WINTER HABITAT USE BY MOOSE IN SOUTH-CENTRAL ALASKA

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ABSTRACT: The moose (*Alces alces*) associated with the tri-valley system at the head of Turnagain Arm in south-central Alaska are particularly important for wildlife viewing and hunting. A more thorough understanding of the distribution and habitat use patterns of moose during winter (i.e., Dec - Mar) in this area was needed to develop and implement habitat management activities for this population. Habitats available to moose were 3 shrub communities (53%), 2 forest communities (32%), and a herbaceous/grass/barren community (15%). During deep-snow winters moose selected deciduous forests and alder (*Alnus* spp.)-willow (*Salix* spp.) communities. Mixed deciduous-conifer forests, sweetgale (*Myrica gale*), and herbaceous-grass communities were avoided. A mixed willow-sweetgale community was used in proportion to its occurrence. Moose used plant communities that provided greatest access to preferred forage species (e.g., willow). Opportunities exist to enhance habitat by manipulating plant communities to make preferred species more available during moderate- to deep-snow winters.

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Due to their close proximity to Anchorage, Alaska, the moose inhabiting the Twentymile, Placer and Portage tri-valley system at the head of Turnagain Arm in south-central Alaska are a particularly important resource. Almost one-half of Alaska's human population lives within easy access of the Twentymile River Valley, making it one of the most popular special permit hunting areas in the state. Yearly summer visitation in Portage Valley exceeds 600,000 people. Nearly 50 percent of the visitors surveyed indicated that additional wildlife viewing opportunities would be desirable, underscoring the value of this highly visible large mammal in enhancing the recreational and educational experiences of Alaska's visiting population (U.S. Dep. Agric. For. Serv., *unpubl. data*). Management goals for this area include maintenance of a huntable and viewable moose population that addresses these demands.

Severe winters during 1970 - 1972 resulted in major population declines of moose in South-central Alaska during 1973 - 1977 (Alaska Dep. Fish and Game, *unpubl. data*). Similar effects of severe winter weather on moose numbers have been reported for other populations (Rolley and Keith 1980, Thompson 1980). Consecutive mild winters after 1978 allowed the moose population to increase (Alaska Dep. Fish and Game, *unpubl. data*). Since reaching a population high in 1990, annual counts of moose in this area declined nearly 50% by 1995. This decline may be due to deterioration of the food supply (R. Sinnott, Alaska Dep. Fish and Game, *pers. comm.*).

Maintaining and enhancing winter habitats used by moose may contribute to stabilizing the moose population in this area at a level consistent with public demand. A

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more thorough understanding of the distribution and habitat use patterns of moose during winter (i.e., Dec - Mar) in this area was needed to develop and implement habitat management activities for moose. As the primary manager of land and habitats within the range of this moose population, the Glacier Ranger District of the USDA Forest Service undertook a study in 1992 - 1993 to identify distribution patterns of moose within winter range and describe winter habitat use patterns.

STUDY AREA

The study area included Twentymile, Placer, Portage and Bear valleys in South-central Alaska and was approximately 14,000 ha in size. The four valleys were bordered by the Chugach Mountains to the north and the Kenai Mountains to the south. The study area was a flat mesic, alluvial flood plain bordered by steep side slopes. A mosaic of vegetation types, including open marsh and bogs, shrub cover, and small forested areas dominated by black cottonwood (*Populus trichocarpa*) occurred throughout the area (Davis and Pittman 1992). Stands of old-growth white spruce (*Picea glauca*) and alder (*Alnus* spp.) were located on the side slopes. January was the coldest month of the year with mean monthly and daily temperatures of -5.4°C and -9.6°C, respectively. Mean annual precipitation was approximately 154 cm, and the mean annual maximum snow pack ranged from 102 cm in areas adjacent to Turnagain Arm, to 152 cm in areas further inland (Blanchet 1983). Portage Valley and Turnagain Arm often experienced extremely high winds, with speeds frequently between 60 and 90 knots.

METHODS

Vegetation communities on the floors of Portage, Placer, Twentymile, and Bear valleys were described and mapped to Viereck *et al.* (1992) Level V in 1993 (C. Hubbard and W. Queitzsch, U.S. Dep. Agric. For. Serv., *unpubl. data*). Vegetation data were collected in 1992 and 1993 from transects located throughout the study area. Vegetation mapping was done on 1:31,360 color photography flown in 1990 using data collected from the vegetation transects. Information on land forms and soils available in an ArcInfo™ geographic information system (GIS) database (D. Davidson, U.S. Dep. Agric. For. Serv., *unpubl. data*) contributed to the delineation of vegetation communities. Completed vegetation maps were digitized from aerial photography into a format directly compatible with the GIS database.

Locations of moose during winter were recorded during flights in fixed-wing aircraft at approximately 150 m above ground surface. Counts were obtained by scanning the ground area within view of the observer on the right side of the aircraft. Number and location of animals were recorded on aerial photographs of the study area. Six flights were conducted during 11 February - 3 April in 1992. Two types of aircraft, a Supercub and a Cessna 185, were used. Four pilots and three observers were used; one individual observed for three flights, a second observed for two and a third observed for one flight.

In 1993 the study area was divided into subunits that were surveyed systematically along transects to ensure full coverage of the study area. Transects were generally flown parallel to the longest axis of the subunit and were spaced to minimize the area the observer was required to search. A Cessna 185 was piloted by an individual familiar with the area and objectives of the study. Ten surveys were conducted in 1993 during 16 December - 17 March. One primary observer conducted 7 of the 10 surveys; another individual observed for 2 flights, and a 3rd individual observed for 1

flight.

Moose locations obtained during aerial surveys were transferred from aerial photographs to mylar laid over 1:63,360 orthophoto quadrangle maps and digitized into a GIS. Information associated with each location included number of moose sighted and date of the observation. Monthly snowfall data were obtained from the U.S. Department of Commerce climatological recording station in Portage Valley.

We used the study *Design 1* as described by Thomas and Taylor (1990) for assessment of habitat use (i.e., individual moose were not identified; only use of vegetation communities was recorded through repeated surveys). The amount and location of all vegetation communities was determined for the whole study area through analysis of vegetation data in the GIS database. The availability of vegetation communities was assumed to be equal for all animals since moose readily moved throughout the study area. Observations of moose were overlaid with vegetation communities to determine habitat use through GIS analyses. To meet the assumption that observations of moose were independent, observations of individuals and observations of groups were each considered single observations (Alldredge and Ratti 1986). The null hypotheses examined were that use of habitats by moose occurred in proportion to the availability of habitats and that habitat use patterns did not differ among years of the study.

Chi-square contingency tests were used to determine if habitat use differed among survey years. The Neu *et al.* (1974) method for Chi-square goodness-of-fit analysis was used to test the hypotheses that observed habitat use corresponded to expected patterns based on habitat availability. If the null hypothesis was rejected and a significant difference ($P < 0.05$) was detected in use versus availability, family confidence intervals were established using the Bonferroni Z-statistic as modified by Neu *et al.* (1974). This helped determine which vegetation communities were used in proportions greater or less than availability ($P < 0.05$).

RESULTS

Six vegetation communities were described in the study area (Table 1). All vegetation communities were distributed through all valleys in the study area (Fig. 1). Habitats available to moose were 2 forest communities, 3 shrub communities, and a herbaceous/grass/barren community. These communities composed 32%, 53%, and 15% of the study area respectively. The deciduous forest community was characterized by an open canopy of black cottonwood or Kenai birch (*Betula kenaica*) with an understory of willow or alder. The mixed/conifer forest community had a canopy of scattered Lutz spruce (*P. glauca* x *lutzii*), black cottonwood, and white birch (*Betula papyrifera*) in varying amounts with a dense understory of alder or devil's club and limited willow.

The alder-willow shrub community was dominated by dense, tall Sitka alder with tall Sitka (*Salix sitchensis*), feltleaf (*S. alaxensis*), and barclay (*S. barclayi*) willows with a mean height of 2.5 m. The willow-sweetgale shrub community was characterized by low (i.e., 1.5 m mean height), closed stands of undergreen (*S. commutata*), barclay, Sitka, and feltleaf willows mixed with sweetgale. The sweetgale shrub community was dominated by low stands of sweetgale mixed with low densities of dwarf birch (*Betula nana*) and willows; mean height was 0.9 m. The herbaceous/grass/barren community represented those areas without forest or shrub cover. In addition, during winter approximately 2500 ha of the study area were ice-covered rivers, streams, lakes, and ponds.

Table 1. Vegetation communities in Portage/Bear, Placer, and Twentymile valleys, South-central Alaska.

Vegetation Community	Description	Area (ha)	Proportion of Total Land Area
Forest			
Deciduous	Black cottonwood (*Populus trichocarpa*) or Kenai birch (*Betula kenaica*) overstory with a willow (*Salix* spp.) or Sitka alder (*Alnus crispa sinuata*) shrub layer	2183	0.187
Mixed/conifer	Spruce (*Picea* spp.) or birch/cottonwood/spruce overstory with alder, willow, or devil's club (*Oplopanax horridus*) shrub layer	1519	0.130
Shrub			
Alder-willow	Tall alders and willows dominate with scattered cottonwood and spruce in the overstory	2561	0.219
Willow/sweetgale	Low willows, alders, and sweetgale (*Myrica gale*) dominate	3044	0.261
Sweetgale	Sweetgale dominates; dwarf birch (*Betula nana*) and willows are often present	578	0.050
Herb./grass /barren	Forbs, sedges, or grass dominate or sites are without vegetative cover	1788	0.153
Subtotal		11673	1.000
Water	Rivers, streams, lakes, and ponds	2502	
Total		14175	

Moose were observed throughout the study area, however, densities of moose seen varied by valley. Densities were consistently higher in Twentymile Valley, followed by Portage/Bear valleys, and Placer. Although snow depth measurements were not made in each valley, observations of snow levels during aerial surveys indicated that valleys with less snow accumulation had higher densities of moose. The frequencies of the size of groups of moose observed were similar in 1992 and 1993. Moose were observed most often as single animals with decreasing numbers of observations of larger groups. Aggregations of more than 10 moose were observed infrequently. Mean group size was 2.6 for both years.

Total snowfall for Portage Valley was 355 and 279 during 1992 and 1993, respectively (Table 2). Total snow depths, by month, for each year followed a similar pattern. Snow fall and snow accumulation during the winters of 1992 and 1993 exceeded long-term means by up to a factor of 4.

Chi-square goodness-of-fit tests revealed that moose selected habitats in different proportions than expected from availability during all winters evaluated ($P < 0.05$). Habitat-use patterns were similar during 1992 and 1993. Deciduous forest and alder/willow shrub communities were used more ($P < 0.05$) than expected in 1992 and 1993 (Table 3). Mixed/conifer forest, sweetgale shrub, and herbaceous/grass/bar-

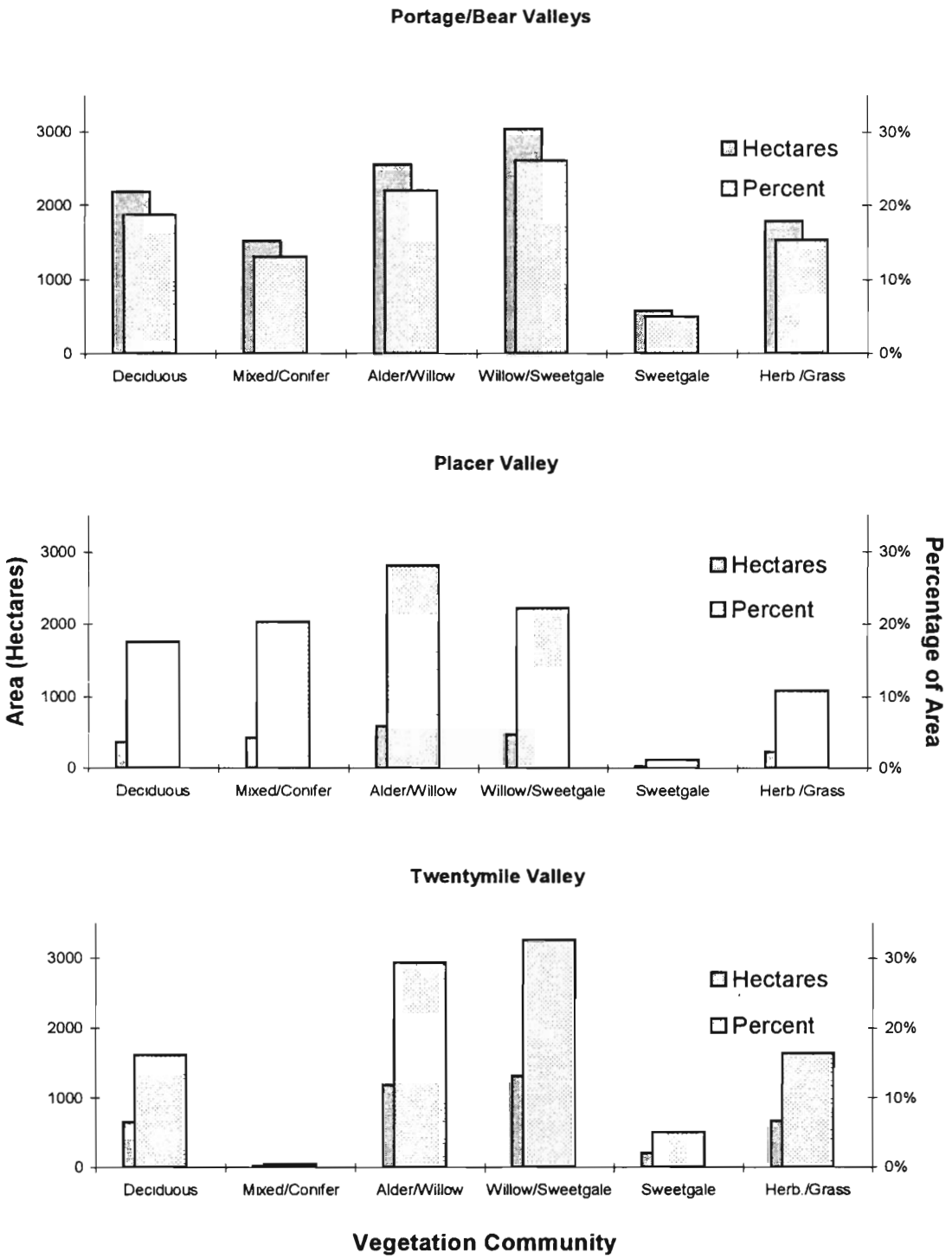

Fig. 1 Area and percentage of plant communities in Portage/Bear, Placer, and Twentymile valleys, South-central Alaska.

Table 2. Snowfall amounts recorded in Portage Valley, South-central Alaska.

Winter	Snowfall by Month (cm)			Total
	December	January	February	
1991-92	213.4	54.6	86.9	354.9
1992-93	135.9	41.9	101.6	279.4
10 yr mean	56.6	78.0	80.5	215.1

	Snow depth by Month (cm)		
	February	March	April
1992	139.7	152.4	208.3
1993	96.5	73.7	99.1
1961-90 ave.	71.1	81.3	81.3

Table 3. Occurrence of moose observed in vegetation communities in Portage, Placer, Twentymile and Bear valleys, South-central Alaska during winter 1992 and 1993.

Vegetation Community	Area (ha)	Proportion of Total Area	Number of Observations of Moose	Expected Number of Observations of Moose	Proportion of Moose Observations in each Community (p_i)	Confidence Interval on Proportion of Occurrence (p_i) (95% Family Confidence Coefficient)
Forest						
Deciduous	2183	0.187	170	123	0.259	$0.214 \leq p_1 \leq 0.304$
Mixed/conifer	1519	0.130	58	85	0.088	$0.059 \leq p_2 \leq 0.118$
Shrub						
Alder-willow	2561	0.219	194	144	0.296	$0.249 \leq p_3 \leq 0.343$
Willow/ sweetgale	3044	0.261	160	171	0.244	$0.200 \leq p_4 \leq 0.288$
Sweetgale	578	0.050	12	33	0.018	$0.004 \leq p_5 \leq 0.032$
Herb./grass/ barren	1788	0.153	62	100	0.095	$0.064 \leq p_6 \leq 0.125$
Total	11673	1.000	656	656	1.000	

ren communities were used less ($P < 0.05$) than expected during the same time period. The willow/sweetgale shrub community was used in proportion to its availability. Moose using patches of mixed/conifer forests may not have been as observable as moose using more open vegetation communities. However, the majority of mixed/conifer forest patches had open canopies, were less than 4 ha, and generally did not preclude observations of moose.

DISCUSSION

Riparian habitats are key winter moose range through much of Alaska (LeResche *et al.* 1974, Peek *et al.* 1974, Mould 1979) and elsewhere (Dorn 1970, Peek 1974a, Boonstra and Sinclair 1984, Goulet 1985). The primary attractants are the riparian willow communities that are often renewed by erosion, flooding, or ice scouring (Telfer 1984). Willow and Kenai birch have been identified as preferred winter foods of moose in south-central Alaska (Peek 1974b, Cushwa and Coady 1976). These factors appeared to have affected observed habitat use patterns of moose during winter in the Portage, Placer, and Twentymile valley system.

The habitat use patterns observed during this study appeared to indicate the response of moose to deep snow in this riparian area. Moose used plant communities during winter that provided greatest access to preferred forage species (e.g., willow). During the winters of 1992 and 1993 deciduous forest and alder/willow communities were preferred. Both communities had a large component of tall willow that continued to be available to moose despite the heavy snowfall. These communities also provide overstory tree cover, although it was limited in some areas. Similar habitat use patterns were reported by Joyal (1987) and Hundertmark *et al.* (1990). The willow/sweetgale community, which was dominated by low willow plants, was used in proportion to its occurrence. Greater utilization of this community by moose may have been precluded by deep snows since moose do not usually dig through snow to obtain food (Pruitt 1960). Plant communities on the study area without a willow element were avoided during this study (e.g., sweetgale community). Sweetgale has been shown to have low digestibility and provides little forage value to moose (Thilenius 1990).

MANAGEMENT IMPLICATIONS

Management actions are needed to address and reverse the recent decline of this moose population if public expectations for hunting and viewing are to be met. Potential causes for this decline may be excessive harvest by humans, predation, or deterioration of habitats. A preliminary analysis by Spalinger and Lottsfeldt (Univ. Alaska, Anchorage, *unpubl. data*) indicated that deterioration of habitats may be the likely cause. This study has demonstrated that riparian willow communities associated with the Portage, Placer, Twentymile, and Bear rivers provide preferred winter habitat for the moose population in this area. Although moose have shown preference for willow communities there appears to be uneven distribution of moose within these communities. This may be the result of differences in accessibility due to snow depths or selection due to nutrient availability in individual plants. Additional work is needed to provide a better understanding of moose distribution in the winter. If nutrient deficiencies are detected, consideration may be given to improving nutrient quality through fertilization.

Vegetation in this area has been influenced by primary succession following glacial retreat, land surface subsidence following the 1964 earthquake, and by recurring flooding that have enhanced willow produc-

tion. However, recent evaluations of these vegetation communities indicated that alder and Lutz spruce are beginning to dominate and replace willow. Opportunities exist to enhance moose habitat in the tall alder/willow communities. These communities exhibit the greatest potential for increased forage production (Van Ballenberghe and MacCracken 1989, Stephenson 1995). The most common willows found in these vegetation stands are undergreen, Barclay, Sitka, and feltleaf (U.S. Dep. Agric., Chugach Natl. For., *unpubl. data*). Barclay, Sitka, and feltleaf willows offer the most promise for browse enhancement for moose (V. Van Ballenberge, U.S. Dep. Agric. For. Serv., *pers. comm.*). Manipulation of these habitats has the potential to delay succession, maintain the willow and eliminate the alder components of the vegetation, and enhance habitat for moose.

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