MICROHABITAT CHARACTERISTICS OF MOOSE WINTER ACTIVITY SITES IN SOUTH-CENTRAL MONTANA

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ABSTRACT: Analysis of microhabitat of animal activity sites may help to determine both site-specific and activity-specific selection criteria and can have important management applications that can replicate similar site characteristics. I compared physical and vegetative characteristics of winter feeding (N = 46), resting (N = 17), and travel route (N = 19) sites of Shiras moose (*Alces alces shirasi*) in south-central Montana to those of 84 randomly selected sites within moose home ranges. Means of tree diameters, tree densities, sapling densities, percent shrub coverages, percent canopy closures, canopy heights, and slopes were not independent of site categories. Feeding sites in riparian habitats were higher in shrub coverage than all other activity site categories and random sites. Feeding sites in riparian habitats had lower percentage canopy closure, lower canopy height, less slope, and lower values of tree density, tree dbh, and sapling dbh than randomly selected riparian sites. Travel corridor sites used by moose in upland forests were higher in percent shrub coverage than randomly selected forest sites, and had less slope, lower average tree dbh, and lower average sapling dbh. A discriminant analysis of riparian habitat sites constructed from measured site variables correctly classified 71% of resting sites, 70% of feeding sites, 57% of travel route sites, and 40% of random sites. A discriminant analysis of upland forest habitat sites correctly classified 81% of random sites and 75% of travel corridor sites. Analysis of Mahalanobis distances indicated that site categories represented significantly different groups, with the exception of random sites and travel corridor sites in riparian habitats. Significant differences in tree and sapling densities, canopy height and closure, shrub coverage, slope and aspect among moose activity sites demonstrate variables common to forest management prescriptions. Such an approach offers potential for forest managers to manage individual sites in ways that create microhabitat moose may use for specific activities.

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Animals demonstrate habitat selection at various levels (Owen 1972), including selection of a geographic range (first-order selection), selection of a home range (second-order selection) and selection of habitats (third-order selection) (Johnson 1980). Johnson (1980) classified fourth-order selection as the selection of food items at a feeding site. However, a level of selection preceding this, but subsequent to habitat selection, would be the selection of particular microhabitat components within a given habitat type. For this reason, an examination of microhabitat selection is necessary to appreciate the means by which animals integrate selection at multiple levels.

Traditionally, many studies have examined use vs. availability in an effort to document habitat preference. However, Peek *et al.* (1982) concluded that only comparisons between home ranges with different amounts of the same habitat could be used to determine a habitat requirement. Shiras moose demonstrate flexible habitat preferences. Moose integrate all levels of selection on a seasonal basis to optimize their ratios of energy expenditures to forage intake. Understanding selection preferences at different levels in a geographic area is a first step toward understanding the mechanisms through which moose discriminate between habitats of different quality. Such understanding is important for managers of moose populations seeking to manipulate both proportional habitat abundance and the specific characteristics of available habitats.

In this study, I documented physical and vegetative characteristics of 84 winter feeding, resting, and travel route sites of Shiras moose in south-central Montana to those of 100 randomly selected sites within moose home ranges from 1989 to 1992. Such activities dominate moose time budgets (Belovsky and Jordan 1978, Regelin *et al.* 1985, Van Ballenberghe and Miquelle 1990). My objectives were to determine if microhabitat characteristics at sites associated with specific activities differed from each other or from randomly available sites within moose home ranges. Such information was intended to serve as a basis for integrated moose-habitat management on national forest lands in south-central Montana.

STUDY AREA

The Fiddler and Fishtail Creek drainages are tributaries of the Stillwater River in south-central Montana along the northeastern edge of the Absaroka-Beartooth Mountains. Moose in this area use elevations between 1500 m and 2800 m during winter in terrain characterized by gently rising east-facing slopes of the Fishtail and Stillwater Plateaus in Carbon and Stillwater Counties, MT, and are near the eastern edge of historic moose range in Montana (Stevens 1971, Peek 1974). Ratios of collared to uncollared observed moose on repeated winter survey flights indicated that the area contained approximately 60-70 individuals within approximately 125 km^2, or approximately 1 moose/2 km^2 (S. T. Stewart, MDFWP, pers. commun.). The population was female-dominated at a ratio of approximately 1 male: 3 females. Both sexes were hunted in the area by permit only. Annual harvests have averaged 10-20 individuals since 1980 (C. E. Eustace, MDFWP, pers. commun.). Hunter harvest and success rates (>75% annually and steadily increasing, C. E. Eustace, pers. commun.) suggested an increasing population. Other ungulates present on the study area included mule deer (*Odocoileus hemionus*), white-tailed deer (*O. virginianus*), elk (*Cervus elaphus*), and domestic cattle and sheep.

Long, cold winters and short, cool summers typify climate. Snow began to accumulate by November and usually remained until May. During the main period of the study (1989-91), mean January and July temperatures at the Mystic Lake, MT reporting station near the center of the study area (elevation 1997 m) were -3 C and 18 C, respectively. Annual temperatures ranged from -46 C to 38 C. Annual rainfall averaged 56.8 cm and annual snowfall averaged 386 cm (U. S. Department of Commerce 1992).

Upland areas usually were dominated by immature stands of lodgepole pine (*Pinus contorta*) to the base of the plateaus, with less frequent occurrence of Douglas fir (*Pseudotsuga menziesii*) on steeper north slopes of lower elevation ridges. Subalpine forests of Engelmann spruce (*Picea engelmannii*) and subalpine fir (*Abies lasiocarpa*) occurred on mesic sites at higher elevations. On mesic sites at low and intermediate elevations, widely dispersed stands of quaking aspen were common, and often adjacent to shrub-dominated wetland communities characterized by mountain alder (*Alnus incana*), willow (mainly *Salix phylicifolia* and *S. discolor*), and red osier dogwood (*Cornus stolonifera*). On drier sites at lower elevations, stands of Ponderosa pine (*Pinus ponderosa*) often occurred adjacent to upland shrub communities dominated by chokecherry (*Prunus virginiana*), ninebark (*Physocarpus malvaceus*), and wild plum (*Prunus americana*).

METHODS

Selection of Moose Activity Sites

Thirteen moose were captured by helicopter darting (Nielson and Shaw 1967) between 20 December 1988 and 16 January

1991 and fitted with identifiable belting-type radio collars (SB2 transmitter and Lonner module collar, AVM Instrument Co., 2356 Research Drive, Livermore, CA 94550 and Mod 500 transmitters, Telonics, 932 Impala Avenue, Mesa, AZ 85204). From November through May, 1989-92, resting, feeding, and travel route sites were located by following fresh (≤ 24 hours old) snow tracks of radio-collared moose away from the animal. Resting sites (N = 17) were identified by the presence of a moose bed. Feeding sites (N = 46) were identified by track configurations around recently browsed plants. Such sites were examined carefully to make sure there was no recent evidence of other wild ungulates or livestock at the site. Travel route sites (N = 19) were defined as sites located along repeatedly used travel routes of moose (normally between independent drainages) where tracks indicated that moose maintained a steady walking pace without stopping to rest or eat for ≥500 m. All examined sites of each type were ≥ 100 m from any other examined site. Eighty-four systematic, randomly located sites in home ranges of radio-collared moose were examined for comparison to selected resting, feeding, and travel route sites. Random sites were located along principal Universal Transverse Mercator (UTM) grid lines in home ranges at 500 m intervals from randomly selected starting points.

Each site was treated as the center of a 10 m X 10 m (0.01 ha) plot. In each such plot, 8 variables were measured: canopy height (m), canopy closure (%), shrub coverage (%), slope (%), tree density (individuals/ha), tree dbh (cm), sapling density (individuals/ha), and sapling dbh (cm). I chose these variables because they were useful in describing sites (especially to forest managers) for detailed management prescriptions, they were relatively independent of seasonal variation, and they could be measured in all habitat types.

Numbers and dbh of all trees (≥ 12 cm dbh) and saplings (< 12 cm) in each plot were recorded by species. Shrub coverage, by species, was measured by line-intercept (Canfield 1941) along a 10 m line through the center of the plot on a north-south axis. Slope and canopy height were determined with a clinometer. Canopy closure was determined by visual estimation at the center of the plot and recorded to the nearest 10%.

Analysis

Site variables were evaluated using a General Linear Models procedure (Analysis of Variance for unbalanced designs) for each variable. Site categories were treated as the effect. Previous investigations of home range (Van Dyke *et al.* 1995a) and habitat use (Van Dyke *et al.* 1995b) revealed that moose in this population concentrated use in riparian habitats interspersed with short, deliberate movements through forest habitat to adjacent riparian areas. Therefore moose activity sites and random sites initially were placed in one of two categories: riparian or upland forest. Further comparisons were made between different categories of activity sites and random sites within, but not between, categories.

Differences between all pairwise combinations of site category variables were evaluated by Fisher's Least Significant Difference test for multiple means. Variables measured as percentages were subjected to arcsin transformation (Zar 1984:239-241) prior to testing to increase conformity to normal distributions.

A discriminant analysis was performed using previously measured site variables to construct ≥1 discriminant functions which could be used to identify site types within riparian and upland forest categories. Mahalanobis distance (SAS Institute Inc. 1989:678) probabilities were used to evaluate whether activity site categories had, overall, significantly different characteristics.

RESULTS

Riparian Site Differences

In riparian habitats (Table 1), site types differed significantly in 5 of 8 variables (GLM, 84 df, $P \leq 0.03$, all variables), and approached significance in a sixth (sapling dbh, $P = 0.07$). Shrub coverage, canopy closure, canopy height, slope, and tree density differed between site categories. Feeding sites had higher average shrub coverage than all other site categories. Feeding and resting sites differed from travel corridor and random sites in tree density (Fisher's LSD test, 81 df, $P < 0.05$). Feeding and resting sites differed from random sites, but not from travel corridor sites, in canopy closure, canopy height, slope, and sapling dbh (Fisher's LSD test, 81 df, $P < 0.05$). Travel corridor sites had higher average shrub coverage than random sites (Fisher's LSD test, 81 df, $P < 0.05$), but did not differ from random sites in any other variable. Overall, resting and feeding sites were more similar to each other than random and travel corridor sites, and vice versa.

A discriminant analysis constructed from these same site variables correctly classified 71% of all resting sites, 70% of feeding sites, 57% of travel route sites, and 40% of randomly selected sites. Shrub coverage, tree density, canopy closure, and slope contributed significantly to the discriminant function, and sapling dbh approached signficance ($P = 0.07$). Probabilities associated with generalized squared distances (Mahalanobis distances) between groups (site categories) in riparian areas indicated that site categories represented significantly different groups ($P \leq 0.05$, all cases), with the exception of random sites and travel corridor sites ($P = 0.65$).

Upland Forest Site Differences

In upland forest habitats (Table 2), travel corridor sites had greater shrub coverage and average tree dbh and less slope and sapling dbh than randomly selected sites (Fisher's

Table 1. Average values of 8 habitat components of resting sites (N=17), feeding sites (N=46) and travel corridor sites (N=17) used by moose in riparian habitat compared to randomly selected riparian sites (N=15) in moose home ranges in south-central Montana, 1989-92. SE in parentheses. P = probability that means of different site types are equal.

	Site type								
Variable	Resting		Feeding		Travel		Random		P
Shrub coverage (%)	32.4	(14.2)	51.1^{a}	(19.4)	30.6	(19.3)	35.5	(14.6)	<0.01
Canopy closure (%)	11.5^{b}	(11.4)	12.7^{b}	(14.6)	20.7	(12.4)	28.9	(25.9)	<0.01
Canopy height (m)	13.2	(10.7)	17.1^{b}	(15.4)	25.7	(14.4)	26.6	(14.3)	0.03
Slope (%)	7.3^{b}	(5.1)	6.8^{b}	(3.8)	9.4	(3.6)	11.3	(6.4)	<0.01
Tree density (stems/ha)	182.4^{c}	(203.8)	187.0^{c}	(199.6)	657.1	(350.5)	646.7	(435.7)	<0.01
Tree dbh (cm)	12.7	(10.7)	13.0^{b}	(10.8)	18.3	(9.1)	19.4	(9.0)	0.12
Sapling density (stems/ha)	817.6	(1083.5)	1243.8	(1946.8)	814.3	(762.5)	1886.7	(2001.0)	0.34
Sapling dbh (cm)	2.9^{b}	(3.3)	2.6^{b}	(2.2)	3.5	(3.4)	4.6	(2.9)	0.07

a Different from all other site types. Fisher's Least Significant Difference Test. P<0.05

b Different from random site types. Fisher's Least Significant Difference Test. P<0.05

c Different from travel and random site types. Fisher's Least Significant Difference Test. P<0.05

LSD test, 79 df, $P \leq 0.04$, all cases). Differences in tree densities between site categories approached significance ($P = 0.06$), but values of canopy closure, canopy height, and sapling density were not different ($P = 0.20$. 0.89, and 0.49, respectively).

A discriminant analysis constructed from the above site variables correctly classified 81 % of random sites and 75 % of travel corridor sites. Shrub coverage, tree dbh, sapling dbh and slope contributed significantly to the discriminant function, and tree density approached signficance ($P = 0.06$). Probabilities associated with generalized squared distances (Mahalanobis distances) between groups (site categories) in upland forest areas indicated that site categories represented significantly different groups ($P < 0.01$).

DISCUSSION

The study's foundational null hypothesis, that microhabitat characteristics would not differ between activity site types located in similar habitat, was rejected. Moose in this population showed evidence of selection at microhabitat levels, as well as evidence that such selection was activity specific. In particular, resting and feeding sites, though similar to each other, showed the strongest departures from random sites. Travel routes within riparian habitat appeared to be randomly selected in all characteristics except shrub coverage, but travel routes used between riparian habitats in upland forest vegetation differed from random forest sites in 5 of 8 variables examined.

Examination of differences in site variables permits a generalized picture of preferred resting and feeding microhabitat. Sites for these activities had higher shrub coverage, but reduced canopy closure, canopy height, slope, tree density, and sapling dbh. Together, such characteristics show relationship to variables associated with forage density (shrub coverage), variables that would tend to increase forage production (reduced canopy closure, reduced tree density, and reduced slope), or variables enhancing forage availability and palatabilty (lower canopy height and sapling dbh). Similarly, differ-

Table 2. Average value of 8 habitat components of forest travel sites (N=12) used by moose compared to randomly selected forest sites in moose home ranges (N=69) in south-central Montana, 1989-92. SE in parentheses. P = probability that means of different site types are equal.

	Site type				
Variable	Travel		Random		P
Shrub coverage (%)	27.0	(20.3)	12.6	(11.5)	<0.01
Canopy closure (%)	33.3	(22.2)	42.2	(22.0)	0.20
Canopy height (m)	32.4	(14.8)	33.0	(12.6)	0.89
Slope (%)	8.7	(4.4)	16.0	(12.2)	0.04
Tree density (stems/ha)	683.3	(464.8)	1117.4	(761.0)	0.06
Tree dbh (cm)	22.5	(5.6)	16.7	6.9	<0.01
Sapling density (stems/ha)	2000.0	(1618.1)	2762.3	(3696.8)	0.49
Sapling dbh (cm)	4.3	(2.8)	6.8	(2.5)	<0.01

ences between travel corridor sites and random sites within upland forest habitats showed relation to forage availability (increased shrub coverage and decreased sapling dbh along travel corridors) or to energy conservation and ease of movement (reduced slope and lower tree density along travel corridors).

Peek *et al.* (1974) noted that moose in Minnesota made greater than expected use of sites with <124 trees/ha, a density similar to this study's estimates of resting and feeding sites in riparian areas (182.4 and 187.0 trees/ha, respectively). The higher shrub coverage along travel routes suggests that such routes may have provided more incidental foraging opportunity. If so, this suggests that moose exercise some selective preference and forage availability considerations not only in core feeding areas, but even when using travel routes between adjacent areas. Overall, microhabitat data support conclusions derived from large scale habitat selection in this moose population (Van Dyke *et al.* 1995b) that forage availability was a primary habitat selection criteria.

Management Implications

The categorization of moose activity sites in terms of significant differences in tree and sapling densities, canopy height and closure, shrub coverage, slope and aspect suggests that it is possible to describe moose activity sites in terms of variables relevant to precise forest management prescriptions. Such an approach offers potential for forest managers to manage relatively small areas in ways that create microhabitat favorable to specific activities. Sites associated with ≥ 30% shrub coverage, <200 trees/ha, and ≤ 7% slope may provide superior feeding and resting sites for moose in this area of Montana. In general, site-specific management activities that reduce stand densities at relatively level forested sites, with concurrent increases in shrub coverage, may provide disproportionate benefits to moose. Even relatively small areas with such characteristics could be expected to receive disproportionately heavy use by moose. In consideration with data from moose core areas, forest and wildlife managers may wish to consider more intensive, site-specific management of areas which could provide the characteristics documented in this study. Such management could prove more cost-effective than management aimed at larger land units. This may be particularly applicable for western moose populations where preferred habitats are patchily distributed. In addition, conventional wisdom that moose show no selection in travel routes between core foraging areas is not supported by this study. Managers may wish to consider manipulation of forest characteristics between adjacent riparian areas which reduce energetic cost to moose, particularly in areas where core foraging areas (riparian habitat) is patchily distributed. Selected microhabitat characteristics described here may provide a first approximation to such efforts.

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