CHARACTERISTICS OF MOOSE CALVING SITES IN NORTHERN MAINE AS DETERMINED BY MULTIVARIATE ANALYSIS: A PRELIMINARY INVESTIGATION[1]

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Abstract: An initial effort was made to describe moose calving sites in Maine using a more quantitative approach than previously has been attempted. Ten calving sites were compared to 20 randomly selected sites in northern Maine. Stepwise discriminant analysis was used to select variables that best described the differences between the two groups. Six variables were important in distinguishing calving sites from random sites. The discriminant function that describes site differences is presented. Calving sites in Maine are characterized as undisturbed and poorly drained areas often dominated by cedar although non-forested calving sites were also represented. They are typically close to water and may have small diameter browse species present on the site. Validation of the model by the jackknifed classification procedure demonstrated that the model correctly classified 96.7% of the sites.

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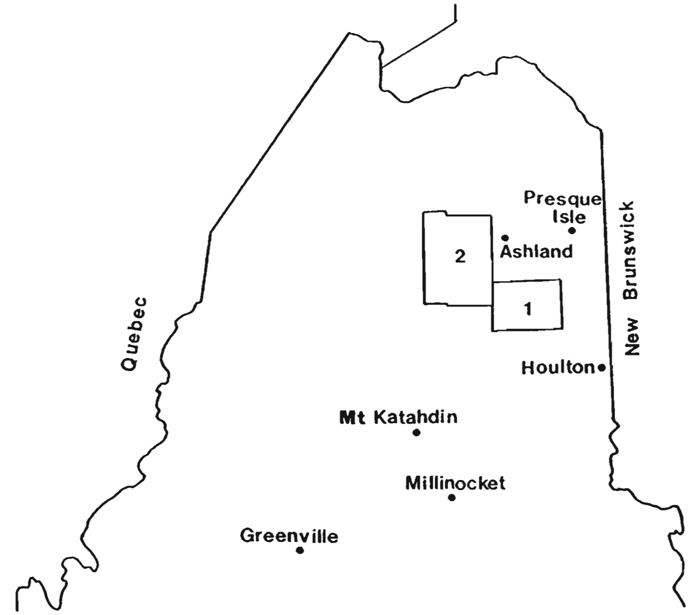
Descriptions of moose (*Alces alces*) calving sites are not new. Peterson (1955), citing personal observations and the works of Seton (1927), Clarke (1936), and Cowen (1946), suggested that, just before giving birth, cows seek secluded areas, frequently selecting peninsulas and islands. Three characteristics were typical of moose calving sites in Wyoming: secluded shelter, available browse, and proximity to a source of water (Altmann 1958, 1963). In contrast Markgren (1969) found no evidence that calving sites in Sweden were near food or water. Seclusion seed to be the most consistent feature of the sites he examined. Stringham (1974) indicated that moose in Alaska selected moderately dense to dense forested stands dominated by paper birch (*Betula papyrifera*), and trembling aspen (*Populus tremuloides*). Cows fed on plants available at the calving site and water was always more than 75 meters from the site.

This study is part of an ongoing cooperative research effort by the Maine Department of Inland Fisheries and Wildlife, the Maine Cooperative Fish and Wildlife Research Unit, and the University of Maine to examine seasonal home range and habitat relationships of moose in Maine. It attempts to objectively characterize moose calving sites in Maine and develop a model that can be used to classify potential calving locations.

STUDY AREA

This study was conducted on two separate study areas in northern Maine. One is centered at Mooseleuk lake in Piscatiquis County and the other is centered at St. Croix Lake in Aroostook County (Figure 1). Most of the land on which this study was conducted is privately owned paper company land. Commercial timber harvests occurred on both areas during this study. A small portion of the St. Croix Lake study area was treated with herbicides late in the summer of 1984. Both study areas have extensive networks of logging roads that facilitated ground telemetry. Moose on both study areas have been subjected to legal hunting since 1980.

The study areas lie within the spruce-fir-northern hardwoods zone described by Westveld et al. (1956). Beech (*Fagus grandifolia*), yellow birch (*Betula alleghaniensis*), and sugar maple (*Acer saccharum*), predominate on lower slopes and well-drained flats. paper birch, aspen (*Populus* spp.), and red maple (*Acer rubrum*) tend to occupy higher mountain elevations or more poorly drained sites. Red spruce (*Picea rubens*), white spruce (*P. glauca*), and balsam fir (*Abies balsamea*) are the predominant softwoods and generally occupy the upper slopes and lowlands. Black spruce (*Picea mariana*), northern white-cedar (*Thuja occidentalis*), tamarack (*Larix laricina*), and hemlock (*Tsuga canadensis*), are also common, particularly on the most poorly drained sites. White pine (*Pinus strobus*) occurs as individual trees or in small groupings across the area.



1- St. Croix Lake Study Area
2- Mooseleuk Lake Study Area

Figure 1. Location of study areas in northern Maine.

METHODS

Moose calving sites were located by monitoring radio-collared cows with ground telemetry during late May and early June in 1984 and 1985. During the first three days after parturition, cows remain in the immediate vicinity of the newborn calf (Peterson 1955, Altmann 1958, 1963). When three consecutive of radio relocations indicated this sedentary behavior we walked in on foot with the radio equipment and attempted to locate the cow and her calf. When visual observations were unattainable, were searched the area for calf tracks, beds, blood and afterbirth to confirm the presence of a new calf.

We did not to observe actual births. Therefore, locations of all calving sites were inferred (Markgren 1969, Stringham 1974). But because we were able to get close to the cow-calf group before being detected and found indirect evidence of a new birth, we believe the data accurately reflect conditions at the calving sites.

Three prism plots (Avery 1975) were measured at each calving site. The first tree sample point was centered at the calving site. The second sample point was located 10 paces away along a random compass bearing. The third sample point was also located 10 paces away from the first point but along a bearing 90 degrees clockwise to the random bearing. Canopy closure was estimated using a spherical densiometer. Tree species and diameter breast height (DBH) were recorded for each tree tallied and used to calculate basal areas and stem densities. Percent cover of

shrubs, forbs, and dead and downed matter (including slash) was estimated using the step-point technique (Hays et al. 1981) at 20 points (the paces to the second and third sample point). A clinometer and compass were used to determine slope and aspect at the site. Distances to roads and water (seeps, streams, and ponds) were determined on the ground when distances were short, or with aerial photography when distances were long. Similar information was collected on 20 random sites within the study area. The locations of random sites were determined by generating pairs of random Universal Transverse Mercator coordinates.

Because each tree species generated 4 variables and each shrub species represented a separate varaible, the total number of variables (102) exceeded the number of observations (30), making it necessary to reduce the dimensions of the problem. A Principal components analysis was done on the variables to see what factors underlie the distribution of the variables and which variables explained the greatest amount of variation in the data set. Twenty-six variables that best defined the endpoints of the factor axes were selected. Because some variables were highly correlated ($r \geq 0.7$), those which explained less of the variation were deleted (Chatfield and Collins 1980), leaving 21 variables for discriminant function analysis.

Stepwise discriminant analysis was performed using SAS and BMDP statistical packages. Significance levels for entry into and removal from the model were set at alpha ≤ 0.1 (Costanza and Afifi 1979). A jackknifed classification procedure was used to validate the model (Jennrich and Sampson 1983).

RESULTS AND DISCUSSION

Principal components analysis indicated that moose calving site selection was influenced by stand density, tree size, drainage and accompanying upland or lowland vegetation, stand closure, and site disturbance. Twenty-one variables reflecting these underlining factors were retained (Table 1) for use in the stepwise discriminant analysis.

Random and calving sites were best discriminated by the variables: red spruce basal area, cedar basal area, aspen basal area, percent raspberry cover, red maple DBH, and distance to water. The discriminant function that incorporates these variables into a predictive model is:

$$f_x = 5.46 - 0.26\ \text{PIRUBA} + 0.30\ \text{THOCBA} - 2.14\ \text{POTRBA} - 0.40\ \text{ACRUDBH} - 1.02\ \text{DISTW} - 0.12\ \text{RUSP}$$

(see Table 1 for explanation of acronyms)

The sqauared canonical correlation for this model was 0.806. Because sample sizes were too small to allow validation using independent data, a jackknifed classification was used, resulting in a 96.7% correct classification (Table 2).

The variables and their coefficients imply certain site conditions characterizing moose calving sites in northern Maine. As the values of the variables with negative coefficients

Table 1. Variables retained for stepwise discriminant analysis of moose calving sites from random sites in Maine, 1984 - 1985.

Variables	Codes	Mean		Standard deviation	
		Calving	Random	Calving	Random
Stand closure (percent)	CLOSE	67.00	75.20	32.90	22.30
Mean diameter breast high[1]	MEANDBH	15.21	7.87	7.39	5.10
Percent cover of *Linnaea borealis*	LIBO	4.00	3.25	8.10	7.12
Red spruce basal area[2]	PIRUBA	3.93	8.53	4.17	10.82
Balsam fir					
basal area	ABBABA	6.33	5.93	6.75	6.91
diam. breast high	ABBADBH	13.56	10.53	17.47	8.47
Cedar					
basal area	THOCBA	15.00	0.53	13.35	1.38
diam. breast high	THOCDBH	19.57	6.12	11.75	13.90
Beech					
basal area	FAGRBA	0.07	1.53	0.21	3.31
diam. breast high	FAGRDBH	3.25	3.02	10.28	5.79
Yellow birch					
basal area	BELUBA	0.67	1.67	1.13	2.23
diam. breast high	BELUDBH	8.20	18.31	13.36	18.64
Sugar maple					
basal area	ACSABA	1.00	2.80	1.64	4.33
diam. breast high	ACSADBH	9.14	6.15	15.77	10.32
Red maple					
basal area	ACRUBA	0.00	4.30	—	5.14
diam. breast high	ACRUDBH	0.00	9.71	—	10.87
Aspen					
basal area	POTRBA	0.00	0.37	—	1.34
diam. breast high	POTRDBH	0.00	1.74	—	5.11
density	POTRDNSY	0.00	80.10	—	304.00
Percent cover raspberry (*Rubus* spp.)	RUSP	6.00	21.25	9.37	30.47
Distance to water (100 meter units)	DISTW	0.10	5.45	0.32	3.44

[1] Centimeters.
[2] Meters^2 / hectare.

Table 2. Jackknifed classifications of moose calving sites and random sites using the discriminant function from Maine, 1984-1985.

Group	% correct	Number of sites classified into group	
		Calving site	Random site
Calving site	100.0	10	0
Random site	95.0	1	19
Total	97.5	11	19

decrease and the values of those with positive coefficients increase, the site is more likely to be classified as a calving site.

Eight of the calving sites were in forested habitats. The other two sites were in unforested habitat on the margin of bogs.

Red spruce and cedar are both representative of lowland vegetation. Somewhat unexpectedly their coefficients have opposite signs. Red spruce achieves better growth on moderately moist, better-drained sites (Harlow et al. 1969) while cedar is commonly the dominant species on poorly drained sites (Westveld et al. 1956). Thus moose are not simply selecting lowland areas, but are using the more poorly drained sites with small red spruce dominated by cedar as calving sites.

Aspen and raspberry are both indicative of site disturbance (Bormann and Likens 1979, Harlow et al. 1979). The negative coefficients of aspen basal area and percent raspberry cover indicate that as these values increase, suggesting more extensive or more recent disturbance, the less likely it is to be a calving site.

The negative coefficient of red maple indicates that as DBH increases the site is more likely to classified as random. Red maple is common on poorly drained sites but is also found growing on moist upland with the northern hardwoods (Harlow et al. 1979). Red maple is an important browse species (Peek 1974). As DBH increases the potential for red maple to provide forage decreases. Small red maples may be an important forage species associated with the poorly drained sites that are selected for calving. This would be consistent with the observations of Altmann (1958, 1963) and Stringham (1974) that moose feed on the calving sites. Although small red maple were at, or immediately adjacent to, several calving sites it should be noted that red maple was not recorded within any of the tree sample plots at calving sites. Therefore, it is possible that this is simply an artifact of the small sample size.

The negative coefficient for distance to water indicates that sites close to water are more likely to be selected for calving than those at a distance. The mean distance to water from calving sites was less than 100 meters while the distance from random sites was more than 500 meters. This contrasts with Markgren's (1969) findings and concurs with Peterson (1955), Altmann (1958,1963), and Stringham (1974).

Moose calving sites may be characterized as undisturbed and poorly drained sites often dominated by cedar although non-forested calving sites area also represented. Calving sites are typically close to water and may have small diameter browse species present on the site. It is encouraging that the model is in general agreement with earlier subjective observations in regard to proximity to water and presence of food on the site. It is our observation that moose select secluded sites, as noted by earlier workers, but it is difficult to quantify such a characteristic. The model may hint at seclusion by its suggestion that moose select physically undisturbed sites, although lack of physical disturbance and seclusion are not strictly synonymous.

Because of the limited data available for constructing the model it is premature to draw more than general conclusions or make specific management recommendations. This study is valuable in demonstrating that moose are selective in their choice of calving sites and that important characteristics of those sites can be quantified. As more data are collected and the model refined it can become a useful tool for directing management policy and decisions.

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