CHARACTERISTICS OF POST-PARTURITION AREAS OF MOOSE IN NORTHEAST MINNESOTA

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ABSTRACT: Habitat used 3-4 weeks post-parturition is important to survival of moose (*Alces alces*) calves because neonates are vulnerable to predation, and cows require adequate forage when calf mobility is limited. Radio-collared cows were located and visually observed from helicopters from 21 May-5 June, 2004-2007 to identify post-parturition areas in northeastern Minnesota that were defined as 100 ha surrounding the cow-calf location. We determined cover type composition in post-parturition areas compared to the 95% kernel home range of moose. Buffers of 5, 10, 25, and 50 ha were created around post-parturition areas to determine cover type composition at smaller spatial scales. Post-parturition areas were also compared to equivalent areas surrounding cows without calves. Post-parturition sites had more lowland conifer and shrubland or regenerating/young forest cover types than random locations within the home range. Cows with calves selected areas with larger proportions of lowland conifer, shrublands, and regenerating forests than did cows without calves. These cover types could have been used for cover and for foraging, respectively. There was no difference in the amount of water available in post-parturition areas (3.5% ± 0.8) when compared to home ranges (3.5% ± 0.8). Distances between consecutive post-parturition locations (1.7 ± 0.4 km) were less than expected when compared to distances to random points within the home ranges (3.3 ± 0.4 km).

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Key words: *Alces alces*, calves, habitat, moose, Minnesota, post-parturition.

Moose (*Alces alces*) calving site studies have typically been conducted by searching for parturition sites 3-4 days after birth (Leptich and Gilbert 1986, Langley and Pletscher 1994, Bowyer et al. 1999). Identifying parturition sites is important because calf mobility is limited for the first 3-4 weeks after birth (Altmann 1958, 1963). Further, cows occupy a post-parturition area within their home range where the cow-calf pair lives for 3-4 weeks. This area is used during the period when calves are most vulnerable and presumably it facilitates calf recruitment into the adult population. Identifying habitat characteristics of post-parturition areas of moose in northeast Minnesota is important given that recruitment rates are currently declining (Lenarz et al. 2011).

Cow moose give birth at sites that provide some hiding cover but do not necessarily have the highest quality or quantity of forage available (Leptich and Gilbert 1986, Langley and Pletscher 1994, Bowyer et al. 1999). This is often interpreted as a trade-off between avoiding predators and meeting nutritional requirements (Bowyer et al. 1999), and may be important to consider as influencing choice of calving habitat in Minnesota where black bear (*Ursus americanus*) and wolves (*Canis lupus*) occur.

The variability in vegetative cover and density, visibility, and proximity to water has made describing calving sites difficult (Addison et al. 1990) because births may occur from hilltops to islands (Wilton and Garner 1991, Addison et al. 1993, Chekchak et al. 1998). Undisturbed lowland areas dominated by conifers and near water were associated with calving in Maine (Leptich and Gilbert 1986), as were areas with mature, mixed, and coniferous forests when water and islands were not available in New Hampshire (Scarpitti et al. 2007).

A boreal forest mix is the matrix from which moose in northeast Minnesota choose a parturition site. Important habitat types in the home ranges of moose are young mixed conifer and deciduous forests, including aspen (*Populus tremuloides*), paper birch (*Betula papyrifera*), and balsam fir (*Abies balsamea*). Early successional forests (11-30 years post disturbance) are used because forage is within reach of moose (Kelsall et al. 1977). Summer ranges consist largely of black spruce (*Picea mariana*) lowlands as well as uplands and cut over areas dominated by paper birch, aspen, and balsam fir (Peek et al. 1976). In early summer, moose generally use upland, lowland, and plantation areas in proportion to their occurrence (Peek et al. 1976).

If parturition sites are chosen from within a cow's home range, limits exist as to where a calf can be born, and the availability of suitable habitat for parturition could be important. Further, characteristics of the larger post-parturition area used by the cow-calf pair during the following 3-4 weeks have not been studied in detail. The objective of this study was to identify and describe post-parturition habitat of cow moose in northeastern Minnesota.

STUDY AREA

Lake and Cook counties (47°30'N, 91°21'W) in the Arrowhead Region of northeastern Minnesota are part of the Northern Superior Uplands (Fig. 1) (Minnesota DNR [MNDNR] 2010). The southern boundary of the Northern Superior Uplands coincides with the boundaries of the Canadian Shield as it extends into Minnesota. Upland vegetation consists of fire-dependent forests dominated by a mix of white (*Pinus strobus*) and red pine (*P. resinosa*), aspen, paper birch, white spruce (*Picea glauca*), balsam fir and white cedar (*Thuja occidentalis*). Jack pine (*P. banksiana*) stands and conifer swamps of tamarack (*Larix laricina*) and black spruce are also present. Northeast Minnesota has a humid continental climate with cold winters and warm summers. Precipitation occurs as snow (180 cm annually) with snow cover typically in December-April, and rain (70 cm annually) of which 40% occurs during the growing season.

METHODS

Adult female moose (n = 36) were captured beginning in February 2002 and fitted with radio-collars (Lenarz et al. 2009). These moose were monitored weekly for mortality from February 2002-March 2008. Annual 95% kernel home ranges were based on locations from radio-telemetry flights. The average home range size of cows used in this study was 40 ± 5 km^2 ($\bar{x}$ ± SE), ranging from 8-312 km^2 (Moen et al. 2011).

Calving begins in northeast Minnesota and Ontario around 10 May, with peak calving during the following 3 weeks (Addison et al. 1993, Bowyer et al. 1998, Lenarz et al. 2005). The parturition site was unknown because it was not known when or where calves were born prior to the time they were sighted from the helicopter during the survey period from 21 May-5 June. We assumed that if calves were present, they were observed. If no calves were observed, it was unknown whether the cow was barren, or had given birth and already lost the calf. We assumed that cows without calves (whether barren, still pregnant, or lost calf) would not operate under the same impulses as cows with calves, and therefore would exhibit different habitat preferences.

Because cows restrict movement after birth (Poole et al. 2007), we assumed the parturition site was near the post-parturition location of the cow-calf pair. We defined the post-parturition area as 100 ha (565 m radius) surrounding the post-parturition location (Poole et al. 2007). We used 100 ha as the post-parturition area because we did not know exactly when or where calves were born, but

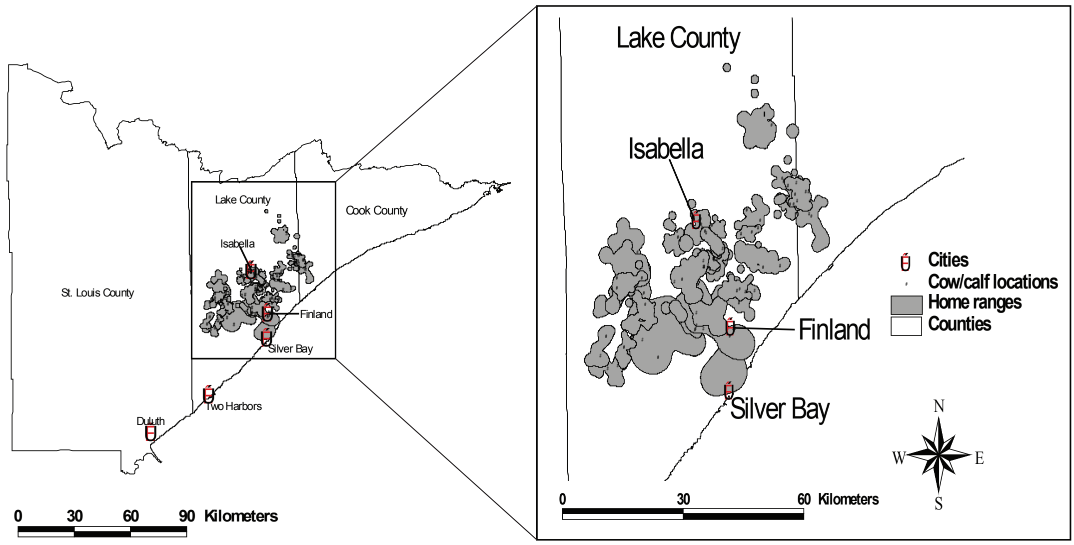

Fig. 1. Home ranges of radio-collared cows are outlined in black within the arrowhead region of northeast Minnesota (Moen et al. 2011). Dots indicate cow-calf locations obtained during post-parturition helicopter flights, 2004-2008.

a 100 ha area around the point location likely included much of the post-parturition area used by the cow-calf pair (Poole et al. 2007).

Helicopter flights from 21 May-5 June, 2004-2008 were used to locate radio-collared cows to identify presence of calves. If a cow-calf pair was observed, a waypoint was taken to establish the center of the post-parturition area; those cows were not relocated during subsequent search flights. If no calf was observed in the subsequent flight, it was assumed that the cow was barren or the calf was lost (Lenarz et al. 2010). For these cows, the location from the first flight was used as the point location for a cow without calf. Cows without calves were analyzed separately and compared to cows with calves. The position error of cow-calf locations was estimated as $\leq$100 m based on past experience (M. Schrage, unpublished data).

Post-Parturition Habitat Composition

Cover types of post-parturition areas were identified within the home ranges of cows using 2 independent satellite imagery classification systems; the Gap Analysis Program (GAP), Level II and the Land Use Land Cover (LULC) classification system. Both are raster datasets derived from LANDSAT Thematic Mapper (TM) images with 30 m resolution (MNDNR 2007). GAP Level II classifies 10 different cover types and LULC defines 16. We used the 2 coverage datasets available in Minnesota that had the highest accuracy and similar land cover classifications. The GAP coverage data was collected in 1991-1993 while LULC was collected in 1995-1996. Because of the elapsed time between the 2 coverage datasets, and because both GAP and LULC have similar cover type classifications, it was important to check for consistency between them. Some forest harvest occurred within the study area since the GAP and LULC coverage data were collected, but other major disturbance was limited. The study moose were south of a large blowdown in the Boundary Waters Canoe Area Wilderness in 1999, and south of 2 large fires in northeast Minnesota in the past 20 years.

We first identified habitat characteristics of post-parturition areas and then tested with ANOVA for variability of cover type composition near the post-parturition area at the 100 ha scale by generating 16 additional points within the defined area. The 16 points radiated from the center of the known cow-calf location at 90º angles and 100 m intervals within the post-parturition area. These 16 points were also buffered to 100 ha.

To compare cover type composition of post-parturition areas to the home range, 25 random points were generated within each home range using ArcView 3.3. Buffers of 100 ha were applied to each random point and represented potential post-parturition areas. To test whether cows with calves selected for post-parturition cover type characteristics at finer spatial scales, buffers of 5, 10, 25, and 50 ha were created around all points and locations, and each set of random points was compared to the cover type composition within post-parturition areas with ANOVAs. The estimated position error was used to set the smallest buffer size for characterizing cover type composition to 5 ha (126 m radius).

We also estimated cover type composition when cows were not observed with calves during flights. Location of cows without calves and random locations within their respective 95% kernel home ranges were examined at the same spatial scales as those of cows with calves; differences in cover type composition were determined with ANOVA and χ^2.

Water

We measured water bodies classified as lakes, rivers and streams, beaver ponds, and other available water within the 100 ha area surrounding each location on screen using Farm Service Administration (FSA) color orthophotos from 2003-2004. The FSA photos were used because the satellite imagery data did not include fine scale water features that may be important to moose. We randomly distributed 200 points across the spatial extent of the composite home ranges of all cows. Water bodies within 100 ha surrounding each random point were used to estimate overall water body availability within the study area. Water body type and availability within the post-parturition areas were also compared (*t*-tests) to water body type and availability within 100 ha around locations of cows without calves.

We also compared straight-line distance to water between cows with calves and cows without calves. Distance was measured from the known location of the animals to the nearest water body using FSA color orthophotos from 2003-2004.

Finally, we compared distance between consecutive post-parturition locations to the distance from post-parturition location to 30 random points within the home range to test whether consecutive post-parturition locations were closer together than would be expected of a random distribution.

STATISTICS

Cover types within the post-parturition areas and within home ranges at different buffer sizes were compared with ANOVA and linear regression using Statistix (version 9.0; Analytical Software, Boca Raton, Florida). Post-parturition areas of cows with calves were also compared to areas surrounding the location of cows without calves using a χ^2 test for independence. The amount of different water types were compared using ANOVAs. Differences in percent water type available between post-parturition areas and random areas were compared with *t*-tests. Means are presented throughout as $\bar{x} \pm$ SE. We used Excel 2007 (Microsoft Corp., Redmond, WA) for *t*-tests and χ^2 tests.

RESULTS

Habitat Composition

The 100 ha post-parturition area covered 4 ± 6% of the average home range. In both the GAP and LULC only 4 cover types comprised >90 ± 7% of the area within home ranges (Table 1). GAP cover type categories covering >90% of the area included lowland conifer, shrublands, upland conifer, and upland deciduous forests. In LULC the 4 cover types

Table 1. Cover type composition of the home ranges of 36 radio collared moose in northeast Minnesota using the GAP and LULC classified cover types from LandSat satellite imagery.

Gap	Percent home range cover	LULC	Percent home range cover
Lowland conifer	22 ± 0.6	Conifer	18 ± 0.5
Upland conifer	13 ± 0.4	Bog	17 ± 0.7
Shrubland	19 ± 0.5	Regenerating/ young forest	14 ± 0.6
Upland deciduous	42 ± 0.8	Mixed forest	42 ± 0.8
Sum	**96 ± 2.6**		**91 ± 7.0**

covering >90% of the area were conifer and mixed forests, regenerating/young forests, and bog (Fig. 2). Cover type classifications for GAP and LULC describe similar habitats with different names.

We identified 70 post-parturition locations, and all were in the home range of the maternal cow; certain cows had multiple births during the study. Cows with calves selected areas with more lowland conifer and shrublands (GAP), or conifer and bog (LULC) than cows without calves at all spatial scales we examined (χ^2_2 >5.9, *P* <0.004). The selection of lowland conifer and shrublands (GAP) and conifer and bog (LULC) was stronger as the buffer surrounding the post-parturition location was reduced from 100 to 5 ha. Cows without calves had less lowland conifer and shrublands and more upland conifer and deciduous in the GAP coverage (Fig. 3), and had more mixed forest and regenerating/young forests and less conifer and bog in the LULC coverage.

Cover type composition did not change as areas surrounding post-parturition and random locations were reduced incrementally from 100 to 5 ha ($F_{2, 70}$< 0.7, *P* ≥0.69). Lowland conifer was about 22% of the area in the random locations compared to 24-30% of the post-parturition areas in the GAP coverage (Fig. 4a). Similarly, in the LULC conifer was about 18% of the area in random locations compared to 17-21% of the post-parturition areas (Fig. 4b). Mean area of lowland conifer increased as the buffer around the post-parturition location was reduced from 100 ha to 5 ha, but differences were not significant because of high variability among cows. The contrast between random locations and post-parturition locations suggests that some non-random actions were occurring associated with the lowland conifer cover type. Upland deciduous forest may be negatively correlated with

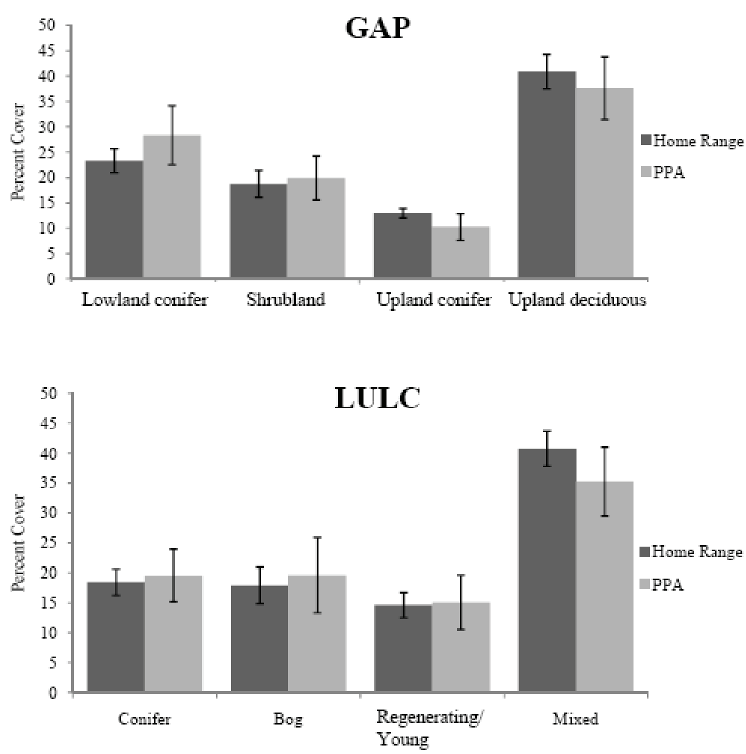

Fig. 2. Cover type composition in 100 ha areas around random areas in the home range and in 100 ha areas around the post-parturition locations using GAP and LULC datasets, northeastern Minnesota.

lowland conifer ($P = 0.051$, n = 70), however the increase in lowland conifer ($R^2 = 0.006$, $P = 0.12$) and subsequent decrease in upland deciduous ($R^2 = 0.0014$, $P = 0.48$) were not correlated as buffer size declined.

We divided cows with calves into 3 groups based on lowland conifer within post-parturition areas compared to lowland conifer within home ranges (Fig. 5). The 3 groups were defined as to whether lowland conifer in the post-parturition area was above, within, or below the 95% confidence interval of the random potential post-parturition areas within the home range of each cow. The variability among groups indicates why we found no significant differences in mean value of lowland conifer between random and post-parturition areas. Within the group with higher than expected lowland conifer in the post-parturition area (41% of cows), there was a subgroup (5 of 29) with >80% lowland conifer in the post-parturition area while home ranges had about 20% lowland conifer available.

Water

Cows with calves were closer to water than cows without calves ($p = 0.011$) (Fig. 6). The amount of water bodies in post-parturition areas was not different from the amount in random areas distributed across the study area (Fig. 7). Lakes, rivers and streams, beaver ponds, or other water were present in 80% of post-parturition areas, 60% of random areas, and 70% of areas surrounding cows without calves. Water covered about 3.5 ± 0.8% ($\bar{x}$ ± SE) of the area within 100 ha areas randomly distributed throughout the spatial extent of all home ranges. This was the same as the 3.5 ± 0.8% water measured within 100 ha post-parturition areas. Cows without calves had half as much water within 100 ha (1.6 ± 0.5%); the largest difference being the absence of lakes. Post-parturition areas and random areas consisted of approximately 2.5 ± 0.8% lakes, while areas around cows without calves were about 1.5 ± 0.3% lakes. Beaver ponds were present in 27% of 100 ha post-parturition

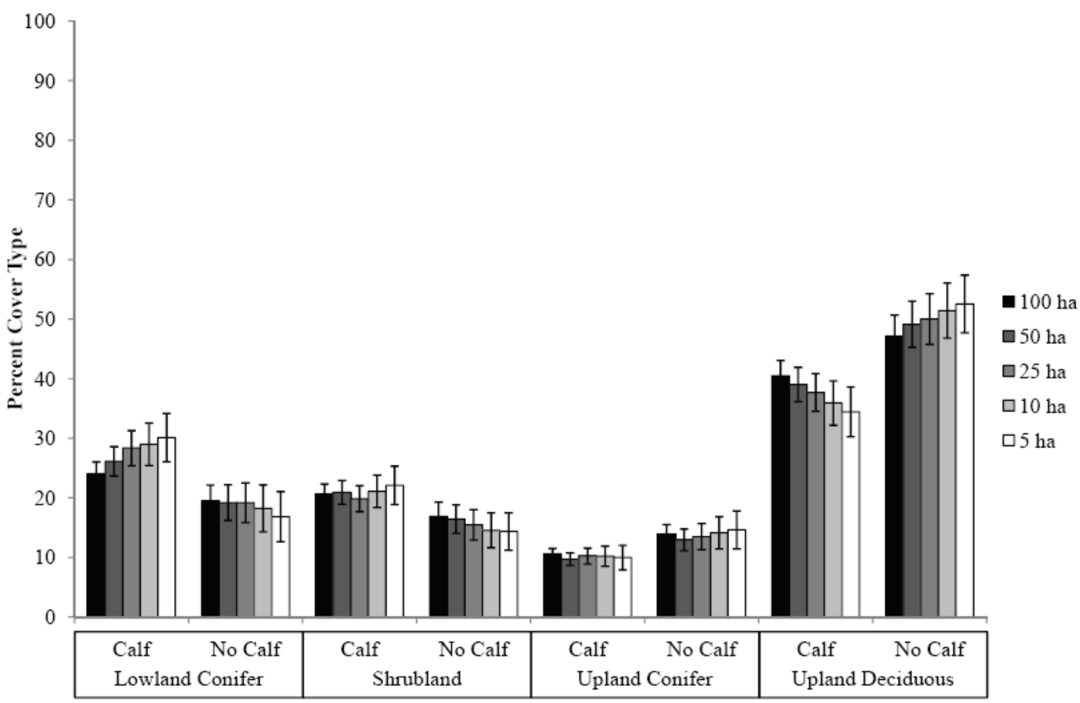

Fig. 3. Change in cover type composition as the area surrounding known cow-calf locations and locations of cows without calves was incrementally reduced from 100 ha to 5 ha, northeast Minnesota. Vertical error bars represent 95% confidence intervals.

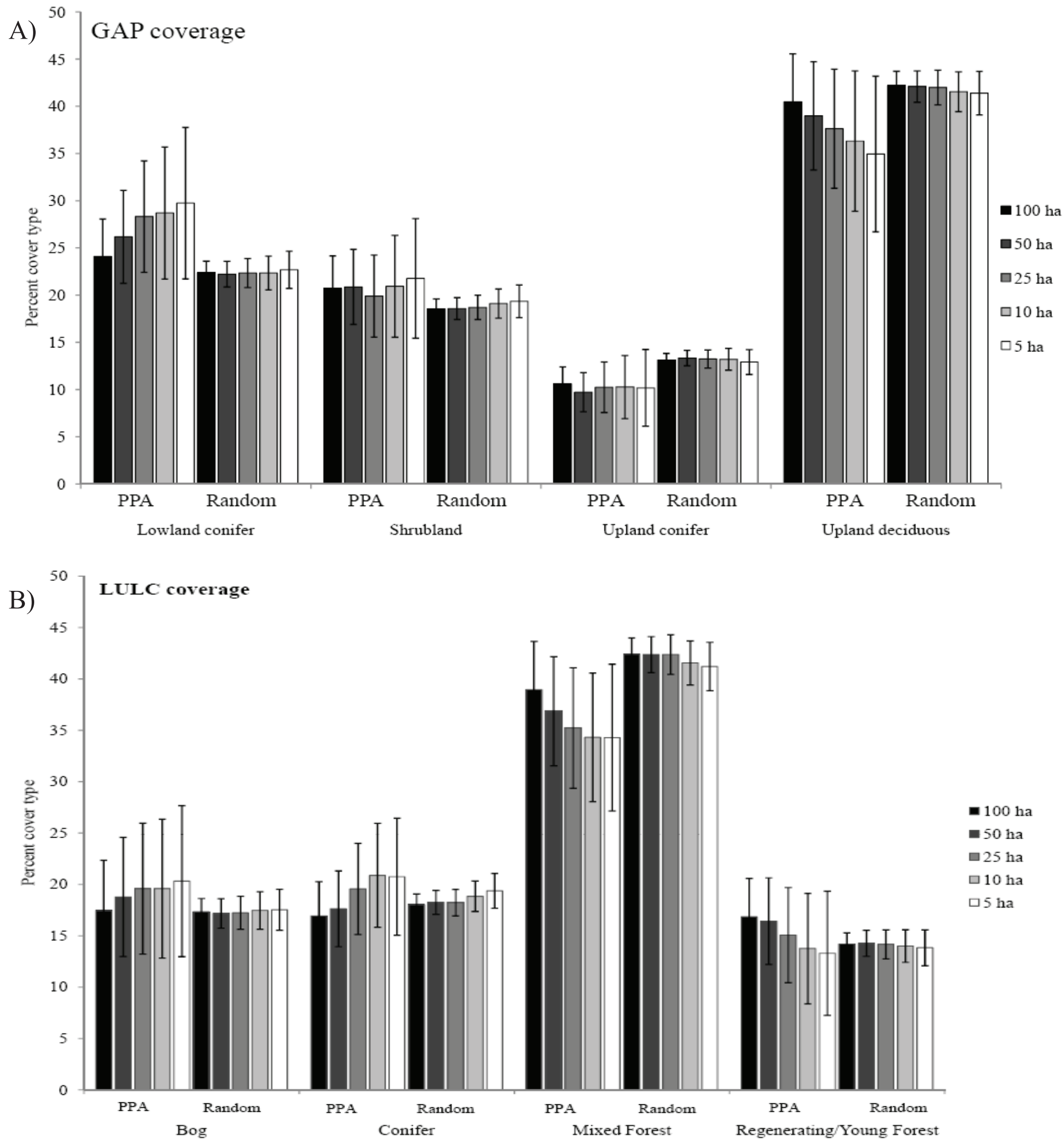

Fig. 4. Change in cover type composition as the area surrounding the known cow-calf locations (PPA) and random locations were incrementally reduced from 100 ha to 5 ha in the GAP cover type (A) and the LULC cover type (B), northeast Minnesota.

areas, 18% of 100 ha random areas, and 37% of 100 ha areas surrounding cows without calves. Beaver ponds were more common in areas surrounding cows without calves than in random areas ($\chi_2^{\ 2} = 8.48$, $P = 0.0036$).

Distance between Post-Parturition Sites

Of 36 cows observed with calves, 23 gave birth in ≥2 years, resulting in 34 paired parturition events. Post-parturition locations in consecutive years were closer to each other than distances between post-parturition locations and random locations in the home range (observed: 1.7 ± 0.4 km, n = 34; random: 3.3 ± 0.4 km, n = 34) (Fig. 8). The minimum distance between consecutive post-parturition locations was 39 m and the maximum was 4,333 m. Many (34%) post-parturition locations were within 1 km, and 60% were within 2 km of the previous year's location.

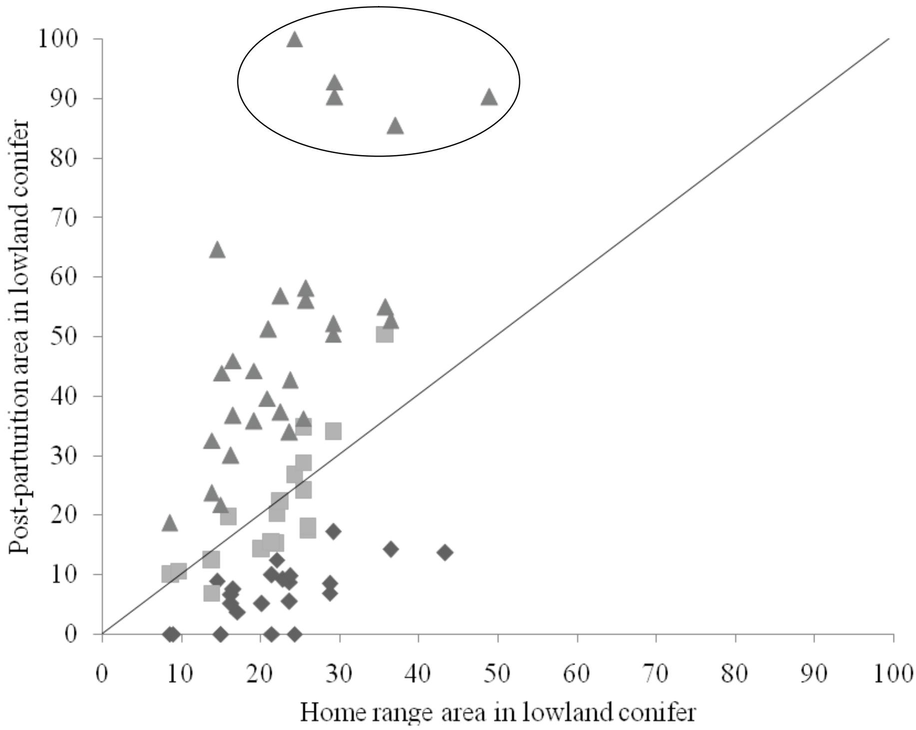

Fig. 5. Lowland conifer in the 100 ha post-parturition area was compared to lowland conifer in the home range of moose cows in northeast Minnesota. The 1:1 line would indicate similar proportions of lowland conifer in the post-parturition area as in the home range. Cows either selected for lowland conifer (triangles), used lowland conifer in accordance to its availability (squares), or avoided lowland conifer (diamonds). A subset of cows had post-parturition areas with a very high proportion of lowland conifer relative to the home range (circled triangles).

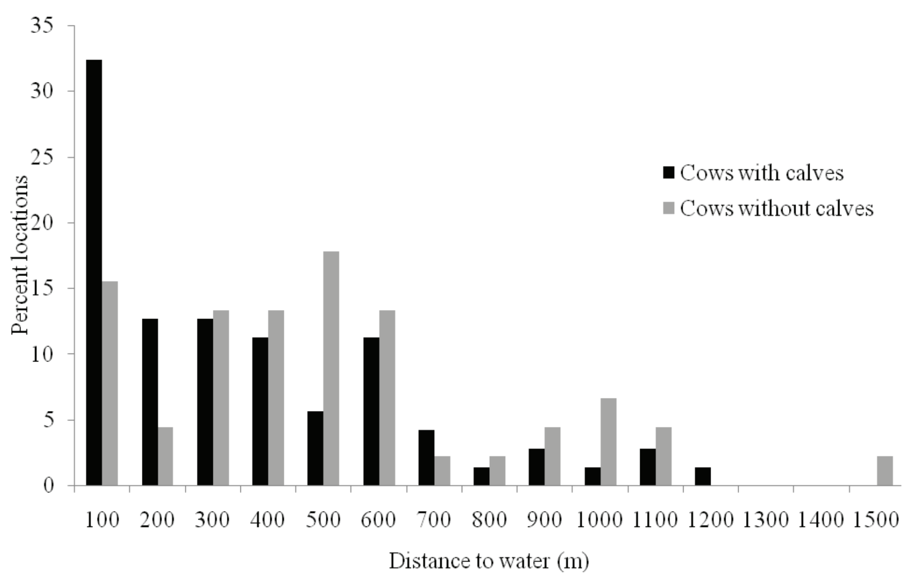

Fig. 6. Frequency distribution of distance of cows with calves and cows without calves to water bodies; distance was determined using aerial photograph interpretation. Water bodies included lakes, rivers, beaver ponds, and other water in northeast Minnesota.

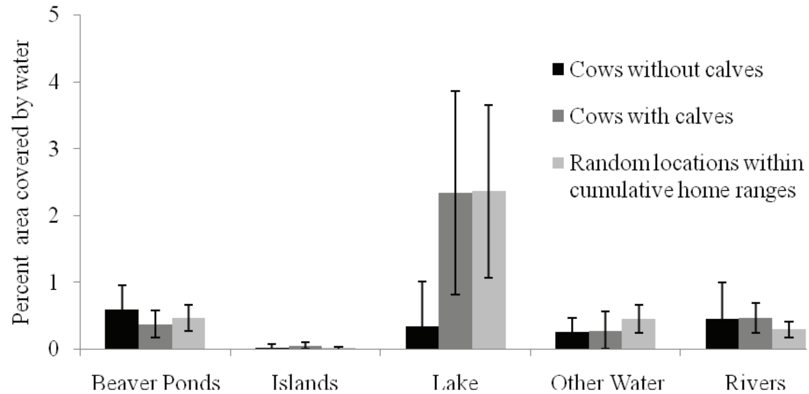

Fig. 7. Amount of each water body found within post-parturition areas, random areas, and areas surrounding cows without calves in northeast Minnesota.

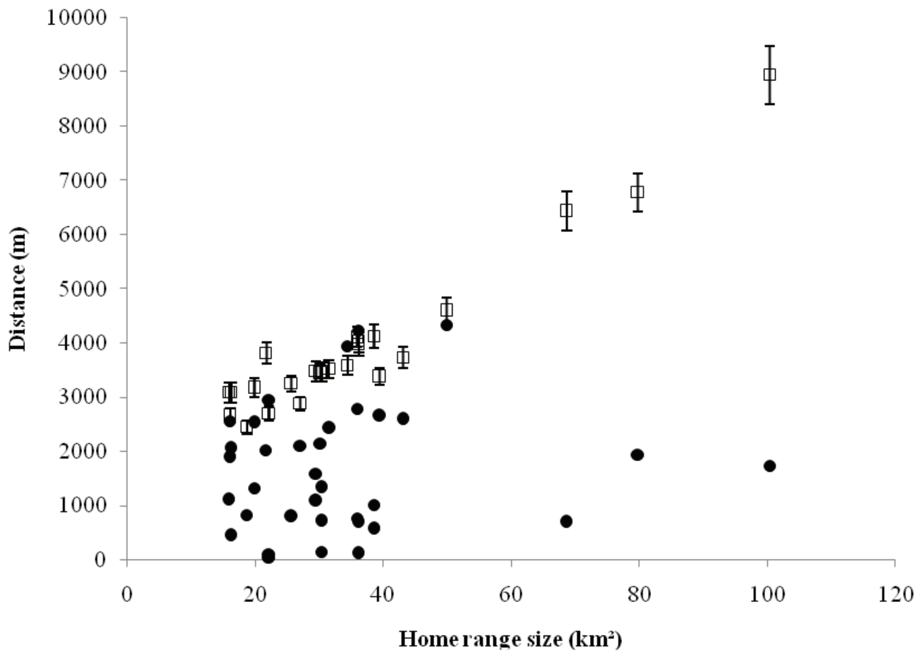

Fig. 8. Distance between consecutive post-parturition locations of moose cows (circles) compared to average distance to 30 random points within their home ranges (squares), northeast Minnesota. Vertical error bars represent 95% confidence intervals of distance to random locations within the home range.

DISCUSSION

Post-parturition areas had more lowland conifer and shrubby areas with a water component than areas used by cows without calves in GAP coverage at all spatial scales. Lowland conifer would likely provide hiding cover that is important in other regions with predators (Stringham 1974, Leptich and Gilbert 1986, Langley and Pletscher 1994, Bowyer et al. 1999). It is suggested that cover types providing better foraging and less hiding cover are used more by cows without calves. Because the cows were visually located only 1-2 times each survey period, we cannot be certain that cows without calf had not previously lost a calf, were still pregnant, or barren. We found high variability among cows in use of cover types after calving, which is consistent with previous studies. Despite this high variability, we identified trends in cover type use by cows with calves and cows without calves.

Defining and identifying specific characteristics associated with the parturition location and post-parturition area is important because this area must support the cow-calf pair for at least 3 weeks. Based on home range measured for these study animals, cows with calves use 1-4% of the home range for 5-10% of the year when calf mobility limits movement. We used a post-parturition area of 100 ha around the calf-cow location (Poole et al. 2007) to compensate for not knowing the actual parturition location. The 100 ha area used by Poole et al. (2007) was the minimum convex polygon encompassing locations of cows with calves for approximately 9 days post-parturition. Using this definition of post-parturition area, cows were variable in cover type use. Yet lowland conifer tended to increase at smaller spatial scales compared to random locations. Possible factors contributing to this variability could be the age of calves (unknown) or how cow-calf movements change during the first 3 weeks post-parturition.

The cow-calf pairs found in areas with >75% lowland conifer (GAP coverage) during the first week of search flights may have represented neonates and preferred birth sites. When we identified areas with high levels of lowland conifer across the home ranges, most post-parturition areas contained this habitat. If lowland conifer is used for post-parturition habitat, then post-parturition habitat is probably not limiting within home ranges of cows in northeast Minnesota. However, because >90% of the 70 cow-calf pairs were found during the first week of flights and parturition dates are unknown, this was a weak test for cover type selection. If cow-calf pairs had been relocated and seen during the second week of flights, a stronger test of cover type selection against cow-calf use would have been possible.

Reports from observers in the helicopter indicated association of cow-calf pairs with beaver ponds, wetlands, small lakes, and rivers during post-parturition flights. The amount of water in defined post-parturition areas, in simulated post-parturition areas, and in 100 ha buffers around cows without calves was relatively low (generally <3.5%); however, cows with calves were generally observed nearer these small water features than cows without calves. While moose have used islands as calving sites in other areas (Peterson 1955, Bailey and Bangs 1980, Stephens and Peterson 1984, Addison et al. 1990, Wilton and Garner 1991), there were few islands available in the study area. Each post-parturition location was observed on an aerial photograph, and these locations were not identified as islands in any habitat type, including islands in bogs.

Different degrees of calving site fidelity have been defined in multiple calving studies. In Algonquin Provincial Park in Ontario fidelity was observed in the repeated annual use of calving areas on islands (Addison et al. 1990). Cows in managed forests following Moose Habitat Guidelines in Ontario had higher degrees of parturition site fidelity (<3 km between consecutive parturition sites) relative to progressively clear-cut forests (4.87 km). Parturition sites within 1 km of the site used the previous year were used by 25% of cows (n = 35) (Welch et al. 2000). Using similar criteria to compare distance between consecutive post-parturition locations, we found 60% of cows were within 2 km of the previous year's location and 34% were within 1 km. Even with potential movements of cows away from parturition sites in the weeks following parturition, and without knowing the exact parturition location or age of calves, distances between post-parturition locations of individual cows in consecutive years were closer than expected from a random distribution. Despite these sources of variation, an element of fidelity to a post-parturition area was still observed and may have a basis in cover type composition.

The study was designed originally to acquire a sample of newborn calves to follow to adulthood to obtain an estimate of calf survival; therefore, helicopter flights occurred after peak calving to maximize the number of observed calves. However, this resulted in a range of age among calves, and likely introduced some of the variability in cover type composition and presence of water. A study employing GPS technology and vaginal implants or more frequent visual observations of cows during the calving period would provide more precise measurements of calving sites, timing of birth, post-parturition movements, and habitat use.

MANAGEMENT IMPLICATIONS

At this point the variability observed among cows indicates that the presence of multiple cover types in close proximity to one another may be an important characteristic of post-parturition areas in northeast Minnesota. The most common cover types within the home ranges were also important post-parturition habitat. This indicates that moose may adapt to local conditions when selecting post-parturition areas. Cows with calves tended to use more areas of lowland conifer, shrubland, and bogs and were nearer water than those cows without calves. Lowland conifer, shrubland, and bog cover types are among the most common within the home ranges of radio-collared cows, after mixed forests. Availability of lowland conifer, shrubland, and bogs is likely not a limiting factor for moose in northeast Minnesota; however, managers should consider these cover types and the presence of water when planning timber harvests or road construction.

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