Proc. Fifth Bienn. Symp. North.
Wild Sheep and Goat Council 1986

SUMMER HABITAT USE BY BIGHORN EWES AND LAMBS

Gary C. Brundige, Department of Wildlife and Fisheries Sciences
South Dakota State University, Brookings, SD 57007

Thomas R. McCabe, Department of Wildlife and Fisheries Sciences
South Dakota State University, Brookings SD 57007

Abstract: Habitat use by bighorn sheep (Ovis canadensis) ewes and lambs in Custer State Park, South Dakota was determined. Six habitat types were classified based on a combination of topograpy and vegetation. Radio-telemetry was used to monitor sheep movements and habitat use. Availability of each habitat was determined from aerial photographs. Availability of habitats within the home range (HRAH) of the bighorn sheep was compared to the total availability of habitats (TAH). Highly significant differences existed between HRAH and TAH indicating that determination of actual available habitat can influence apparent habitat selection. Bighorn sheep selected steep rocky habitat with a ponderosa pine overstory and avoided dense stands of ponderosa pine saplings. Habitats selected by bighorn sheep occurred in greater proportion within the home range than the total available habitat. Sheep avoided habitats having reduced visibility, but once a minimum threshold of visibility had been exceeded other factors influenced use. Bighorn sheep were never located further than 80 m from escape terrain and all locations were within 1 km of water.

The Black Hills and Badlands of South Dakota were traditional range for Audubon's bighorn sheep (Ovis canadensis auduboni) until this subspecies became extinct by 1916 (Buechner 1960). Rocky Mountain bighorn sheep (O. c. canadensis) were introduced to the Black Hills in Custer State Park (CSP), a 29,250 ha park, in 1964. The population increased to 100-150 animals by 1975 (Trefethen 1975), but has failed to increase above this level with a population estimated at 100 animals at present.

Most studies on Rocky Mountain bighorn sheep report distinct summer and winter ranges with traditional migration routes. Migration is often an elevational shift (Martin 1981, Erickson 1972) or a seasonal shift to different plant communities (Deming 1964, Bradley 1964). However, introduced bighorn sheep populations often fail to establish traditional migration patterns and remain restricted to the site of introduction (Geist 1971).

Several researchers have demonstrated the importance of steep, rocky terrain to bighorn sheep (Welch 1969, Geist and Petocz 1977, Morgantini and Hudson 1981). These areas provided increased protection from predators during lambing and lamb rearing (Irvine 1968). Bighorn sheep

summer activity centers also showed proximity to water in addition to precipitous terrain (Graham 1968, Hinkes 1978), with sheep remaining close to permanent water resources during dry periods, but utilizing their entire range during wet periods (Irvine 1968).

This study was designed to determine which specific habitats were selected by bighorn ewes and lambs in CSP during summer, based on observed use and proportional availability of these habitats to the sheep.

ACKNOWLEDGMENTS

We thank L. Layne for field assistance. Personnel of Custer State Park assisted with trapping and logistics. Funding was provided by a grant from the Foundation for North American Wild Sheep, Custer State Park and Federal Aid administered by the South Dakota Department of Game, Fish and Parks.

STUDY AREA

This study was conducted in CSP, which is situated in the southeast corner of the Black Hills of South Dakota (Fig. 1). Bighorn sheep are resident in the French Creek Natural Area, which is located in the central portion of the park. French Creek Natural Area encompasses French Creek Canyon, which is approximately 19 km long, 800 m wide, and ranges from 140 to 270 m in depth. French Creek Canyon represents a typical canyon in the southern Black Hills with exposed granite cliffs and a predominantly ponderosa pine (Pinus ponderosa) cover interspersed with steep, grassy slopes. These canyons typically have a narrow riparian zone adjacent to semi-permanent streams.

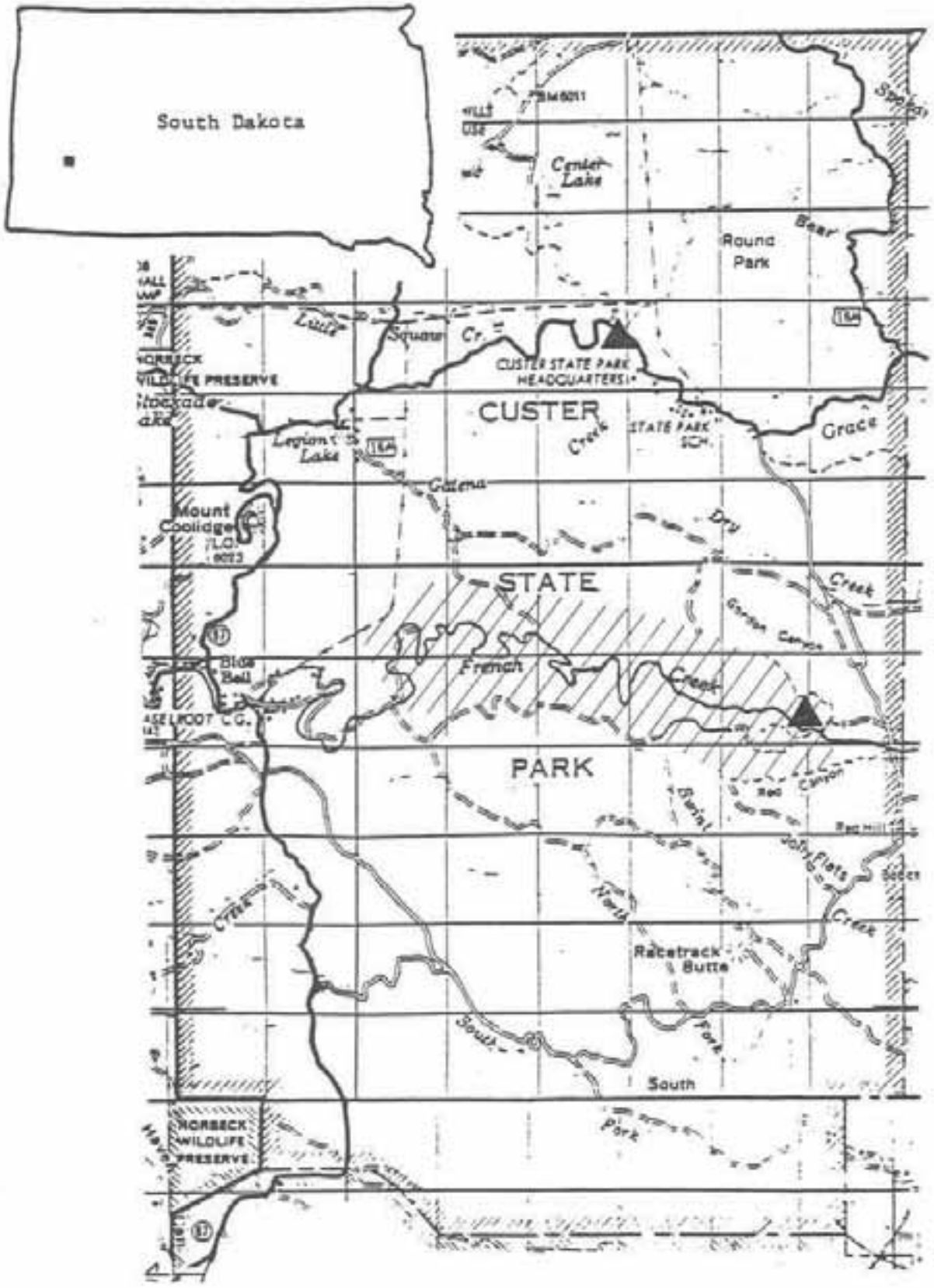
METHODS

Movements

Bighorn sheep movements were monitored using radio-telemetry from early May through August, 1984. Sheep were baited with alfalfa hay and apple pomace, and trapped with a drop net (Schmidt et al. 1978). Fourteen ewes were marked, 10 of which also were equipped with color-coded radio-transmittered collars (Advanced Telemetry Systems Inc., Bethel, MN). Radio-collared ewes were monitored until visual verification of location could be established.

To insure random relocation sampling throughout the diurnal period, fixes were taken during 8, 2-hour time periods starting at 0500 h and ending at 2100 h. Telemetered sheep were assigned a number 0 through 9. Numbers were randomly selected for each of the 8 time periods and the corresponding sheep was located during that time frame. No sheep was located twice in the same time period until all sheep had been located

Figure 1. French Creek Canyon study area in Custer State Park, South Dakota, and bighorn sheep trap sites.



in all time periods.

Information recorded for each observation included time, location (UTM coordinates), percent slope, exposure, position on slope, distance to escape cover, and habitat type.

Habitat Sampling

Six habitat types were visually delineated based on a combination of topography and vegetative cover. Habitats were characterized as mixed grass-forb meadows with no overstory (mxgr/forb), riparian with several deciduous overstory species (ripr), ponderosa pine stands with a grass-forb ground cover (pipo/grfb), steep rocky canyon sides with a grass-forb understory and a ponderosa pine overstory (stro/pipo), steep rocky canyon sides with a grass-forb understory but no overstory (stro/grfb), and dense stands of ponderosa pine (dest/pipo).

Habitat understory charactertistics were then sampled using a 20 x 50 cm frame to define a sample plot (Daubenmire 1959). Four sites were randomly selected within each habitat type for placement of 30 m transects which were aligned parallel to the contour within the habitat to be sampled. At 1.5 m intervals along the transect, a left or right perpendicular direction was randomly selected (coin toss) and the plot was placed at 1 of 6 randomly chosen (die roll) incremental marks on a 1.5 m pole at 0.25 m intervals.

Overstory characteristics were sampled using 10, 0.01 ha sampling sites randomly located in each habitat type. All trees greater than 2 m in height were counted and diameter at breast height (dbh) measured. Canopy cover was estimated from 4 readings of a spherical densiometer (Lemmon 1956, 1957) placed on the site center, 1 in each compass quarter. Horizontal obstruction was determined from 4 readings at 10 m of a density checker board, 1.5 m x 1.5 m, placed in the center of the site. One reading was taken from each compass dirction.

Habitat Availability and Selection

To determine habitat availability, sheep locations were plotted and home range was determined using the modified minimum polygon method (Harvey and Barbour 1965). Maximum distance sheep traveled between areas of use was determined and this distance was then added around the home range perimeter to encompass total available habitats (TAH). Habitats within the home range were considered home range available habitat (HRAH).

Habitat availability within these areas was determined by stereoscopy using color photographs (1:24000 scale) and a point grid overlay. TAH and HRAH frequencies were recorded from 3,958 point observations. To ascertain whether HRAH was characteristic of TAH, proportions of habitats within the home range were tested against proportions of total habitats using contingency table analysis.

Selection and avoidance of habitat by bighorn sheep was calculated

from the proportion of observations of sheep in each habitat and the proportional availability of each habitat type (Neu et al. 1974, Byers et al. 1984). Preference ratios were calculated from percent use and percent availability (Risenhoover and Bailey 1985).

Habitat understories were analyzed using discriminant analysis of species composing at least 4% total cover in any 1 habitat. Overstory characteristics were analyzed using analysis of variance.

RESULTS

Habitat

Discriminant analysis discriminated, with 100% accuracy, among all habitats based on understory vegetation with the exception of the 2 steep, rocky habitats (75% accuracy). Steep, rocky habitats had the same 2 dominant species, little bluestem (Andropogon scoparius) and side-oats grama (Bouteloua curtipendula) (Table 1), however, stro/grfb had greater total ground cover than stro/pipo (32% vs 19%). In addition, these 2 habitats differed in overstory, stro/pipo with a dominantly ponderosa pine overstory and stro/grfb without any overstory.

Overstory characteristics were not significantly different ($P < 0.05$) between habitats except dest/pipo (Fig. 2). Dest/pipo stands were composed of ponderosa pine trees with an average dbh of 7.5 cm and a mean of 14,340 stems/ha as compared to average dbh of 19.9 - 23.4 cm and average stem densities of 840 - 880 stems/ha in all other types of overstories. Riparian habitat, although very similar to other habitats in overstory structural characteristics, was composed of deciduous trees with very few ponderosa pine trees. All other overstories were composed almost exclusively of ponderosa pine. Burr oak (Quercus macrocarpa) was the only other tree species encountered in any habitat but riparian.

Dest/pipo also had a significantly ($P < 0.05$) greater canopy cover (74.3%) than any other habitat (49.2% to 56.6%). Horizontal obstruction was significantly ($P < 0.05$) greater in dest/pipo stands at 52.4% than the other habitats (18.3% to 23.0%).

HRAH was significantly different from TAH ($X^2 = 133.14$, $df = 5$, $P < 0.001$). The most available habitat, pipo/grfb, occurred less than expected in the home range (Table 2), as did dest/pipo and mxgr/forb. However; both steep rocky habitats and riparian habitat were more abundant than expected within the home range.

Hatitat Selection

Bighorn sheep used habitats in different proportions than present in TAH ($X^2 = 16.7$, $df = 5$, $P < 0.01$). Sheep selected stro/pipo and avoided dest/pipo and pipo/grfb (Table 3). Other habitats were used in proportion to their availability. Selection of habitats by the bighorn sheep in HRAH was similar, to their habitat selection in TAH, however, bighorn sheep used pipo/grfb in proportion to its availability and

Table 1. Percent ground cover composition in each of 6 habitats in Custer State Park bighorn sheep range (standard deviation).

Habitat type	Andropogon gerardi	Andropogon scoparius	Bouteloua curtipendula	Bouteloua gracilis	Poa species	Psoralea tenuiflora	Rhus radicans	Scirpus atrovirens	Non-vegetation
Ponderosa pine/ grass forb	1.3 (1.4)	2.3 (3.0)	5.4 (5.1)	1.6 (1.9)	9.2 (6.9)	0	0	0	55.7 (13.2)
Steep rocky/ ponderosa pine	1.9 (1.7)	5.9 (4.5)	4.0 (3.9)	0	0	0.1 (0.2)	1.3 (1.8)	0	81.0 (5.3)
Steep rocky/ grass forb	3.5 (2.5)	9.3 (5.7)	7.4 (6.0)	1.6 (2.0)	0	0.1 (0.2)	0.5 (0.9)	0	67.9 (10.6)
Doghair	0	0	0	0	0	0	0	0	97.5 (0.0)
Riparian	0	0	0.2 (0.4)	0	1.8 (2.1)	0	14.1 (7.6)	16.3 (5.6)	24.8 (11.9)
Mixed grass/ forb	6.2 (2.8)	5.0 (5.4)	2.1 (4.0)	8.3 (8.2)	12.7 (5.3)	4.0 (5.4)	0	0	11.6 (10.4)

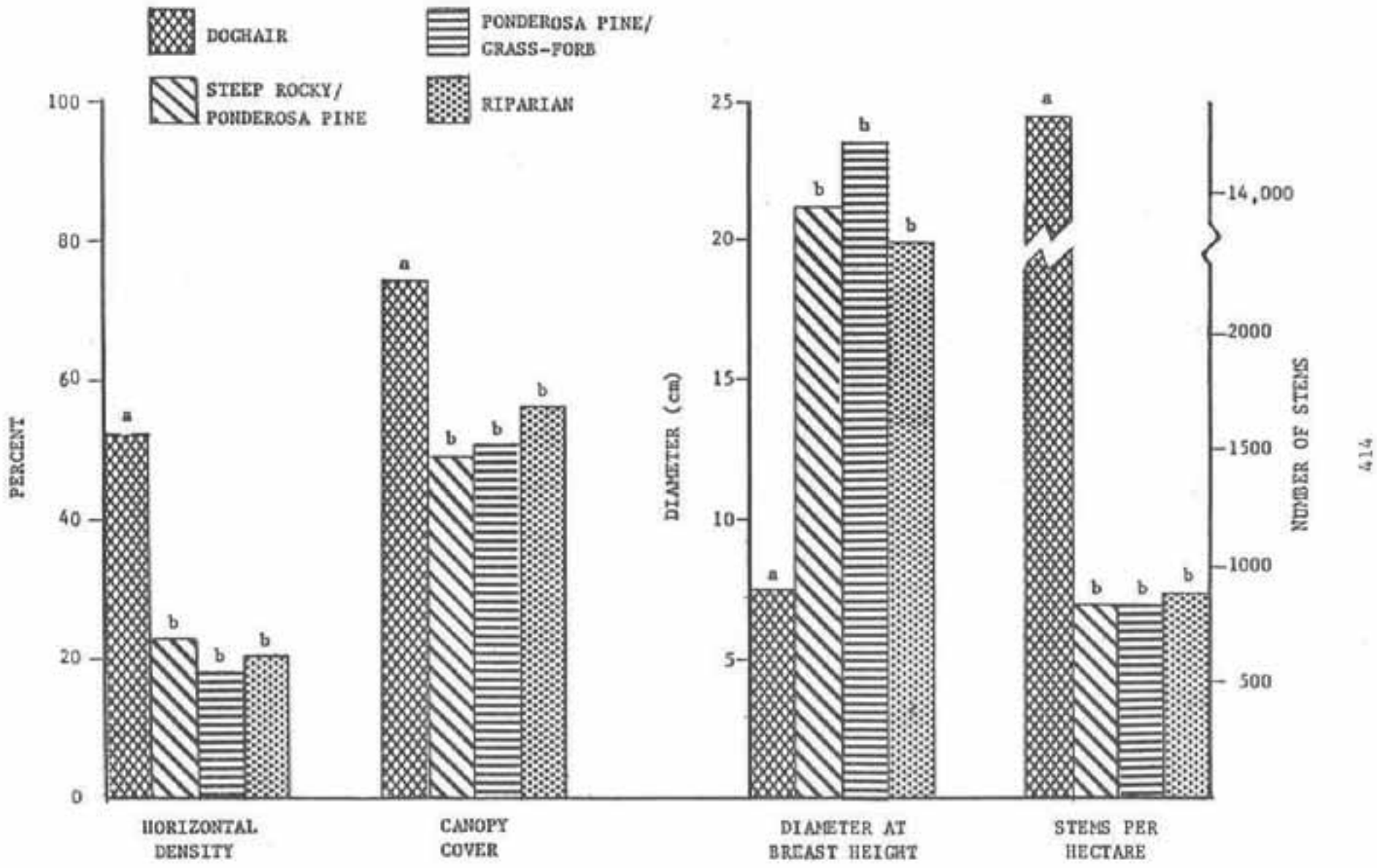


Fig. 2. Characteristics of habitat overstories in Custer State Park bighorn sheep range (characteristics with the same letter are not significantly different $\alpha=.05$).

Table 2. Availability of 6 habitat types within the modified minimum home range of bighorn sheep in Custer State Park, South Dakota, compared with total habitat availability in 1984.

Habitat Type	Total Availability (TAH)	Home Range Availability (HRAH)	
Ponderosa pine/ grass forb	39.4%	30.8%	*
Steep rocky/ ponderosa pine	20.1%	34.2%	*
Steep rocky/ grass forb	4.0%	8.7%	*
Doghair	23.2%	17.6%	*
Riparian	2.2%	3.8%	*
Mixed grass/ forb	11.2%	4.8%	*

* Indicates significant difference at $P \leq 0.05$

Table 3. Habitat selection by Custer State Park bighorn ewe-lamb groups, May-August 1984.

Habitat Type	Proportion availability (total)	Proportion availability (home range)	Proportion observations (P_i)	Preference ratio*	Confidence interval for proportion of use P_i	
Ponderosa pine/ grass forb	0.394	0.308	0.273	0.69	$0.174 \leq P_1 \leq 0.371$	a
Steep rocky/ ponderosa pine	0.201	0.342	0.545	2.75	$0.443 \leq P_2 \leq 0.662$	ab
Steep rocky/ grass forb	0.040	0.087	0.042	1.06	$0.000 \leq P_3 \leq 0.086$	b
Doghair	0.232	0.176	0.000	0.00	$0.000 \leq P_4 \leq 0.000$	ab
Riparian	0.022	0.038	0.042	1.95	$0.000 \leq P_5 \leq 0.086$	
Mixed grass/ forb	0.112	0.048	0.091	0.81	$0.027 \leq P_6 \leq 0.154$	

* Preference ratio = use divided by total availability

[a] Indicates significantly different use than total availability at $P < 0.05$

[b] Indicates significantly different use than home range availability at $P < 0.05$

stro/grfb slightly less than its availability in HRAH.

Bighorn sheep were never located farther than 80 m from escape terrain, which was defined as areas having greater than 100% slope with large rock outcrops. Sheep were observed on the middle third of the slope 44% of the time, while only 27% of the observations were off the slope either at the top or bottom. Over 90% of the locations were within 0.5 km of available water, with no sheep being located farther than 1 km from a water resource.

DISCUSSION

Risenhoover (1981, in Risenhoover and Bailey 1985) reported that bighorn sheep avoided areas with tall, dense vegetation but would use these areas when visibility was increased through thinning. Peek et al. (1979) and Riggs and Peek (1980) also reported that bighorn sheep will move into ranges that were recently burned to clear vegetation. Once a threshold of visibility has been exceeded, forage density becomes more important in determining habitat selection (Risenhoover and Bailey 1985). This is the case in CSP. There was a slight negative correlation ($r = -0.46$) between preference ratio (habitat use divided by total availability) and horizontal obstruction. Sheep used all areas with horizontal obstructions less than 25%, but totally avoided dest/pipo with horizontal obstruction over 50%.

MacArthur et al. (1979, 1982) have reported that heart rates increased when sheep enter forested areas with reduced visibility. Heart rate is a sensitive indicator of arousal, the first stage of an alarm reaction to stress (Jenkins and Kruger 1975). The added cost of excessive arousal may interfere with health, growth, and reproductive fitness (Geist 1979). Sheep in CSP may avoid dest/pipo stands because of the stress involved and the very limited forage available.

Foraging efficiency of bighorn sheep was negatively associated with distance from escape cover and positively associated with habitat visibility (Risenhoover and Bailey 1985). Bighorn ewe and lamb groups in CSP have restricted their activity to steep, rugged canyons with permanent water supplies. Although forage density was higher in some available habitats than the stro/pipo selected by the sheep, the added security of close proximity to escape terrain together with an acceptable forage density and access to water in this habitat could have led to this selection.

Home range, which is determined by the movements of an animal or group of animals, is influenced by habitat selection. Thus, home range must reflect habitat use. This is indicated by the differences in availability of habitats within the home range of the sheep compared to total habitat availability. Selection for stro/pipo and the close proximity to both water and escape terrain indicated that CSP bighorn ewes and lambs required rugged slopes or canyons near permanent water

supplies.

Recommendations

Dest/pipo stands in the French Creek Canyon should be thinned or burned. Clearing these areas would increase available range which would otherwise remain unused. Carrying capacity also could be increased due to increased forage production stimulated by opening the canopy. Finally, when habitat selection studies are undertaken, the method by which available habitat is determined can influence apparent selection. If only the home range is considered to contain available habitats, true selection may be masked by the fact that home range already reflects this selection.

LITERATURE CITED

Bradley, W. G. 1964. The vegetation of the Desert Game Range with special reference to desert bighorn. Desert Bighorn Counc. Trans. pp. 43-46.

Buechner, H. 1960. The bighorn sheep in the United States, its past, present and future. Wildl. Monogr. No. 4. 174pp.

Byers, C. R., R. K. Steinhorst, and P. R. Krausman. 1984. Clarification of a technique for analysis of utilization-availability data. J. Wildl. Manage. 48:1050-1053.

Daubenmire, R. 1959. A canopy-coverage method of vegetational analysis. Northwest Sci. 33:43-64.

Deming, O. V. 1964. Some bighorn foods on the Desert Game Range. Desert Bighorn Counc. Trans. pp 137-144.

Erickson, G. L. 1972. The ecology of Rocky Mountain bighorn sheep in the Sun River area of Montana with special reference to summer food habits and range movements. Job Final Report W-120-R-2 and R-3.

Geist, V. 1971. Mountain sheep--a study in behavior and evolution. Univ. Chicago Press, Chicago and London. 383 pp.

_____. 1979. Life strategies, human evolution, environmental design. Springer-Verlag, New York. 495pp.

_____., and R. G. Petocz. 1977. Bighorn sheep in winter: do rams maximize reproductive fitness by spatial and habitat segregation from ewes? Can. J. Zool. 55:1802-1810.

Graham, H. 1968. Habitat studies in the San Gabriel Mountains bighorn range in California. Desert Bighorn Counc. Trans. pp. 54-57.

Harvey, M. J., and R. W. Barbour. 1965. Home range of Microtus ochrogaster as determined by a modified minimum area method. J. Mammal. 46:398-402.

Hinkes, M. 1978. Desert bighorn habitat management plan, Black Mountains, Arizona. Desert Bighorn Counc. Trans. pp. 36-38.

Irvine, C. A. 1968. The desert bighorn sheep in the Fry Canyon area of southeast Utah. Desert Bighorn Counc. Trans. pp. 12-17.

Jenkins, W. L., and J. M. Kruger. 1975. Modern concepts of the animal's physiological response to stress. Pages 172-183 in E. Young, ed. Capture and care of wild animals. Ralph Curtis Books, Hollywood, FL.

Lemmon, P. E. 1956. A spherical densiometer for estimating forest overstory density. For. Sci. 2:314-320.

_____. 1957. A new instrument for measuring forest overstory density. J. For. 55:667-668.

MacArthur, R. A., R. H. Johnson, and V. Geist. 1979. Factors influencing heart rate in free-ranging bighorn sheep: a physiological approach to the study of wildlife harassment. Can. J. Zool. 57:2010-1021.

_____., V. Geist, and R. H. Johnson. 1982. Cardiac and behavioral responses of mountain sheep to human disturbance. J. Wildl. Manage. 46:351-358.

Martin, S. A. 1981. Summer and fall habitat use and migration patterns of the Rock Creek segment of the Beartooth sheep herd. Job Completion Report W-98-R-5, B-11. Denver Public Library. 44pp.

Morgantini, L. E., and R. J. Hudson. 1981. Sex differential in use of the physical environment by bighorn sheep (Ovis canadensis). Can. Field Nat. 95:69-74.

Neu, C. W., C. R. Byers, and J. M. Peek. 1974. A technique for analyusis of utilization-availability data. J. Wildl. Manage. 38:541-545.

Peek, J. M., R. A. Riggs, and J. L. Lauer. 1979. Evaluation of fall burning on bighorn sheep winter range. J. Range Manage. 32:430-432.

Riggs, R. A., and J. M. Peek. 1980. Mountain sheep habitat-use patterns related to post-fire succession. J. Wildl. Manage. 44:933-938.

Risenhoover, K. L. and J. A. Baily. 1985. Foraging ecology of mountain sheep: implications for habitat management. J. Wildl. Manage. 49:797-804.

Schmidt, R. L., W. H. Rutherford, and F. M. Bodenham. 1978. Colorado bighorn sheep-trapping techniques. Wildl. Soc. Bull. 6:159-163.

Trefethen, J. B. 1975. An American crusade for wildlife. Winchester Press, New York. 409pp.

Welch, R. D. 1969. Behavioral patterns of desert bighorn sheep in south-central New Mexico. Desert Bighorn Coun. Trans. pp. 114-129.