CALVING SITES OF MOOSE IN CENTRAL ONTARIO

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ABSTRACT: Fifty-four calving sites of moose (*Alces alces*) were located during the calving and early postpartum period in Algonquin Park, Ontario. The major objective was to capture calves for other studies. Objectives influenced methods and subsequent possible interpretation of results. Thus, although 44 of 54 sites were on islands, this may reflect only disproportionately large amounts of time searching islands and not a propensity for moose to calve on islands. Similarly, there is no suggestion that certain types of habitat actually were preferred by moose. This cannot be done using the resources and techniques available in this study. Moose used a variety of hardwood, conifer, hardwood-conifer mixed, and occasionally open habitats for calving. Sites varied greatly in tree density, shrub density, shelter, visibility around sites, and in proximity to water. Many sites were elevated on slopes and did not have hiding cover or shelter from weather close at hand. Most sites were in areas believed to provide predator avoidance characteristics.

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Brief descriptions of limited numbers of calving sites of moose (*Alces alces*) are available from the U.S.S.R., Wyoming, Sweden, Alaska, and Maine (Knorre 1959, Altmann 1963, Markgren 1969, Stringham 1974, Leptich and Gilbert 1986). In the present study many calving and postpartum bedding sites were found in Algonquin Park while locating moose calves for studies on the productivity and health of moose (Addison *et al.* 1985; McLaughlin and Addison 1986).

There is provision for protection of known moose calving sites within timber management guidelines in Ontario. This is probably based on a hypothesis that the habitats of calving sites are unique and/or in limited supply. Knowledge required to address this hypothesis includes information on the variation in vegetational and physiographic characteristics of calving sites within various forest regions.

The objective of this study was to describe habitat characteristics of calving and postpartum bedding sites of moose that might be useful in further studies to evaluate predictors of potential calving sites. It was not an objective of this study to test hypotheses about selection of sites by moose or about the uniqueness of calving and early postpartum sites.

STUDY AREA

The study area is approximately 5000 km^2 centred around Big Trout Lake (45°46'-N, 78°7'W) in Algonquin Provincial Park, in central Ontario. The area has irregular topography over granitic bedrock, with mixed forests and many lakes. It is within the Algonquin-Pontiac Section of the Great Lakes - St. Lawrence Forest Region (Rowe 1972). Hunting of moose has been prohibited within the study area since 1886 (Addison 1974). Densities of moose increased from 0.1 to 0.2 per km^2 in 1974 and 1975 (Wilton and Pashuk 1982) to 0.5 per km^2 in 1984 (M. Wilton, pers. comm.).

METHODS

Locating calving sites was ancillary to our primary objective of capturing moose calves to raise in captivity. The major areas searched were islands and peninsulas readily accessible by boat or aircraft and small enough so that cows with calves could be driven to water for capture. Ground searches were conducted as described by Addison *et al.* (1985). Areas previously identified as calving sites were also checked. Some mainland calving sites were found while tracking radio-collared cows. Other mainland sites were on peninsulas that were thoroughly searched. These methods did not provide random sampling within the study area. Calving and postpartum site refers to an area with beds which may have been used for up to two weeks postpartum before discovery. The areas were clearly defined by bedding sites and extensive use by adult-calf groups whereas surrounding areas lacked beds and other sign. Some beds could be specifically identified as the location of parturition because only one bed was present or because the calves were too young to have moved. These single beds were usually large. When numerous beds were present, the calving bed could not be distinguished from other postpartum beds. In these cases, the largest bed with the greatest disturbance of ground vegetation was arbitrarily designated as the primary bed and other beds as secondary beds. Measurements characterizing sites are made in relation to the primary bed. Parameters characterizing sites were selected for their description of vegetation and for their possible relevance to moose-predator interactions.

Standing trees within a circular plot of 0.04 ha (0.1 acre) centred at the primary bed were identified and classed into sizes of 5-9.9 cm, 10-25 cm, and greater than 25 cm diameter at breast height (DBH). Number and species of standing dead trees were recorded and the number of dead trees on the ground was ranked from low to high (1-3). Woody plants less than 5 cm DBH and over 75 cm high were classed as shrubs. Shrub were classified within a circular plot with a radius of 2 m. Plots were centred 4 m from the primary bed in a direction providing representative shrub cover.

Conifer canopy cover over beds was measured after leaf-fall so that measurements were similar to site characteristics early in the calving period. The canopy directly above the bed was photographed using a 52 mm lens, the image projected on a square grid containing 100 squares, and the conifer cover calculated as the percentage of squares with conifer.

The maximum surrounding area in which predators would be visible to a cow standing at the primary bed was also measured following leaf-fall. The average height of the eye of a standing moose was measured from immobilized and captive moose as 1.8 m. The height of black bears (*Ursus americanus*) and timber wolves (*Canis lupus*), the local predators, was estimated as 0.75 m. Visibility was measured along eight bearings at 45° intervals. The maximum straight line distance that a grid board (0.75 m square) at ground level could be seen from 1.8 m above the primary bed was measured. The area of visibility was calculated from the polygon formed by joining adjacent maximum visibility points. This technique was used to obtain a consistent measure of openness. It does not imply that vision is more sensitive than hearing for early detection of approaching threats.

The positions (distance and direction) of primary beds relative to the nearest hill, water, possible escape routes by water less than 200 m to adjacent land, nearest hiding cover, cliff (if present within 100 m), campsite, habitat edge, opening in the canopy, and shelter tree were also measured. The species and canopy height of shelter trees were recorded. Identification of shelter trees was based on subjective assessment of which tree would provide shelter from sun, rain, snow,and wind. Hiding cover was cover suitable for calves or cows to hide from human sight, as viewed from the bed. Identification of hiding cover was based on observations of moose that were disturbed from beds. Combined overhead (canopy) and lateral (ground vegetation) shelter of primary beds from wind, rain, snow, and sun were ranked from low to high (1-3). Habitat edge was defined as a change in habitat based on presence or absence of trees or on changes in predominant tree cover between conifer, deciduous, and mixed conifer-deciduous stands.

Calving sites were grouped into the following types based on overall visual classification of the site: mature hardwood, mature mixed, high density conifer, low density conifer or mature hardwood-conifer edge habitats (Table 1). Conifers were divided into two habitat types because of the vast differences in appearance between high and low density conifer sites. A few sites were in early successional forests, open areas, or other habitats that did not fit the above classifications.

Initially, data were analyzed using a principal component analysis on most non-directional variables (Norusis 1985). However, several measures indicated that principal component analysis was inappropriate for the data set. The Kaiser-Meyer-Olkin measure of sampling adequacy was 0.2; it should have been greater than 0.5 or preferably greater than 0.7 (Norusis 1985). In addition, few of the correlation coefficients between variables were significant, suggesting that few variables shared common factors. A subset of 16 variables representing the basic habitat structure of sites were chosen and analyzed using a principal component analysis (Norusis 1985). Principal component analysis was inadequate with these variables because the first 3 components accounted for less than 50% of the variation and it took 6 components to account for 72% of the variation. Thus principal component analysis did not fulfil its primary purpose which is to the reduce the number of variables in order to simplify analysis.

Various physical and biotic features among habitats were examined using analyses of variance (Morrison 1982, Zar 1984). When statistically significant variation was found, differences between habitats were examined using the Neuman-Keuls test (Zar 1984). Visible area in windward and leeward quarters were compared using the t-test (Morrison 1982, Zar 1984). Frequency distributions of direction measurements were plotted in 30° intervals and mean and median angles and angular deviations were calculated. The Raleigh test was used to detect non-uniform distributions. That test can detect a unimodal concentration or, with the appropriate transformation, a diametrically opposed bimodal concentration (Zar 1984).

Table 1. Habitat distribution of calving sites of moose in Algonquin Park, Ontario.

	Number of beds		
Habitat	Islands	Mainland	Total
Mature hardwood	17	2	19
Mature mixed (conifer-hardwood)	5	-	5
High density conifer	5	3	8
Low density conifer	6	1	7
Mature hardwood-conifer edge	5	2	7
Early successional hardwood, mixed or edge	3	1	4
Open or open-conifer edge	2	1	3
Other	1	-	1
Total	**44**	**10**	**54**

Log transformation of distance and area measurements and arcsine transformation of percentage data were used in statistical analyses but original values are reported in tables and text. Probabilities of < 0.05 were considered significant.

RESULTS

A total of 145 islands, 19 peninsulas, and a limited number of mainland areas were checked for calving between 5-31 May from 1981 to 1985. More than 75% of islands in the study area were searched and 52% were surveyed during 2 or more years of the study.

Types of Calving Sites

Fifty-four calving sites were located. Forty-four sites were on islands and 10 sites on the mainland. Islands with calving sites were 1-69 ha ($\bar{x}$ = 16) in area and a maximum of 40-370 m ($\bar{x}$ = 135) from the shore to the centre. Eighty percent of the islands were less than 20 ha in area and 160 m from shore to centre. Islands used for calving were located 4-640 m from the mainland. However, presence of intervening islands reduced the greatest minimum direct swimming distance by water from the mainland to calving islands to 370 m. Eighty percent of the islands were within 150 m of the mainland.

Forty-six calving sites were grouped into 5 major habitats (Table 1). In addition, 4 sites were in early successional forests with few large trees and a high density of small trees; 3 sites were in the open or at open-conifer edge; and 1 mixed site was dominated by an unusu-

Table 2. Density of vegetation at calving sites of moose in Algonquin Park, Ontario

	Hardwood	Mixed conifer -hardwood	High density conifer	Low density conifer	Hardwood-conifer edge
Live trees[a] Total	451±174[b] (247-963)	494±119 (370-642)	1309±199 (1112-1655)	702±148 (395-840)	781±121 (642-1013)
5-9.9 cm DBH	114±70 (0-272)	128±88 (49-272)	547±203 (272-815)	198±112 (25-321)	232±79 (99-346)
9-25 cm DBH	178±140 (0-593)	178±76 (99-272)	579±137 (395-766)	346±148 (173-593)	414±139 (198-618)
>25 cm	159±61 (74-272)	188±44 (148-247)	183±60 (99-247)	159±115 (25-296)	136±77 (49-296)
Dead conifer trees[a]	51±115 (0-370)	59±56 (0-124)	314±402 (25-1247)	183±118 (74-420)	148±262 (0-766)
Shrubs[c]: deciduous	1.0±1.1 (0-3.9)	0.5±0.5 (0.1-1.4)	0.4±0.7 (0-1.8)	0.4±0.5 (0-1.1)	1.9±3.1 (0-9.5)
coniferous	<0.1 (0-0.1)	0	0.5±0.5 (0-1.4)	0.5±0.6 (0-1.7)	0.2±0.3 (0-0.8)

[a] Number/ha.

[b] Mean ± standard deviation (range).

[c] Number/m^2. Shrubs <5 cm diameter and >0.75 m tall were counted.

ally high density of shrubs.

Vegetation at Calving Sites

Hardwood sites were dominated by hard maple (*Acer saccharum*) (Table 3), with a high proportion of large trees. Shrubs were primarily hard maple, red maple (*Acer rubrum*) and striped maple (*Acer pensylvanicum*); conifer shrubs were virtually absent (Table 2).

Mixed forest sites were dominated by large eastern hemlock (*Tsuga canadensis*), hard maple, and yellow birch (*Betula alleghaniensis*), with small beech (*Fagus grandifolia*) or balsam fir (*Abies balsamea*) (Table 3). Shrubs were primarily hard maple; no conifer shrubs were present (Table 2).

Balsam fir, and to a lesser extent hemlock, were the dominant trees and shrubs in the conifer habitats (Table 3). Deciduous shrubs were few in number, except for 3 sites where beaked hazel (*Corylus cornuta*) was abundant.

At mature hardwood-conifer edge sites, hard maple, white birch (*Betula papyrifera*), and balsam fir were common (Table 3). Shrubs, almost all hard maple, were very dense (9.5/m^2) at one site.

Ground cover of three calving sites in, or near, "forest openings" was thick with raspberry (*Rubus* sp.) and, especially near the edge, with fallen dead balsam fir.

Vegetation was particularly dense at two sites that did not fit into the above groups. One site, at an edge between early successional hardwoods and conifers had 2125 trees/ha with 51% of the trees conifer. The second unusually dense site was a unique mixed habitat dominated by very dense (16.1/m^2)

Table 3. Species composition of live trees at calving sites of moose in Algonquin Park, Ontario

	Hardwood	Mixed conifer -hardwood	High density conifer	Low density conifer	Hardwood-conifer edge
Hard maple	77±25[a]	27±16	<1	4±7	22±24
Red maple	4±14	<1	2±3	0	10±16
Yellow birch	3±7	8±8	<1	5±9	6±10
White birch	<1	0	3±4	4±7	18±19
Other deciduous[b]	5±12	14±19	2±3	2±2	2±4
Balsam fir	9±15	20±23	61±19	45±21	28±28
White spruce (*Picea glauca*)	<1	0	4±9	6±10	5±8
Black spruce (*Picea mariana*)	0	0	6±3	1±3	0
Eastern hemlock	<1	27±10	13±12	25±27	7±8
Eastern white cedar (*Thuja occidentalis*)	1±4	3±6	6±9	<1	1±3
White pine (*Pinus strobus*)	0	0	3±5	6±10	2±3

[a] percent of total trees in plot - Mean±1 SD

[b] Striped maple, beech, black cherry (*Prunus serotina*), ironwood (*Ostrya virginiana*), basswood (*Tilia americana*).

clumps of hazel.

Physical and Biotic Features

Physical and biotic features measured at calving sites (Tables 4, 5) had large ranges (Table 4).

All but two calving sites were on hills. Although calving sites were found from the bottom to the top of hills, 71% of sites were on the upper half of hills, and 41% of sites were on the top 25% of the hills. Aspect of the slope at island sites varied widely (range 300°, angular deviation 77°) (see Zar 1984). All beds were on sites with good drainage. Only 1 bed had exposed rocks.

Calving sites on islands were not concentrated close to water (Table 4). While some were close to shore, others were as far from the shore as possible. Most mainland sites fell within similar ranges, although some were farther from shore (Table 4). Escape destinations from islands were the mainland or another island of greater than about 0.1 ha. Cows with calves seen leaving an island usually did so by the shortest water route. Distances from the shore nearest a calving site to another island or mainland were 80-760 m and over 200 m at 27 of 44 (61%) of sites. In contrast, the shortest water distance to another island or mainland was 4-170 m ($\bar{x}$ = 92). Calving sites were 18-92% (up to 1220 m) of the maximum possible land distance removed from these shortest escape routes (Table 4).

Campsites were present on 22 of 24 calving islands. One calving site was only 42 m from a campsite, but was on top of a steep hill overlooking the camp and not visible from it. Two other calving sites, within 135 m of campsites, were separated from the camp-

Table 4. Physical and biotic features of calving sites of moose in Algonquin Park, Ontario

	No. of calving sites	Mean	Range	Median
Island sites				
Distance to nearest shore (m)	44	83	16-172	83
Distance to shore closest to other land	44	291	50-1220	210
Mainland sites				
Distance to nearest shore	10	153	12-665	84
All sites				
Distance to nearest campsite	50	340	42-1800	228
Visible area (m^2)	54	2395	332-11946	1792
Length of hill (m)	52	79	12-397	69
Position on hill (% distance from bottom)	52	66	0-100	74
Aspect of hill(°)	51	156	--	166
Distance to nearest shelter tree	54	19	0-186	4
Distance to nearest hiding cover	54	27	0-117	19
Distance to nearest canopy opening[a]	53	8	0-84	0
Distance to nearest habitat edge	51	38	0-245	22

[a] Distance (m) to nearest canopy opening allowing sufficient sunlight to reach ground for basking; deciduous trees in pre-leaf out condition.

site by a cliff. Another calving site, 83 m from a campsite, was on an island only 150 m long. All other calving sites were at least 150 m from campsites. The area of visibility around calving sites varied from 332 m^2 to over 1 ha (Table 4). Distance of maximum visibility in any direction varied from 3 to 110 m. The mean visibility, 24-28 m, did not vary with direction (ANOVA, $P>0.05$). Prevailing winds in spring are from the south-west. The mean areas of visibility were not different in the windward, south to west, and in the leeward, north to east, quadrants (t-test, $P>0.05$). Visibility at mature hardwood and mixed forest sites was greater than at conifer sites, but there was substantial variation within habitats (Table 5).

Hiding cover was up to 117 m from calving sites, but was often within 20-30 m (Table 4). Sites in mature hardwood forests were

Table 5. Comparison[a] of features of calving sites of moose among major habitat types

	Mean±standard deviation by habitat[b]				
Shore[c]	HDCON	LDCON	MIX	EDGE	HARD
(island site)	33±23	64±33	89±20	97±46	105±29
Visible area	HDCON	LDCON	EDGE	MIX	HARD
(m^2)	811±244	1521±1487	2018±1247	3481±2320	3706±2585
Shelter tree[c]	LDCON	HDCON	MIX	EDGE	HARD
	2±2	2±2	3±2	3±2	48±52
Hiding cover[c]	HDCON	LDCON	EDGE	MIX	HARD
	12±7	13±11	18±12	37±28	44±27
Canopy opening[c]	HARD	EDGE	MIX	LDCON	HDCON
	0±0	4±6	5±3	20±25	31±28
Overhead conifer	HARD	EDGE	MIX	HDCON	LDCON
cover (%)	5±17	48±29	54±29	70±19	79±16

[a] Each variable varies among habitats (ANOVA, $p<0.05$). Values not underscored by the same line are different (Newman-Keuls, $p<0.05$). Other variables in Table 4 not different among habitats (ANOVA, $p>0.05$) (length of hill, position on hill, and distances to campsite and shore closest to other land). Statistical analyses used log transformation of distance and area measurements, arc sine transformation of percent.

[b] Hardwoods (HARD); mixed conifer-hardwood (MIX); hardwood-conifer ecotone (Edge); high density conifer (HDCON); low density conifer (LDCON). Number of sites as given in Table 1.

[c] Minimum distance from bed (m).

farther from hiding cover than those in conifer forests or hardwood-conifer edge sites (Table 5). Hiding cover most often was dense vegetation but sometimes was composed, at least in part, of topographic features. The index of shelter was low at all mature hardwood sites and high at all but one conifer site. Shelter at mixed forest and hardwood-conifer ecotone sites was medium (9 of 13 sites) or low. Overhead conifer cover and distance of bed from a shelter tree followed a similar pattern (Table 5). Trees judged to be shelter trees were most frequently hemlock (40%), white spruce (25%) and balsam fir (20%). All sites in mature hardwood habitats were open to direct sunlight or precipitation prior to leaf-out (Table 5).

Fallen trees presented a barrier to easy mobility at some calving sites, but were generally not abundant. The number of fallen trees was low at almost 75% of the sites and was high at only 3 of 54 sites.

A single bed was found at 16 of 54 calving sites. Five or fewer beds were found at 80% of calving sites. However, 11, 15 and 23 beds were found at 3 sites. The maximum distance between beds at a site was 3-206 m ($\bar{x}$ = 67, median 52). The area of a site, when 3 or more beds were present, was 32-8500 m^2 ($\bar{x}$ = 1210, median 434). Beds were often in more than one habitat when numerous beds were present at a site. However, there was no consistent use of beds in either one or in a variety of habitats.

Eleven sites were located at habitat edges. Other sites were 7 - 245 m from edges ($\bar{x}$ = 53, median 34).

DISCUSSION

Moose used a variety of habitats for calving and postpartum activities in Algonquin Park. Beds were found at sites with tree densities less than 200/ha and over 2000/ha; at sites with no conifers and sites with trees exclusively conifer; and at sites a few metres from a shoreline and up to 600 m from a shoreline. Other physical attributes of calving and postpartum sites also were extremely variable.

Discovery and types of calving and postpartum sites likely were influenced by the character of the forest and by search techniques. Few sites were found within early successional forests perhaps because such forests were uncommon in the study area. Sites found may have been much closer to water than if areas searched had been selected in a random manner and if access had not depended on float planes and boats. Relative use of island and mainland sites for calving cannot be inferred from our data because the majority of time was spent searching islands where calves were most easily captured for other studies. No calving sites were found in bogs and fens but bogs and fens were not present on islands.

Food and water are requirements at or near calving sites, certainly for those cows which remain at a site for a number of weeks. Food and water were near calving sites of moose in the U.S.S.R. (Knorre 1959), Wyoming (Altmann 1963), and Maine (Leptich and Gilbert 1986). Calving sites in Alaska were not within 75 m of water (Stringham 1974). In the present study, 34 (63%)sites were within 100 m of water and some mainland sites were several hundred metres from water. The observed proximity to drinking water obviously meets the needs of cow-calf groups during the calving and early postpartum period.

Calving sites in Algonquin Park were not evaluated for relative abundance of food. However, densities of shrubs and browsable trees were low at and near many sites. Although moose did feed on herbaceous plants near the beds, there was little evidence of browsing. The limited browsing may be accounted for, in part, by the limited time that cows had been on many sites before our discovery of them, by their grazing on newly emerged herbs, and by possible reduced feeding by cows during the calving and early postpartum period. Aquatic plants are important foods of moose in late May and June in Ontario (Fraser *et al.* 1982). However, concentrations of aquatic plants were uncommon around islands with calving sites and near mainland calving sites. Nevertheless, most sites in this study, like those found in Sweden (Markgren 1969), probably were not chosen because of a relatively high abundance of food.

Seclusion and shelter are provided by similar features in some habitats but not in others. Both were typical of moose calving sites in Wyoming (Altmann 1963). Most calving sites in Alaska were in dense to moderately dense cover (Stringham 1974) and calving sites in Sweden were found in a variety of habitats, but were usually in areas secluded from surrounding terrain (Markgren 1969; Cederlund *et al.* 1987). In the present study, calving sites in conifer habitats had many features offering seclusion and shelter. Calving sites in hardwood-conifer edge sites were also sheltered with measurements for many shelter characteristics overlapping those of conifer sites. However, approximately half of calving sites were in unsheltered locations, at least early in the calving period. These included sites in mature hardwoods, in mature mixed forests, at the few sites with early successional vegetation, and the sites in forest openings. Thus, there is evidence that, for this study area and the weather conditions experienced during the four years of the study, shelter from inclement weather for neonates was not critical to their survival.

There are advantages and disadvantages for moose being in areas with limited shelter in mid to late May. Adult moose are extremely cold tolerant and easily heat stressed (Renecker and Hudson 1986). On warm days, moose may become overheated on calving sites in open habitats. Obviously this was not a serious problem since, at many sites, all beds were almost fully exposed to sunlight prior to leafout of hardwoods. Avoidance of heat stress by cows may be facilitated by the advanced state of moulting of winter hair by late May. The insulative qualities of the coat of neonates is obviously sufficient to maintain their body temperature despite the occurrence of some freezing weather and occasional snowfalls during the first two weeks postpartum.

The potential for conflict with humans was not a major determinant of the location of calving sites. Campsites were present on most of the islands, near most mainland calving sites, and were heavily used during the calving period. There may be a minimum distance from campsites that moose tolerate, since almost all calving sites were separated from campsites by at least 150 m or by a cliff or steep hill. However, calving sites usually could have been situated much farther from campsites than they were. Humans at campsites may not be a threat to moose since campers spend little time away from the campsite while on shore and since moose in Algonquin Park are not hunted.

Moose may choose specific sites for calving in Algonquin Park as an antipredator tactic. This might possibly occur even on islands and peninsulas where moose may have already isolated themselves from predators (Seton 1909; Peterson 1955; Klein *in* Stringham 1974; Stephens and Peterson 1984). Timber wolves and black bears are predators of moose in or near the study area (Pimlott *et al.* 1969, Voigt *et al.* 1976, Wilton *et al.*. 1984).

In Algonquin Park, wolves rarely pursued white-tailed deer (*Odocoileus virginianus*) into water (Pimlott *et al.* 1969). Both water and conifer cover are reported to be important to moose in encounters with wolves (Stephens and Peterson 1984). Conifer sites would appear advantageous, therefore, because they are usually close to water for escape from predators. Why, then, are such a high proportion of calving sites remote from water escape routes?

There could be disadvantages for moose using the conifer calving sites closer to water. Wolves in Algonquin Park used low areas adjacent to swamps and beaver ponds as resting sites and their movements were concentrated along water courses (Joslin 1967; Voigt 1973). Beaver (*Castor canadensis*), the principal summer prey of wolves in Algonquin Park during the 1970's (Voigt *et al.* 1976), foraged within a maximum of 50 m of ponds (Hall 1971). If beaver remained an important summer prey during the present study, much of the hunting by wolves may have been in habitats close to water. In this case, moose calving at shoreline conifer sites could have potentially increased exposure to wolves. There are no similar data for hunting habits of black bears within the study area.

Bergerud *et al.* (1984) proposed that cow caribou in British Columbia reduce predation by wolves on calves by moving from valleys into rugged mountains, leaving areas where wolves and their prey, other caribou and moose, are concentrated. Similarly, moose using calving sites in hardwood forests on hills away from the water may reduce predation by avoiding areas commonly used by wolves. Another advantage of hardwood calving sites is that young calves can more readily follow their mothers to safety in open habitats. In dense habitats, calves frequently get caught on windfalls or dense shrubs when pressed to keep up with the cow. Also, open habitats on hills may enhance early detection of approaching predators by sound or sight and permit earlier initiation of avoidance responses.

The absence of close hiding cover and water for escape at elevated hardwood and mixed sites may be less compromising for moose than for smaller cervids, such as white-tailed deer. White-tailed deer tend to hide their young and spend much time away from them (Lent 1974) whereas in the present study moose stayed with their young during the early postpartum period. Moose are large enough to defend their young. Cows often attacked vigorously when we restricted their access to water or approached close to their calves. Lockhart (1890, *in* Seton 1909) and Altmann (1963) reported similar defense of young by cow moose. Therefore, cow moose at bedding sites in open hardwood forests may not only reduce the risk of contact with predators, but may also be able to better defend their young against attacks by predators than would be possible in dense habitats.

The nearest shore to a calving site is not necessarily the likely route for a cow and calf to leave an island. The distance from the nearest shore to other land was often further than a calf could easily swim. Young calves have difficulty swimming more than about 200 m following some running on land. In contrast, the shortest water distance from calving islands to other land was within easy swimming distance and was the route usually used by cows and calves for leaving islands during our searches. Calving sites seldom were located near this preferred escape route. The area of the island closest to the preferred escape route is also the probable location at which predators would come onto islands.

Islands may be special cases for habitats used for calving. For example, predators may rarely go to islands in ice-free seasons. We found predators (black bear) on an island once in more than 300 searches of islands during this study. If perhaps moose do select calving sites in part for their specific predator avoidance characteristics, one could imagine this selective pressure being reduced once on islands. If this occurred, it would be reasonable to hypothesize differences in predator avoidance characteristics between island and mainland calving sites. It was inappropriate to address this hypothesis in the current study because of the large variation in characteristics of calving sites and because of the small number of island and mainland sites.

The present study demonstrates that moose in central Ontario use a variety of habitats for calving and postpartum bedding sites. No features were found to be characteristic of most calving sites. Abundance of food and water, shelter from the elements and immediate proximity of water and cover for escape from predators were not prominent features of calving sites. The study does not permit conclusions regarding selection of calving habitats. However, the possibility that selection of calving sites in part to avoid predators cannot be ruled out. Preservation of habitats with specific characteristics appropriate for calving by moose may be important in some areas. However, this may be unimportant in our study area because of the wide variety of habitats used for calving.

This study identifies future research possibilities. Future studies should determine the adaptability of cow moose for calving in the diversity of habitats and successional stages in uncut boreal forest and in boreal forests cut using modern timber management techniques. It would be instructive to compare calving sites on mainland and island locations in our study area for inferential evidence of selection of sites for antipredator characteristics. Future studies could also evaluate the predictability of sites being in fairly open habitat and on the upper elevations of slopes. Design of studies to address hypotheses about selection of specific types of habitat for calving by moose should anticipate considerable variation in data and the need for many more calving sites than were available in the present study.

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