CHARACTERISTICS OF NEONATAL MOOSE HABITAT IN NORTHERN NEW HAMPSHIRE

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ABSTRACT: Habitat use by parturient moose (*Alces alces*) may have important implications for calf survival and subsequently influence population dynamics. Because neonatal habitat may be limiting or specialized and little descriptive information exists in the northeastern United States, this study was conducted to measure the physical and vegetative characteristics associated with neonatal habitat of 30 maternal moose. There was no difference ($P > 0.10$ for each parameter) in 22 of 23 physical and vegetative parameters measured at neonatal ($n = 30$) and random sites ($n = 30$). However, neonatal sites were about 2X farther ($P = 0.032$) than random sites from cut/regeneration habitat where no neonatal site occurred. Most neonatal sites (> 63%) were located in pole or saw timber stands comprised of mixed or coniferous habitat (> 75%); conifers were the dominant canopy species at 67% of neonatal sites. Characteristics related to forage availability suggest that forage resources were probably not influential in location of neonatal habitat. Mature, mixed, and coniferous habitats may provide microhabitat that helps conceal neonates from potential predators such as black bears (*Ursus americana*), particularly in the absence of islands and open water that are believed to mitigate predation.

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Calf survival is an important factor affecting moose (*Alces alces*) population dynamics (Gasaway et al. 1977, Franzmann et al. 1980), and predation by black bears (*Ursus americana*), brown bears (*Ursus arctos*), and wolves (*Canis lupus*) often occurs in the first few weeks postpartum (Schwartz and Franzmann 1989, Ballard et al. 1991, Osborne et al. 1991, Testa et al. 2000, Bertram and Vivion 2002). Calf mobility following parturition is limited and movements are restricted for 1-2 weeks postpartum (Addison et al. 1990, Langley and Pletscher 1994, Bubenik 1998, Testa et al. 2000). Consequently, the cow-calf pair frequently remains within 20-50 m of the birthing location for up to 2 weeks (Stringham 1974). Habitat use by parturient moose (i.e., neonatal habitat) may have important implications for survival of newborn calves and ultimately affect population dynamics.

Research throughout moose range suggests that habitat features such as open water (Altmann 1958, Bailey and Bangs 1980, Leptich and Gilbert 1986), islands and peninsulas (Clarke 1936, Peterson 1955, Stephens and Peterson 1984, Addison et al. 1993, Testa et al. 2000), and elevated and open sites (Wilton and Garner 1991, Bowyer et al. 1999) provide security for neonates through enhanced detection and avoidance of predators. Vegetative features such as dense or patterned vegetation (e.g., variable canopy cover that creates patches of light and dark areas; Bowyer et al. 1999) may conceal calves and reduce predation risk (Stringham 1974, Leptich and Gilbert 1986, Langley and Pletscher 1994). Further, because lactation is energetically costly (Renecker and Hudson 1986, Schwartz and Renecker 1998),

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selection for quality habitat and forage may relate indirectly to predation rates.

Recent population indices suggest that New Hampshire's northern moose population may have approached stability, despite moderate harvest and presumably favorable habitat. Characteristics of neonatal habitat have not been thoroughly measured in northern New Hampshire, though Leptich and Gilbert (1986) indicated that calving sites in north central Maine contained available forage and were close to water. This study was performed to describe habitat used by parturient moose and determine whether these habitats have specialized features for management consideration. This study was performed in tandem with seasonal habitat and reproductive measurements as part of an extensive 4-year research project. Information from this study will help resource managers evaluate the influence of land use activity on parturient moose and neonatal habitat.

METHODS

Study Area

The study area encompassed approximately 1,000 km^2 of primarily commercial forest land within eastern Coos County, northern New Hampshire (Fig. 1). Much of the study area was in the Androscoggin River

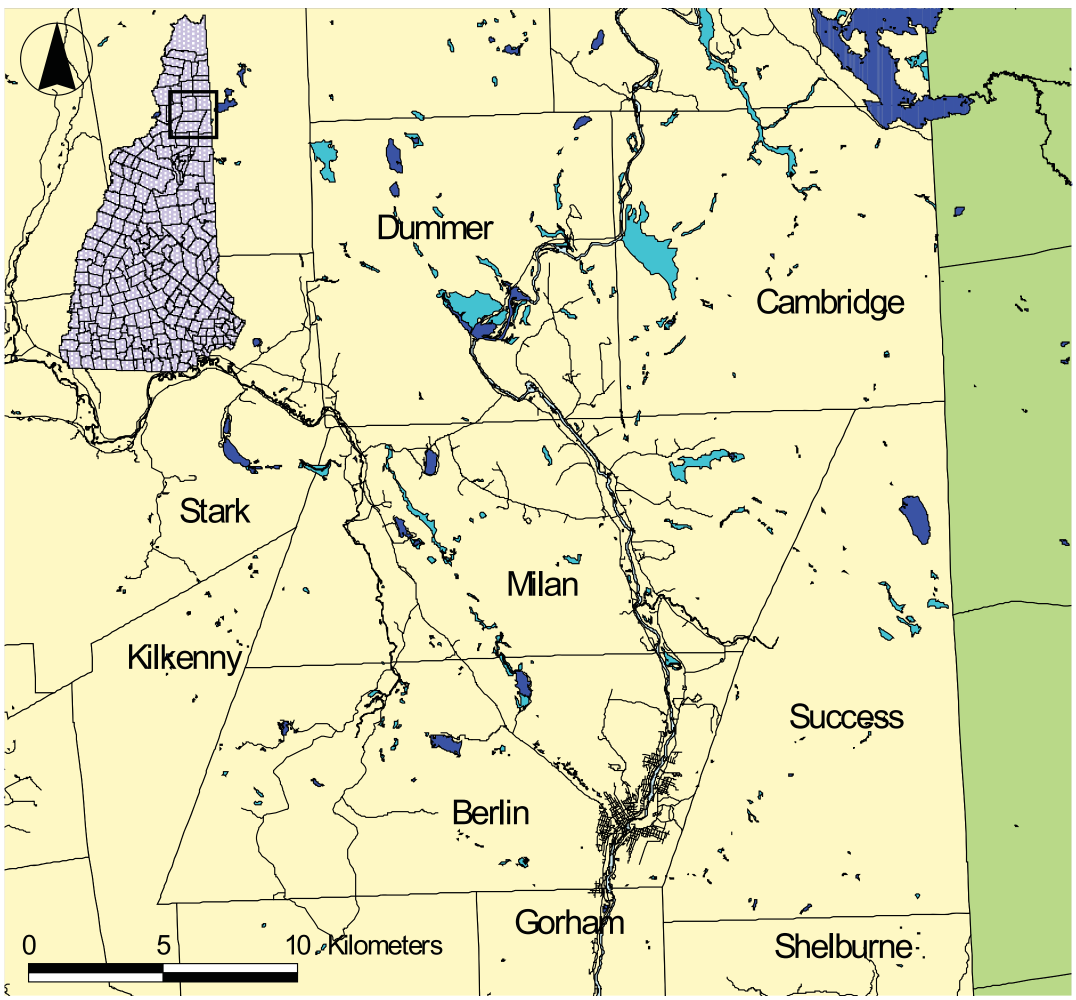

Fig. 1. Approximate geographic location of the 4-year study of moose habitat and population dynamics, December 2001 – August 2005, Coos County, New Hampshire, USA.

watershed where numerous intermittent and perennial streams flow from medium to large mountains with elevation ranging from 300 to 1,200 m. Harvesting of pulp and saw logs was the primary land use. Small areas of cultivated land and pasture occurred primarily adjacent to the Androscoggin River. Motorized (e.g., snowmobiling and ATV), non-motorized (hiking, cross-country skiing, wildlife viewing), and consumptive (e.g., hunting, trapping, and fishing) forms of recreational use by the public were common. Predators in the study area included black bear, coyote (*Canis latrans*), and bobcat (*Lynx rufus*). The estimated moose density was 0.7 moose/km^2; white-tailed deer (*Odocoileus virginianus*) were sympatric with moose throughout the area. Both sexes of moose are hunted annually by a permit-lottery system; hunter success rates typically exceed 85% within the study area (NHFGD 2003).

Dominant forest types were northern hardwoods (36%) as a mix of yellow birch (*Betula alleghaniensis*), American beech (*Fagus grandifolia*), and sugar maple (*Acer saccharum*) on well-drained sites, spruce-fir forests (21%) consisting almost entirely of red spruce (*Picea rubens*) and balsam fir (*Abies balsamea*) on poorly-drained or nutrient-poor sites, and mixed forests (23%) consisting of northern hardwood and spruce-fir species (Degraaf et al. 1992). Other important vegetative communities (16%) were clearcuts and regenerating stands of quaking aspen (*Populus tremuloides*), paper birch (*Betula papyrifera*), and pin cherry (*Prunus serotina*). Numerous wetlands including bogs, marshes, and beaver (*Castor canadensis*) flowages were common. Small developed areas of residential and industrial buildings were minimal and located sporadically. Average annual precipitation was > 100 cm and occurs mostly as snowfall from November-March; seasonal temperatures ranged from < -30 to > +30˚C.

Field Sampling

Direct observations of radio-collared cow moose were attempted by stalking them to within sighting distance 1 – 2 times weekly from 1 May to 1 August, 2003–2005. Incomplete leaf-out in early-mid May provided optimal conditions to observe maternal moose. Neonatal habitat was defined as the site where an observed calf was estimated as 0 – 3 days old based on their limited mobility (Stringham 1974, Larsen et al. 1989). No births were positively identified, although leaf litter and ground-cover vegetation were heavily disturbed at the presumed birth site of several calves. Based on the frequency of monitoring and the limited mobility of calves, it was assumed that sampled habitat was representative of neonatal habitat associated with the birth site. Vegetative sampling was centered at the exact location the calf was first observed.

A random sample of 10 maternal cows was selected each summer to generate 30 neonatal sites. Of 50 random UTM coordinates generated within the 90% adaptive kernel spring home range of each maternal cow, one coordinate was chosen randomly and sampled in an identical manner as the neonatal site. Because moose are not territorial, random points could have occurred within neonatal habitat of another maternal cow.

Physical and vegetative parameters were measured at neonatal and random sites to evaluate the presence and preference of various habitat characteristics. Canopy coverage was estimated using a concave spherical densiometer held at breast height (1.5 m) at the plot center, and equaled the average of 4 measurements taken in each cardinal direction from plot center. The percent shrub-level density was estimated as the proportion of a 2 m tall x 1 m wide white sighting sheet covered by vegetation at 15 and 30 m from plot center. Shrub density was estimated at low (0 – 1 m) and high (1 – 2 m) strata separately, measured in each cardinal direction, then averaged. The percent abundance of bare soil, rock, dead wood, leaf litter, moss, and forbs/grass within a 5 m radius of plot center was estimated visually. Infrequent types of ground cover (e.g., water) were classified as other. The number of snags with diameter at breast height (dbh) > 5 cm were counted, the percent shrub cover 1 – 2 m in height was visually estimated, and the proportion of ground covered by forbs, grasses, and ferns 0 – 1 m in height was estimated visually within a radius of 10 m from plot center.

The habitat type was recorded as northern hardwood, spruce-fir, mixed, cut-regeneration, or other. Stand structure was recorded as saw timber, pole, seedling-sapling, uneven aged, or recently disturbed. The dominant canopy species was recorded and the dbh of all trees within a 10 m radius of plot center was measured. The presence of edge was determined if dissimilar successional changes were visible from plot center.

The elevation, slope, and aspect were derived from digital elevation models using the Spatial Analyst extension within ArcView GIS 3.3 (ESRI 2002). Distance (m) to the nearest road (either Class III paved road or active dirt logging road), nearest open water body (large river or lake/pond), nearest palustrine wetland including beaver ponds, nearest island within a lake, pond, or river, and nearest patch of cut/regeneration habitat was measured with the Animal Movement extension version 2.0 and ArcView GIS 3.3 (Hooge and Eichenlaub 1997).

Data Analysis

Univariate histograms were used to evaluate normality and highly skewed data were appropriately log or arcsine transformed; reported means are absolute values. Differences between continuous parameters at neonatal and random sites were evaluated with two-sample t-tests. Fisher's exact test was used to detect differences between the categorical variables stand age, habitat type, dominant canopy species, aspect, and presence of edge between neonatal and random sites. All t-tests were performed using SPSS 12.0 software and Fisher's exact test was assessed with SAS version 6.

RESULTS

Vegetation and physical characteristics at 10 neonatal and matching random sites were measured each summer, 2003 – 2005. All neonatal sites were associated with cows ≥ 3 years old except one site of a 2-year-old in 2005. Neonatal and random sites were located predominantly (95%) in northern hardwood, spruce-fir, and mixed forest types. Forest cover type did not differ at neonatal and random sites ($P = 0.154$), however, > 75% of neonatal sites were located within mixed and spruce/fir forest types versus approximately 50% of random sites. No neonatal sites and 10% of random sites were located within cut/regeneration habitat. Stand structure was not different at neonatal and random sites ($P = 0.138$), although nearly twice as many neonatal sites were located within pole and saw timber stands as random sites; neonatal sites were located in uneven aged stands half as much as random sites. The dominant canopy species was not different between neonatal and random sites ($P = 0.144$); red spruce and balsam fir were dominant at > 67% of neonatal sites (Table 1).

Edge was largely absent and not different at neonatal and random sites ($P = 0.596$). Aspect at neonatal and random sites was not different ($P = 0.274$), although approximately 50% of both site types were located on south facing slopes. The mean elevation at neonatal and random sites was approximately 450 m and not different ($P = 0.797$); percent slope was low (< 5%) and similar at neonatal and random sites ($P = 0.355$) (Table 1).

Although not different ($P = 0.311$), neonatal sites (mean = 487.2 m) were 100 m farther from roads than random sites. The distances of neonatal and random sites to wetlands, perennial or intermittent streams, and open water were not different; distance to islands was similar and > 3,000 m from both

Table 1. Absolute counts and mean distances of physical parameters measured at 30 neonatal moose sites and 30 random sites in northern New Hampshire, 2003-2005.

	Neonatal	Random	*P*-value
Habitat type (number of sites)			0.15
Northern hardwood forest	7	11	
Coniferous forest	11	9	
Mixed forest	12	7	
Cut/regeneration-shrub	0	3	
Dominant canopy species (number of sites)			0.14
Northern hardwoods species	8	10	
Spruce/fir	21	15	
Aspen, paper birch, or cherry	1	5	
Stand size class (number of sites)			0.14
Seedling/sapling	4	5	
Uneven	7	14	
Pole	12	5	
Sawlog	7	6	
Presence of edge (number of sites)			0.6
Present	10	13	
Absent	20	17	
Aspect (number of sites)			0.27
Northerly (N, NE, NW)	6	3	
Southerly (S, SE, SW)	17	14	
Other (E, W, flat)	7	13	
Slope (%)	2	1.3	0.36
Elevation (m)	464.4	457.5	0.8

neonatal and random sites ($P > 0.05$ for each parameter) (Table 2). However, random sites were 2X closer to cut/regeneration patches than neonatal sites ($P = 0.032$).

The mean diameter at breast height of trees within 15 m of plot center at neonatal

Table 2. Mean distances of physical parameters measured at 30 neonatal moose sites and 30 random sites in northern New Hampshire, 2003-2005.

	Neonatal	Random	*P*-value
Distance to road (m)	487.2	384.9	0.31
Distance to wetland (m)	395.1	401.1	0.95
Distance to stream (m)	612.1	655.7	0.72
Distance to open water (m)	1,059.9	1,252.1	0.24
Distance to island (m)	3,156.5	3,384.7	0.55
Distance to cut/ regeneration (m)	136.5	69.8	0.03

and random sites (approximately 15.5 cm) was not different ($P = 0.783$), nor was the number of snags ($P = 0.711$). Mean percent canopy cover at neonatal sites (78.6%) was nearly 10% higher than at random sites, but was not different ($P = 0.228$). Mean shrub density measured at low (0 – 1 m) and high (1 – 2 m) strata from 15 and 30 m ranged from 40 to 60% at neonatal sites and was not different at random sites ($P > 0.05$ for each parameter). No ground cover feature was different between neonatal and random sites ($P > 0.05$) (Table 3).

DISCUSSION

Understanding habitat use of parturient moose could have important implications for habitat and population management of moose in northern New Hampshire where commercial forestry continually alters habitat composition and structure. Assuming that habitat use of parturient cows influences calf survival, many authors have suggested that optimal neonatal habitat should provide forage resources to support the high energy demands of lactation (Altmann 1963, Stringham 1974, Leptich and Gilbert 1986, Bowyer et al. 1999), as well as security that reduces predation risk (Stringham 1974; Bailey and Bangs 1980; Leptich and Gilbert 1986; Addison et al. 1990, 1993; Langly and Pletscher 1994; Bowyer et al.

Table 3. Means of vegetation parameters measured at 30 neonatal moose sites and 30 random sites in northern New Hampshire, 2003-2005.

	Neonatal	Random	*P*-value
Tree diameter (cm)	15.8	15.3	0.78
Number of snags	4.2	3.8	0.71
Percent overstory canopy cover (%)	78.6	69.8	0.23
Percent shrub density (hiding cover) (%)			
0–1m at 15m	48.8	51.5	0.72
1–2m at 15m	44.8	47.4	0.72
0–1m at 30m	61.4	60.3	0.91
1–2m at 30m	57.3	54.7	0.75
Average shrub density	53.1	53.5	0.95
Percent cover within 10m of plot center (%)			
Shrub (dbh <5 cm, <3 m tall)	35	46.7	0.13
Forbs/ferns	38.3	34	0.52
Percent of ground covered within 5m of plot center (%)			
Forbs/grass	32.7	35.4	0.62
Leaf litter	28.6	33.9	0.44
Moss	28.2	20.7	0.28
Dead wood	14.7	13	0.64
Soil	4.5	4.9	0.76
Rock	2.5	2.1	0.73

1999). Site location could enhance either or both forage resources and security, and the relative importance of either is probably a function of local conditions.

Peak calving in northern New Hampshire and throughout moose range occurs in mid-late May (Schwartz 1998, Scarpitti et al. 2005) when spring vegetation is generally not yet abundant. Although forage availability was not directly measured, the vegetative parameters related to forage (e.g., shrub and forb/grass cover, shrub density, and percent ground cover) were similar at neonatal and random sites (Table 3). Forage availability of preferred species (i.e., aspen, cherry, maple) at most neonatal sites was probably lower than at random sites because > 75% of neonatal sites were located in pole and saw timber stands in mixed and spruce-fir habitat. Further, neonatal sites were not closer than random sites to open water, rivers and streams, or wetlands where new growth typically emerges earliest, and were 2X farther from cut/regeneration patches than random sites. Conversely, the majority of both neonatal and random sites were located on southerly exposures where spring vegetation typically emerges earlier relative to other aspects (Table 1).

The similar vegetative characteristics at neonatal and random sites (Table 3), and increased distance to cut/regeneration patches (Table 2), indicate that forage resources were probably not influential in the selection of neonatal habitat. This may simply reflect that forage is readily accessible regardless of birth site because of high habitat heterogeneity associated with the diverse forest types and timber harvesting (cut/regeneration habitat was within 140 m of all sites sampled) in the study area. Other forestry practices such as thinning and selective harvesting of timber also produce abundant understorey vegetation, particularly in northern hardwoods. Forage resources likely become more important when peak lactation and widely available spring vegetation coincide, approximately 3 weeks postpartum when calves are rapidly growing, more mobile, and less susceptible to predation (Robbins 1993, Schwartz and Renecker 1998).

Site characteristics that provide security and reduce predation may have stronger influence on selection of neonatal habitat. Neonates are susceptible to predation and experience low survival in some regions (e.g., 18 – 50% throughout Alaska and western Canada; Ballard 1992, Ballard and Van Ballenberghe 1998). Although predation of moose calves was not documented, anecdotal accounts of local bear predation were reported, and approximately 25% of neonates did not survive 2 months post-partum (unpublished data). The majority of mortality occurred within 3 weeks of birth (Scarpitti et al. 2005) and some predation by black bears was suspected.

Use of islands, peninsulas, and sites near open water by parturient cow moose is believed to improve their ability to detect and/or escape predators (Peterson 1955; Altmann 1958; Bailey and Bangs 1980; Stephens and Peterson 1984; Leptich and Gilbert 1986; Addison et al. 1990, 1993). However, neither lake nor large riverine islands were abundant and open water was sparsely distributed in the study area; both neonatal and random sites were > 3 km from islands and > 1 km from open water (e.g., large rivers, lakes, and ponds). Other water features were common, mostly small perennial or intermittent streams and flowages, but distance to streams or flowages was similar for neonatal and random sites (Table 1). Such features probably do not improve a cow's ability to detect or escape potential predators (Langley and Pletscher 1994).

Neonatal habitat may occur at high elevation or locally elevated features (e.g., hill tops, upper slopes) to increase visibility and help detect potential predators, as reported in Ontario (Wilton and Garner 1991), Québec (Chekchak et al. 1998), and Alaska (Bowyer et al. 1999). However, no difference in overall elevation was measured at neonatal and random sites (Table 1). Although relative landscape position was not determined, the use of hilltops or upper slopes would not greatly improve visibility because of the well stocked, dense nature of forests within the study area, particularly in mixed and coniferous habitat used by most moose (Table 1).

Prior to spring leaf-out, shrub density (i.e., hiding cover) in spruce-fir and mixed forest habitat is likely greater than in deciduous habitats. Most cows (> 75%) used mixed and coniferous neonatal habitat that may conceal calves from potential predators more effectively than deciduous habitat, particularly in early spring prior to complete leaf-out. Although shrub density at neonatal and random sites was similar (Table 3), vegetation was measured in summer after leaf-out, when density is high in all habitat types potentially masking differences at birth. Measurements were delayed to minimize disturbance of parturient moose. Also, high use of mixed and coniferous habitats by parturient moose may occur in response to the concurrent low use by bears that typically seek areas of emergent vegetation in early spring (Ballard and Van Ballenberghe 1998).

Many moose populations located in more northern regions are affected by restricted nutritional condition and food resources prior to parturition, and experience high neonatal predation from large predators (Ballard 1992). However, forage resources at the southern limit of moose distribution are unlikely limiting, and neonates in this population had relatively low predation rates (20 – 25% maximum). Calf predation in many other populations range from 30 to 85%, of which black bears may account for 30 – 50% (Ballard 1992, Ballard and Van Ballenberghe 1998). Consequently, the potential production of the study population appears high in the absence of high neonate predation and restrictive food resources that influence other regional populations. Ironically, recent population estimates in the study area indicate stability. This study indicates that neonatal habitat is not likely a limiting factor.

Although overall habitat selection pressure in the study area appeared minimal on a relative scale and use of neonatal habitat was probably not influenced by forage availability, higher use of mixed and coniferous habitat suggests a predator avoidance behavior. Historically, predation may have been a stronger selective factor on neonatal habitat use when wolves, black bears, and moose existed in New Hampshire (Silver 1957). Because large islands and water bodies, or other “secluded” features are not available in this region, use of mixed and coniferous habitats likely offers the best conditions to conceal calves and improve survival in the few weeks following parturition when neonates are most susceptible. Forest harvesting practices that continually produce high habitat heterogeneity that includes early successional habitat and mature mixed and coniferous forest stands should provide optimal habitat for parturient moose.

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