each May, and those that had sustained ice damage were repaired, if damage had not disturbed the bottom of the pond. The exclosure in 30 cm of water in Bartlett Pond was removed in the third year because the bottom was disturbed. During the third winter, the exclosure in 75 cm in Leonard Pond sank to the point that moose might have been able to reach plants near the edge of the exclosure. A second group of hogwire panels was placed on top of the original exclosure 2 weeks after ice-out.

The abundance of plants inside and outside the exclosures was evaluated in mid-August for 6 years. In the third and sixth years of the study, biomass was measured by clipping and weighing plants from sample plots inside and outside the exclosures. In the other 4 years, relative abundance of plants inside and outside the exclosure was monitored by a line intercept technique. Observations were made from a canoe using a glass bottom bucket to improve visibility. The canoe was placed inside the exclosure for each sampling session.

We counted the number of plants that touched a 0.82 cm diameter 4 m long rod placed horizontally along the bottom of the pond. Twenty meters of transect inside and outside of each exclosure were searched in each of 4 years. During the second year, it became apparent that the density of vegetation in some of the protected areas made the line intercept sampling method impractical. The rod could not be put in place, nor the plants counted, without disturbing the vegetation and therefore affecting the measurement. Plant contacts with the rod over 100 were probably inaccurate so they were recorded as a minimum number.

Three growing seasons after construction of exclosures, all plants rooted on 3 plots (1 m^2) inside and 3 plots outside of each exclosure, (2 in Leonard Pond and 2 in Bartlett Pond) were pulled, rinsed, oven dried to constant moisture content, and weighed to the nearest 0.1 g. The centers of 3 circular plots were located along a line 1 m inside a randomly selected panel, leaving the rest of the exclosure undisturbed. Another 3 plots were located along a line 1 m outside of the same panel. The edges of the plots were 44 cm from the fence.

Five 1 m^2 plots within the previously unclipped section of the remaining exclosure (Bartlett Pond) and 5 plots adjacent to the exclosure were clipped and weighed after 6 years of protection. The centers of these plots were located on lines 1 and 2.5 m from the panel farthest from the plots that were measured 3 years earlier. A *t*-test was used to compare biomass inside and outside the exclosures.

RESULTS

Differences in plant abundance inside and outside the exclosures in Bartlett pond were readily apparent by visual appearance during the second year of protection. Differences in Leonard Pond were not observed until the third year of protection for one exclosure, and were never observed in the other. The line intercept technique became subjective once the plants became so abundant that the rod could not be placed on the bottom of the pond and the plants accurately counted without disturbing adjacent plants. While not suitable for statistical analysis, it demonstrated the relative magnitude of the change (Fig. 1).

Table 1 summarizes biomass comparisons among 4 exclosures after 3 years and for 1 exclosure after 6 years. After 3 years, plant biomass was greater in 3 of 4 remaining, protected areas than in adjacent unprotected areas ($P < 0.05$). After 6 growing seasons, the biomass was greater inside the one remaining exclosure than outside ($P < 0.05$). The biomass of plants inside exclosure A in Bartlett Pond increased between the third and sixth year of protection ($P < 0.05$) but did not change outside the exclosure.

DISCUSSION

Moose browsing had a dramatic effect on the relative abundance and biomass of aquatic vegetation in 3 of the 4 plots studied. This study suggests that moose are reducing the number of plants and plant biomass in some northern Maine ponds. Similar effects have been reported in other parts of moose range (Murie 1934, Jordan et. al. 1973, Aho and Jordan 1979, Fraser and Hristienko 1983).

What, if any, effect this is having, or will have, on moose is not clear. Other than aquatic plants, potential sources of sodium include road salt and natural licks. Radio-collared moose from the study area did not move to salted highways or identifiable licks (Crossley 1985, Leptich 1986, Thompson 1987, Maine Department of Inland Fisheries and Wildlife, unpublished data). Therefore, aquatic plants are assumed to be their major source of sodium.

Symptoms of inadequate salt intake include unusual appetite for salt, lack of appe-

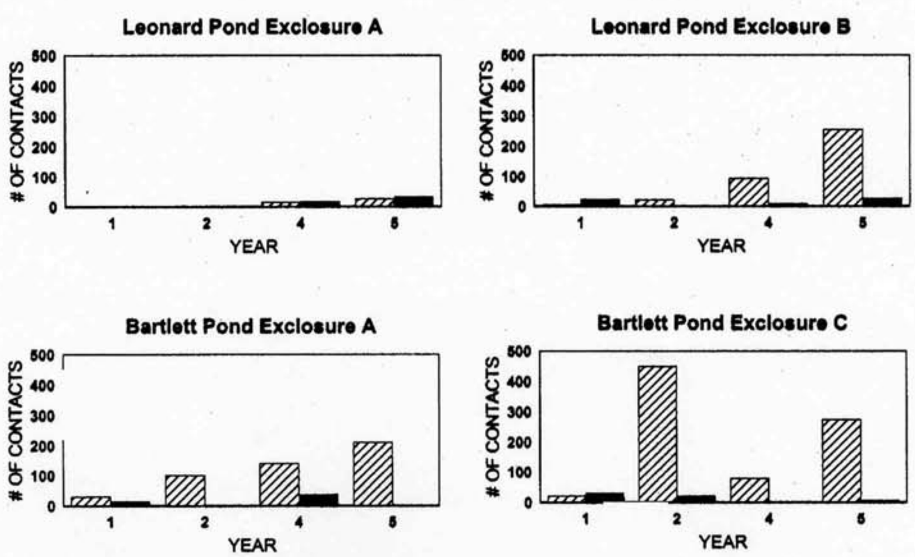

Fig. 1. Number of plant contacts along a 20 m line on the pond bottom in August inside (hatched) and outside (solid) 4 moose exclosures in Maine, USA.

Table 1. Average biomass (g dry wt/m^2 ± 1SD) inside and outside exclosures after 3 and 6 growing seasons.

Pond	Exclosure	August Water Depth (cm)	3 Years		6 Years	
			Inside	Outside	Inside	Outside
Bartlett	A	25	41.6±28.8	0.2±0.2	108.3±35.9	0.2±0.2
Bartlett	C	50	6.1 ± 6.1	0.2±0.1	-	-
Leonard	A	65	1.2 ± 0.3	0.9±0.6	-	-
Leonard	B	50	4.5 ± 2.1	0.3±0.4	-	-

tite, decline in growth, loss of weight, and decreased productivity. Severe restriction of salt intake may prevent reproduction (Maynard and Loosli 1969). Belovsky (1981) suggested that the number of moose might be dependent on the availability of sodium. Jordan (1987) noted that clinical deficiencies beyond a behavioral drive or adrenocortical hypertrophy are unlikely to be displayed by a free ranging population. However, he anticipated that there would be lower reproductive success or a population below what the terrestrial browse could support.

There is some indication that Maine moose have a higher than usual craving for salt, based on the length of time they spent using ponds. Crossley (1985) found that moose in northern Maine, especially cows with calves, were using ponds later into the summer than reported in several other studies (Dunn 1975, Best et al. 1977, Fraser 1979, Fraser et al. 1982). Jordan et al. (1973) found moose on Isle Royale used aquatic plants into September during years when aquatic plants had been noticeably reduced by grazing, but that aquatic feeding declined in late July or early August in years when aquatic plants remained abundant. However, female moose are reported to use mineral licks into the fall in New Hampshire (Miller and Litvaitis 1992) and Quebec (Couturier and Barrette 1988).

Measuring the number of moose seen per hour in 1982, Crossley (1985) recorded moose using 3 ponds, including the 2 in this study, later in the year than an earlier study in Maine (Dunn 1975). Fire tower observers statewide recorded the number of moose they saw entering ponds in 1956 and from 1962 to 1967, and they noted the number of moose entering the water dropped off sharply after July (Dunn 1975). Crossley (1985) observed no decline in lake use by moose from late July through September.

The number of moose entering a pond per hour (Dunn 1975), and the number of moose seen per hour (Crossley 1985), may not be directly comparable, because the length of time moose spend in a pond varies with time of year. Furthermore, due to differences in the density of moose, the numbers of moose observed may not be comparable between the two studies, even if data were recorded in the same way. To make these data sets more comparable, the number of moose Dunn (1975) reported entering the water/hr was multiplied by the average length of a visit (to the nearest hour) for that month. Both sets were expressed as a percent of the maximum activity (Fig. 2). The results indicate the pattern of moose use of ponds has either changed with time, or use in the study area differs from use statewide.

Ponds that appear to be heavily used by moose but have few aquatic plants, are common throughout northern Maine (gen-

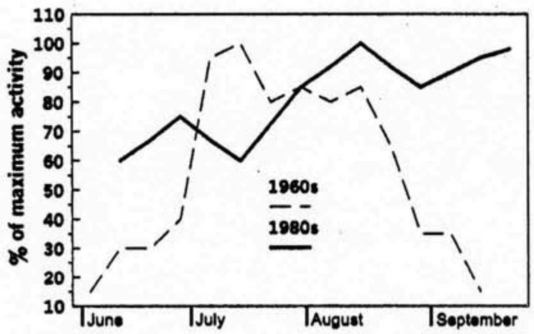

Fig. 2. Use of ponds by moose in Maine during the 1960s (Dunn 1975) and 1980s (Crossley 1985).

eral observation). Moose are using the ponds for more of the year than is usual in other areas of North America and for longer than they did in the past in Maine. The change in the pattern of pond use suggests that moose may be having difficulty meeting some nutritional requirement, most likely sodium. However, there is no indication that moose populations have been affected. Based on the number of moose seen per hour spent hunting, the number of moose continued to increase during this study. There is no difference in the number of calves seen per cow in hunting zones where moose have access to road salt and those zones where moose depend on aquatics (Maine Department of Inland Fisheries and Wildlife, unpublished data).

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