

VISIBILITY: AN IMPORTANT HABITAT FACTOR FOR AN INDIGENOUS, LOW-ELEVATION BIGHORN HERD IN COLORADO

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Abstract: The Waterton Canyon bighorn sheep (*Ovis canadensis*) herd is one of only 7 remaining indigenous low-elevation herds in Colorado. This herd lives in a brushland dominated environment and has exhibited rutting and lambing periods that are at least 2 1/2 months long. Forty percent of the herd's home range consists of Oakbrush in which visibility is poor and sheep avoid this habitat type. They show strong preference for habitats providing good visibility and tend to assemble into larger groups when in these more open types. Sheep in Waterton Canyon are habituated to human activities allowing close observation. During foraging periods, older sheep are more alert than are younger sheep, but all sex-age classes are more alert and forage less efficiently when habitat-visibility is poor. The importance of visibility to success of the evolved predator-evasion strategy of bighorns, and the management implications of visibility in bighorn sheep habitats are discussed.

In recent studies of ungulate behavior, several authors have noted advantages in forming social groups (Berger 1978, Bergerud 1974, Jarman and Jarman 1974, Walther 1969). These advantages include increased foraging efficiency and improved detection of predators. While several authors mention that "openness" or visibility in the habitat is important to success of this strategy, we have found no studies in which "openness" or visibility in the habitat has been measured and correlated with group behavior and foraging efficiency.

Rocky Mountain bighorn sheep (Ovis canadensis canadensis) residing in Waterton Canyon are indigenous and occur at a low-elevation (1707-2347 meters) along Colorado's front range, approximately 40 km from downtown Denver. This herd is one of only 7 indigenous low-elevation herds remaining in the state.

Waterton Canyon bighorn habitat differs greatly from habitats of the more common high-elevation herds in the state. Most of the area is dominated by shrubs, especially oakbrush (Quercus gambellii) and true mountain mahogany (Cercocarpus montanus). The Canyon has mild winters and hot dry summers. In this climate, green forage becomes available on snow-free south-facing slopes in late January and, depending on rainfall, may occur in any month. The period during which forage quality is most limited appears to be late fall and early winter.

Little is known of the ecology of Colorado's low-elevation bighorn herds. Because of different selective forces working on these populations, they may possess unique genetic characteristics favoring reproductive fitness in Colorado's low-elevation environments.

Some unique characteristics have been observed in Waterton Canyon sheep. The lambing season in 1979 was 2 1/2 months long, beginning April 15 and ending June 30, with a peak in mid-May. Other Colorado bighorn herds have more synchronized lambing periods in late-May to early June. Also, many rams in the canyon have horns that are more widely flared than is common in Colorado bighorns. Of 11 Colorado bighorns in Boone and Crockett records (Boone and Crockett Club and National Rifle Association 1977) the 2 from Waterton Canyon have greater horn spreads relative to mean horn lengths than do any of the other 9.

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Objectives

This study is being conducted at Waterton Canyon to assess impacts

of constructing the Strontia Springs Dam on the canyon's herd of 58 bighorn sheep. The project has provided an opportunity to study the ecology of Colorado bighorn sheep in a somewhat atypical brushland environment.

This paper presents data on behavioral responses of bighorns to variation in vegetation density and consequent variation in visibility. (Behavior of bighorns may also be influenced by other factors, such as distance from escape terrain. While we have measured other factors, multi-variate analysis has not been completed. Only the influence of visibility upon behavior is being considered in this paper.)

Methods

Activities of sheep during foraging periods were classified into alert, social, and foraging behavior (Table 1). When foraging bighorns were encountered, behavior budgets of individuals were recorded by describing all activities into a tape recorder. Observation periods were 5-10 minutes per animal unless terminated by the animal moving out of good view. When possible, behavior was recorded for each member of the observed group.

For each observation of foraging behavior, habitat type, group size and composition, and average visibility at 20 and 40 m were recorded. Sex-age compositions of groups were determined following Geist (1968). Average visibility from the center of the area used by each group of sheep was estimated after the animals had moved away. From this point, the percent of each quarter of the compass over which an object 90 cm tall could be seen at both 20 and 40 m from the observer was visualized. Percentages for 4 quarters of the compass were averaged.

Alertness of bighorns was measured as the percent of foraging periods spent in alert behavior and by the frequency of alert postures per minute. Foraging efficiency was measured by the percent of periods spent in foraging behavior.

Alertness and foraging efficiency data were compiled and compared among sex-age classes of sheep. These data were also compiled and averaged for each observed group of bighorns. Group alertness and foraging

efficiency were then tested for linear correlation with group size and with habitat visibility. Group alertness and foraging efficiency were also compiled and compared among habitat types used by the sheep.

The home range of Waterton Canyon sheep, based on distribution of observations during 1979, was divided into 9 habitat types using color aerial photos (Table 2). Using these types, the percent composition of the home range was measured using a table planimeter. Habitat-preference indices were calculated by dividing the percent of bighorn observations in each type by the availability of the type expressed as a percent of the home range.

Average visibility for each habitat type on the home range was determined. For each type, 20 units of the type were selected at random from the home range type map. Visibility was estimated from the center of each Unit in the manner described for estimating visibility at the site where foraging sheep had been observed.

Results

Habitat selection by Waterton Canyon bighorns was based on 368 observations of sheep from January through June, 1979 and January through March, 1980. The sheep preferred open habitats with short vegetation, especially grassy openings and the mountain shrub and open mountain shrub types (Table 2). In contrast, they avoided habitats with dense, tall vegetation especially the oakbrush, conifer-rock outcrop, and Douglas fir types. Preferred habitats provided greater visibility compared to avoided habitat types (Fig. 1).

Analysis of 858 mins. of bighorn foraging behavior indicated differences among sex-age classes (Table 3). Compared to lambs and yearlings, ewes and rams spent a greater percent of time alert during foraging periods. Lambs spent more time involved in social behavior than did other classes. The greatest portion of this time was spent looking at other group members for visual signals, particularly by lambs less than 2 months old. The indicated large differences in behavior among sex-age classes of sheep must be considered when these data are analyzed to determine effects of the environment on behavior. It is expected that effects of environment

Table 1. Classification of bighorn behavior observed during foraging.

Type	Description and Characteristics
Foraging	Feeding; Looking at forage; Moving toward forage. Head is oriented toward the ground.
Alert	Head upright; surveying surroundings for potential danger. May lead to alarm posture.
Social	Interactions among sheep; play; aggression; display; looking at other sheep, moving toward other sheep.

Table 2. Habitat preferences of bighorn sheep in Waterton Canyon, Colorado.

Type	% Available	% Use	Preference Index
Open Mt. Shrub	4.0	36.6	8.25
Grassy Openings	1.8	12.7	7.05
Mt. Shrub	10.8	36.6	3.39
Cliff	4.3	9.1	2.12
Conifer/Rock Outcrop	16.2	3.6	0.22
Oakbrush	40.1	1.9	0.05
Douglas fir	22.3	0.0	- 1/
Others	trace	3.8	- 1/

1/ Preference Index could not be calculated.

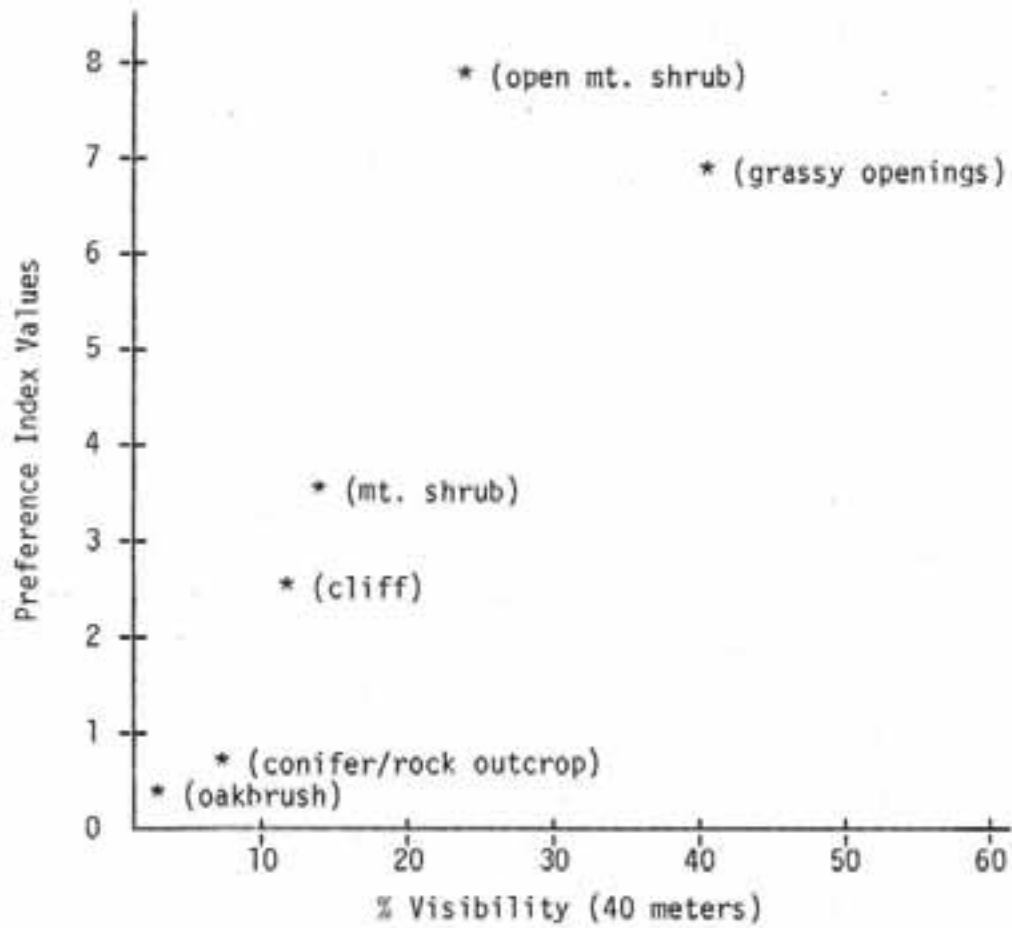


Fig. 1. Habitat preferences of Waterton Canyon bighorn sheep in relation to habitat visibility.

on foraging efficiency will be most pronounced in ewes and rams, the most alert animal.

Linear regression analysis of group foraging behavior revealed that average foraging efficiency was greater when sheep were in large groups ($P < 0.05$). Average foraging efficiency was also greater when sheep were in habitats providing greater visibility ($P < 0.01$). In contrast to foraging efficiency, the number of alert posture exhibited by ewes each minute was negatively correlated with group size ($P < 0.05$).

In summary, bighorns preferred more open habitat types offering good visibility. In these types they tended to assemble into larger groups and to forage more efficiently (Table 4).

Discussion

Bighorn sheep evolved in open, glaciated mountain habitats (Geist 1971) where predators including wolves, cats and bears were apparently abundant. The predator-evasion strategy of bighorn sheep involves foraging diurnally in a large, dispersed group on open habitat near escape terrain. Predators are detected visually, and a large dispersed group of sheep is alert to the potential presence of predators over a large area. In contrast, a small group of sheep has fewer eyes to detect predators and a clumped group of sheep is aware of less areas in its surroundings. Once predators are seen, their presence is communicated visually among the sheep by alarm postures and the animals escape to steep terrain where they are adapted to outmaneuver their enemies. Visibility is necessary in this strategy for predator detection and for inter-sheep communication (Table 5). In addition, visibility in combination with abundant and dispersed forage allows sheep to congregate into a large group of individuals that are dispersed yet in visual communication.

When visibility is comparatively poor, sheep are forced to forage closer together in order to remain in visual contact; or groups may split up reducing the predator-detection advantage of group size. When sheep forage in habitat with poor visibility, they spend more time surveying their surroundings and other sheep for predators or visual signals such as the attention or alarm postures (Geist 1971). Foraging in close

Table 3. Behavior of Waterton Canyon bighorn sheep during foraging periods (n=858 mins. of observation).

Class	% Foraging	% Alert	% Social
Ewes	84	15	1
Lambs	88	3	9
Yearlings	92	6	2
Rams	87	12	1

Table 4. Comparison of bighorn sheep foraging behavior by sex-age class in two habitat types in Waterton Canyon.

Type	n	Mean % Visibility		\bar{x} Group Size	% Time Spent Foraging			
		20m	40m		E	L	Y	R
Grassy Openings	55	93	50	11.7	90	96	92	95
Mt. Shrub	35	56	16	8.4	80	93	88	61

Table 5. Predator-evasion strategy of bighorn sheep.

Strategy	Habitat Requirement
Detect Predators (enhanced by group size and dispersion)	Visibility, low forage, dense forage, uniform forage distribution
Communicate danger	Visibility
Escape to cliffs	Nearby escape terrain

proximity may also result in intraspecific competition and increased social interaction. The resulting increased alert and social behavior reduce foraging efficiency.

A lack of major fires in Waterton Canyon during the past 50 years has allowed areas to become overgrown with brush and conifer vegetation. Consequently, approximately 3/4 of the study area consists of vegetation types in which visibility is poor and sheep avoid these areas. However, sheep must travel through dense vegetation where visibility is poor when moving among open areas and when moving to and from the main lambing area. This may have exposed sheep, especially lambs, to predation. Lamb:ewe and yearling:ewe ratios observed in January of 1979 (Table 6) indicate that recruitment of sheep from 1977 and 1978 lamb crops has been poor. Waterton Canyon appears to be good habitat for large predators such as mountain lion (Felis concolor), bobcat (Lynx rufus), and coyote (Canis latrans) and these species have been observed on the study area. We speculate that predation losses resulted in the low age ratios observed in 1979. In contrast, now that dam construction has begun in the canyon, a large 1979 lamb crop has appeared and survived to the time of this writing. We speculate that construction activities during 1979 have caused large predators to abandon parts of the canyon used by sheep, and allowed good lamb survival. Although this hypothesis is supported only by circumstantial evidence, the sheep use areas on and near the canyon road and the construction area frequently. Further, there have been no symptoms of forage deficiency or of lungworm-pneumonia which might have caused the poor lamb production or survival observed at Waterton in 1977 and 1978.

Visibility is an important habitat requirement of bighorn sheep. While visibility or "openness of vegetation" have been recognized in management recommendations for bighorns (Trefethen 1975:117,174), emphasis in sheep management has been on supplying forage, controlling disease and reducing human disturbance. We may be neglecting the potential of vegetation control to enhance visibility in many bighorn habitats.

Table 6. Recruitment success of Waterton Canyon bighorn sheep from the 1977, 1978 and 1979 lambing seasons.

Observation Time	No. of Ewes in Population	Lamb/Ewe	Yearling/Ewe
January, 1979	24	0.25	0.21
January, 1980	25	0.56	0.24

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QUESTION - RESPONSES

Tom Hobbs: To what extent do you think your comparisons of preference are influenced by ease of your visibility of the sheep: that is, was it easier for you to see sheep in an area of high visibility, thereby biasing all future estimates of preference?

Ken Risenhoover: The sheep in Waterton Canyon are relatively habituated to people and haven't been hunted for sometime now. Due to that I have been able to approach the sheep rather closely in order to measure the foraging regime. We are using radio telemetry also, to help find some of the sheep in the Canyon. I feel that we have covered a lot of the habitat where visibility is poor.

Wayne Heimer: What do you actually see; you say you have seen predators present and you have found kills, or seen kills, that would actually indicate greater predation in the tall brush?

Ken Risenhoover: Unfortunately, we didn't become involved with the study until construction had begun in 1979, as I indicated, and therefore, the thing we had to base these low lamb survival ratios on were what was actually observed in the herd at that time; the lambs that had survived to January of the following year. Since we have been there we haven't observed any predation so to speak. We have found one carcass, but only part of it, and we couldn't determine what had killed it. I have observed, myself, a high density of coyotes and I have observed bobcats. Several of the construction people have seen mountain lions in the area, but I have not seen any mountain lions.

Wayne Heimer: Do the predators prefer the tall brush?

Ken Risenhoover: I couldn't tell you for sure. I would think that an animal that was going to be able to stop a bighorn sheep would have an advantage in habitats where visibility is poor.