Response of Bighorn Sheep to Pinyon-Juniper Burning Along the Green River Corridor, Dagget County, Utah

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Abstract—Rocky Mountain bighorn sheep (*Ovis canadensis canadensis*) within the Green River Corridor have shown a high preference for burned areas within the pinyon pine (*Pinus edulis*) and juniper (*Juniperus osteosperma* and *J. scopulorum*) belt and within ponderosa pine (*Pinus ponderosa*) communities. Burns located within or adjacent to steep rocky habitat, and within core bighorn use areas, received significantly higher use than non-burned areas. Increased use of an area occurred where fire left more open areas with a reduced density of live or standing dead trees. Positive response has been found in small burns of 5 acres to large burns of 600 acres or more. Less significant use was observed on burn areas that were not within the core bighorn sheep area, or at sites with dense standing dead pinyon-juniper. Bighorn group size was significantly larger in burned areas.

Rocky Mountain bighorn sheep (*Ovis canadensis canadensis*) were reintroduced on Bare Top (also known as Bear) Mountain along the Green River Corridor in 1983-1984. Various habitat treatments have been applied to this area to improve and expand bighorn habitat. Historically, Native Americans used fire to maintain desired habitat for game species such as bighorn sheep, which they placed high value on as a resource.

Smith (1992 and 1996) studied this bighorn herd in 1986-1988, and in 1991. He found the most highly preferred habitats were burned areas dominated by grasses. He repeatedly found bighorn sheep in older burned areas and areas with sparse or intermediate cover of trees within the pinyon pine (*Pinus edulis*) and juniper (*Juniperus osteosperma utahensis* and *J. scopulorum*) belt, and at the interface of this belt with ponderosa pine (*Pinus ponderosa*) communities. Smith (1996) studied the response of Bare Top bighorns to clearcutting and prescribed burns applied to cliff-side habitat in 1989. He found that bighorns responded favorably to both habitat treatments by expanding range use and distributions into formerly unused areas, and that bighorns favored clearcuts twice as much as burned areas. Subsequent monitoring (1995-1997) by the Utah Division of Wildlife Resources (UDWR) continues to show a stronger preference for burned and open areas over those occupied by dense trees.

Smith (1992) also looked for bighorn sheep in recently burned pinyon-juniper areas with a high density of standing dead trees. He found that the bighorns generally avoided the areas that had a high density of live or standing dead trees. He considered a high density of live or standing dead trees to reduce the visibility of bighorns to intolerable levels.

Study Area

The principal area of study is on and around Bare Top Mountain which is within the Green River Corridor, Daggett County, Utah. The top of the mountain is comparatively flat with Red Canyon and Flaming Gorge Reservoir on the east, south, and west sides. Red Canyon is a deep canyon with associated side canyons. It was cut by the Green River which runs through the north flank of the Uinta Mountains. These steep rocky canyons which have been cut through Precambrian materials of the Uinta Mountain Group, Weber Sandstone, and other geologic formations, provide important habitat for bighorn sheep. Steep and cliffy canyon walls with warm exposures provide winter forage when snow is deep on the top. These steep areas are also important during the lambing season, and for escape cover (Smith 1992). Wild and prescribed fire has occurred on top of the mountain and along the canyon walls (fig. 1,2). Burns range in size from 5 acres to over 600 acres. Clearcut logging also occurred in 1989 on top of the mountain.

Pinyon and juniper are well adapted to the steep and rocky canyon walls with warm exposures. The density of pinyon-juniper is largely a function of fire history. Fire potential is dependent upon pinyon-juniper density and understory conditions. Many places along the canyon have intermediate densities of pinyon-juniper trees, where a high percent of exposed rock has reduced tree and understory densities necessary to carry fire. In other places fuel conditions have enabled fire to occur, indicating fire to be an important part of the ecology of the area.

The top of the mountain contains ponderosa pine with associated mountain brush and grass communities of sagebrush (*Artemesia tridentata wyomingensis*), bitterbrush (*Purshia tridentata*), snowberry (*Symphoricarpus* spp.), ceanothus (*Ceanothus* spp.), wheatgrasses (*Agropyron* spp.), sheep fescue (*Festuca* spp.), and needlegrass (*Stipa* spp.). Pinyon-juniper also grows on top, however, dense stands have not commonly developed there. Fuels and other conditions have effectively carried fires and reduced pinyon-juniper presence.

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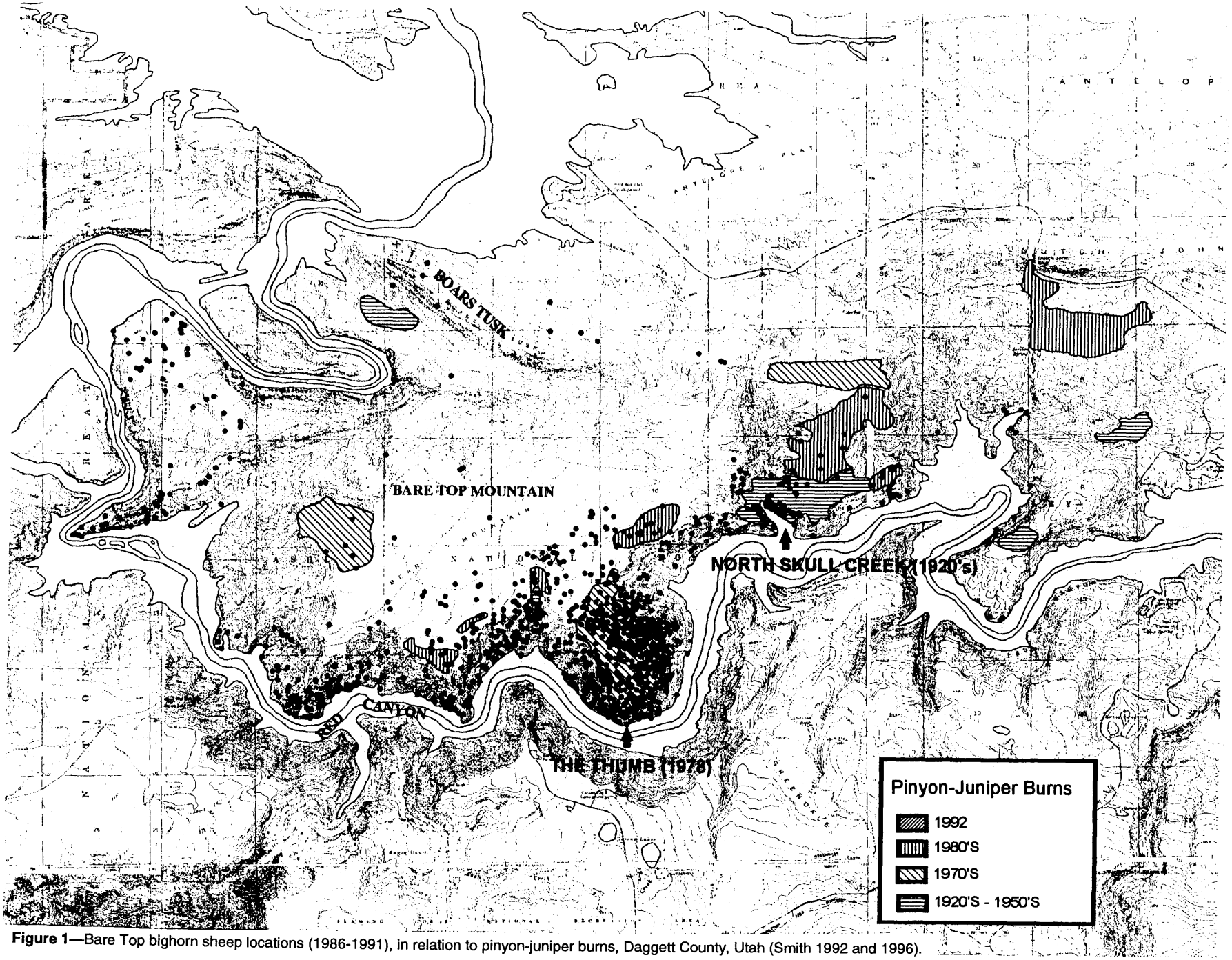

Figure 1—Bare Top bighorn sheep locations (1986-1991), in relation to pinyon-juniper burns, Daggett County, Utah (Smith 1992 and 1996).

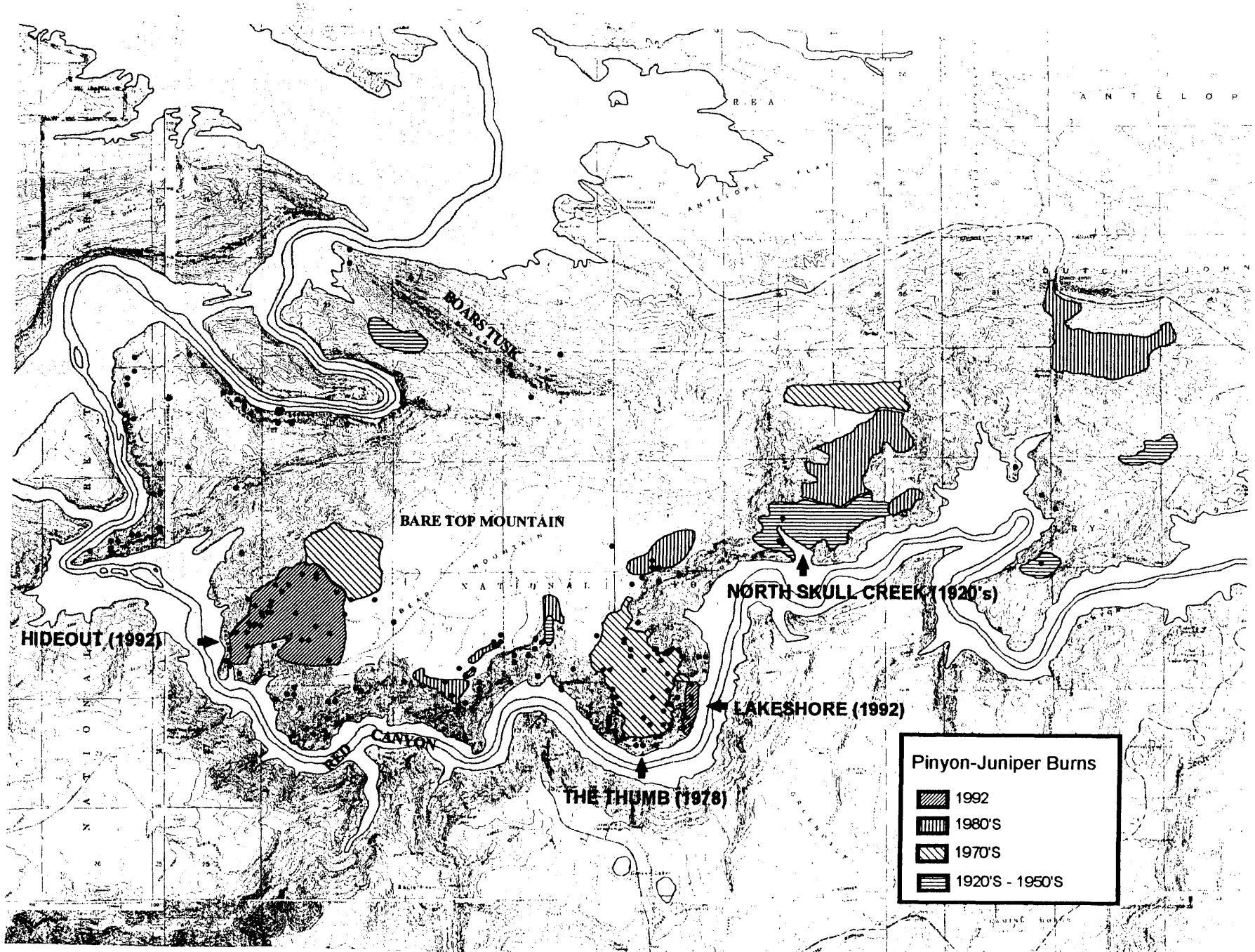

Figure 2—Bare Top bighorn sheep locations (1995-1997), in relation to pinyon-juniper burns, Daggett County, Utah.

Methods

New pinyon-juniper areas were burned in 1992 in a cooperative effort with the U.S. Forest Service and the UDWR. Both burns were located in steep rocky habitat considered to be within the core bighorn use area. The core bighorn use area was from North Skull Creek west along Red Canyon and north to the Boars Tusk (fig. 1,2). Bighorn use of the new pinyon-juniper burn areas before and after burning was compared. Comparisons were made between 1995-1997 bighorn location data, and 1986-1991 bighorn locations from Smith (1992 and 1996).

Bighorn sheep were located primarily using radio telemetry from 1995-1997. Radio-collared bighorns were located from the ground, boat, and fixed-wing aircraft. Ground surveys were performed up to 3 times per month, and fixed-wing surveys once per month. In addition, bighorn locations from helicopter trend counts and incidental observations were also used. Bighorn group size, classification (rams, ewes, and lambs), and burn category was documented for each observation. Bighorn locations and burns were digitized into a geographic information system (GIS). Smith (1992) also used radio telemetry for surveys from 1986-1988. Smith (1996) recorded visual observations of bighorns in 1991 made along an established walking transect (radio telemetry was not used during his 1991 walking transect survey).

The hypothesis, that bighorn sheep use different age burns and non-burned areas in proportion to the area of occurrence, was examined using a chi-square goodness-of-fit test. Selection or avoidance of individual burned or non-burned areas was examined using Bonferroni normal statistics (Neu and others 1974). A comparison of mean bighorn group size between burned and non-burned areas was conducted using a Student's t-test.

Results

Bighorn sheep continued to use the more open, steep and rocky habitat during 1995-1997. Forty-three percent of all bighorn locations from 1995-1997 occurred in burned areas. Twenty-two percent of the bighorn locations occurred in the new burn areas. Smith (1992 and 1996) found less than 2 percent of his bighorn locations in these areas prior to burning. The Hideout burn is 581 acres and was seeded with a mix of grasses and forbs. The Lakeshore burn is 64 acres, and was never reseeded. The core bighorn area was used to test the hypothesis that bighorns utilized burned areas of different ages, and non-burned areas, in exact proportion to their occurrence. Chi-square analysis (goodness-of-fit test) showed a significant difference between the observed and expected bighorn observations for burned and non-burned areas ($X^2 = 133.54 > X^2_{0.99(4)} = 13.27$). Thus the hypothesis was rejected. Next, the analysis technique developed by Neu and others (1974) was used to determine preference or avoidance of burned and non-burned areas. Comparisons of the expected proportion of bighorn observations, to the 95 percent confidence interval on the observed proportions of bighorn observations, were made (table 1). Bighorns were observed in burns, ranging in age from the 1970's to 1992, significantly more than expected (42 percent of the bighorn observations were in these more recent burns, although only 14 percent were expected). Old burns ranging in age from the 1920's to 1950's were used in proportion to their availability (1.5 percent of the bighorn groups were observed, with 2.0 percent expected). Non-burned areas were used significantly less than expected (57 percent of the bighorn observations occurred in non-burned areas, with 84 percent expected).

Bighorn group size comparisons between burned and non-burned areas found burned areas to have a mean (SE) group size of 8.3 (0.84) bighorns, and non-burned areas 5.0 (0.77) bighorns. Burned areas had a significantly higher bighorn group size than non-burned areas ($t = 2.85$, 71 df, $P < 0.01$).

Discussion

Our study shows that bighorn sheep will use new pinyon-juniper burns given the right circumstances. The Lakeshore burn is located on the east side of the Thumb area next to Flaming Gorge Reservoir in cliffside habitat. Prior to burning, trees were cut and piled to increase fire transmission. After burning, few standing dead trees remained allowing good visibility for bighorns. The Lakeshore burn was located next to the Thumb area which already received concentrated bighorn use.

The Hideout burn is located in steep rocky terrain, along Red Canyon, on the southwest side of Bare Top, within the core bighorn use area. In parts of the burn, pinyon-juniper trees were sparse enough that burned skeletons do not reduce visibility for bighorns. Most of the bighorn observations in the Hideout burn are on the west ridge which had a lower density of pinyon-juniper prior to burning.

Table 1—Observed and expected frequencies of bighorn observations in relation to pinyon-juniper burns, Bare Top Mountain, Daggett County, Utah, 1995-1997.

Burn categories	Acres	Observed		Expected [a]		95 percent confidence interval on Pi[b]	Selection behavior[c]
		N	Proportion (Pi)	N	Proportion		
1992 Burns	650	44	0.217	13	0.065	0.143 < Pi < 0.291	Preferred
1980's Burns	190	13	0.064	4	0.019	0.020 < Pi < 0.108	Preferred
1970's Burns	578	28	0.138	12	0.058	0.076 < Pi < 0.200	Preferred
1920-50's Burns	201	3	0.015	4	0.020	− 0.007 < Pi < 0.037	Indifferent
Non-Burned	8,381	115	0.566	170	0.838	0.476 < Pi < 0.656	Avoided
Total	10,000	203	1	203	1		

[a]Derived from the acres of each burn category.
[b]From Neu and others (1974).
[c]Burn categories preferred were used significantly more than expected; burn categories indifferent used as expected; burn categories avoided used significantly less.

Bighorns tend to avoid parts of the burn where the skeletons are dense.

Smith (1992) recommended against using pinyon-juniper burns to create or enhance bighorn habitat. He found bighorn sheep had preference for areas which provide high visibility. The most highly preferred habitats were older burned areas dominated by grasses. He found bighorns avoided high and intermediate densities of pinyon-juniper stands. This avoidance included recently burned stands with high densities of standing dead trees. He observed that older burned areas with low densities of trees were preferred by bighorns. This was consistent with other studies that reported bighorns to seek burned areas. Smith (1992) also found the diets of bighorns in this area were comprised of 79.2 percent graminoids, 6.9 percent forbs, 13.0 percent shrubs, and 1 percent conifers. The rim of Red Canyon was considered by Smith (1992) to be highly important habitat for the bighorns. He found that 95 percent of all observed bighorn activity was confined to steep cliff complexes or was within 300 meters of them.

Smith (1996) found that bighorns responded favorably to both clearcut logging and prescribed burns by expanding range use and distributions into formerly unused areas. He found that bighorns favored clearcuts twice as much as burned areas.

Three criteria must be met when planning pinyon-juniper burns to enhance bighorn use and expand habitat. First, new pinyon-juniper burns must be located within the core bighorn sheep use area. Second, new burns must be within or immediately adjacent (within 300 m) to steep rocky escape terrain. Third, part of the area to be burned should have a lower density of trees, so that the burned skeletons will not reduce visibility for bighorn sheep.

Results of our study indicate that Bare Top bighorns did not significantly use new pinyon-juniper burns north and east of North Skull Creek during Smith's (1992) study primarily because these new burns were not within the core bighorn sheep area and remaining tree skeletons were dense and reduced bighorn visibility. Bighorns were not found to utilize these same burns during our study for the same reasons. It is hoped that as standing dead tree skeletons fall and decay, bighorn visibility and use will increase.

Smith (1992) observed significant bighorn use on an old burn (from the 1920's) at the mouth of North Skull Creek. The Thumb area was burned in 1978 by a wildfire and received the highest concentration of bighorn use during Smith's study (1992).

A significant shift in bighorn use to the new 1992 pinyon-juniper burned areas occurred. The Thumb continues to receive significant bighorn use. The new Hideout burn now receives comparable bighorn use to the Thumb.

Conclusions

Small burns as well as larger burns were selected during all studies. Documented observations verify high bighorn selectivity for burned areas which result in early seral, open communities. Habitat values for bighorn sheep within the pinyon-juniper belt are much higher in early seral communities than in mature pinyon-juniper stands. Visibility is indicated to be a major factor in habitat selection. Conditions that favor greater visibility are also favorable conditions for quantity and quality of forage for the bighorns. The high percentage of graminoids and low percentage of conifers in the diets of bighorns found by Smith (1992) are consistent with the concept that early seral communities are of greater value to bighorns than communities dominated by trees.

Management Implications

Valuable bighorn sheep habitat is associated with early seral plant communities in steep rocky terrain, characterized by good visibility, abundant grasses and grasslike plants, and low density of trees and tall shrubs.

As pinyon-juniper have the capacity to dominate much of the landscape, fire or other disturbances will be required to maintain valuable bighorn habitat. Disturbance intervals short enough to prevent tree dominance is essential to the maintenance of this habitat. Studies in burned sites within the pinyon-juniper belt of the Green River Corridor (Goodrich and Barber 1998, these proceedings) indicate a fire frequency of 50 or more years would likely keep tree density and stature at levels preferred by the bighorns. However, shorter intervals might be required to keep shrub density and stature within levels preferred by the bighorns. Fire intervals of 20-25 years (Houston 1973) and 10-40 years (Winward 1991) have been suggested within the inherent range of variability for montane sagebrush communities. Fire intervals of 20-25 years are indicated to keep density and stature of shrubs at levels favorable for bighorn sheep habitat.

Burning outside core bighorn use areas in mature, dense stands of pinyon-juniper should not be expected to immediately increase available bighorn habitat. Re-burning such dense stands or using additional mechanical treatments, at appropriate intervals, will create and maintain open, early seral communities, increasing its value for bighorns. Expansion of habitat for bighorn sheep in this study area will depend largely on prescribed burning or other treatments that reduce the presence of live pinyon and juniper as well as tree skeletons remaining after fire. Maintenance of bighorn habitat will be highly dependent on repeated treatments. Bighorn sheep densities will be low without such actions.

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