



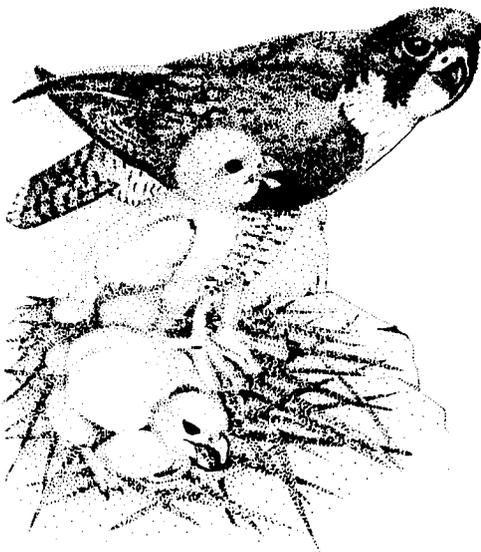
IDAHO BLM

TECHNICAL BULLETIN

AN ANNOTATED BIBLIOGRAPHY ON THE INFLUENCE OF
CATTLE, BURROS, AND HUMAN DISTURANCE ON
BIGHORN SHEEP

by

Jeffrey S. Marks and Alan R. Sands



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**BUREAU OF LAND MANAGEMENT
IDAHO STATE OFFICE
3380 Americana Terrace
Boise, Idaho 83706**

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Boise District Bureau of Land Management

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INTRODUCTION

Without question, humans and their livestock exert a profound influence on natural habitats in the western United States. It is generally believed that most of these influences are detrimental to bighorn sheep populations. Yet, evidence in support of this contention is equivocal.

The purpose of this report is to gather together annotations of most of the published literature that deals, either directly or indirectly, with the influences of cattle, burros, and human disturbance on bighorn sheep. Each annotation is an introduction to the original paper and should not be used as a substitute for it. It is not our intention to summarize this literature into generalities about the influences of livestock and humans on bighorns. Instead, we merely present this information as a means of accessing the original literature.

This report is a by-product of a research project on California bighorn sheep. This research project, which is briefly described below, is a cooperative venture between the Boise District Bureau of Land Management (BLM) and the Idaho Department of Fish and Game (IDFG).

California bighorn sheep were extirpated from most of their historic range by 1940. Factors thought to be responsible for this decline include livestock grazing, disease, and overhunting. Beginning in 1954, California bighorns were transplanted back into parts of their historic range. Because these releases were made in remote areas that were not strongly influenced by livestock or humans, some of these new populations have flourished. Nonetheless, many areas throughout the historic range of the California bighorn remain unoccupied despite opportunities for transplant.

Few research projects have directly assessed bighorn/cattle relationships. Based on limited evidence that bighorns avoid and are out-competed by cattle, managers have been conservative in allowing increased cattle use in habitats occupied by bighorns. As a result, considerable controversy surrounds efforts to establish additional bighorn populations using transplants. In southwestern Idaho, for example, the Owyhee Cattlemen's Association passed a resolution objecting to any further transplants of California bighorns.

Data on the effects of human disturbance on bighorns are also limited. Moreover, the behavioral responses of un hunted bighorns may be different than those of hunted ones. Many areas that are important to bighorns are being considered for wilderness or wild and scenic river designation. Human use in these areas can be high and is expected to increase.

Beginning in 1987, the BLM and the IDFG initiated a study on the year-round ecology of California bighorns in Owyhee County, Idaho. A major objective of this research is to determine the effects of various cattle management practices and human disturbances on California bighorn sheep. It is our belief that this research will significantly improve the ability of state and federal agencies to manage existing bighorn sheep habitats. This research should also aid managers in identifying potential habitats for bighorns and to predict how these habitats will be used by the sheep.

SCOPE

In deciding which livestock to include in the bibliography, we chose to focus on cattle and burros and to ignore domestic sheep, horses, and goats. The incompatibility of domestic sheep and wild bighorns regarding disease transmission is already so well documented that little would be gained by including domestic sheep here (see N. J. Goodson, 1982, Effects of domestic sheep on bighorn sheep populations: a review. Proc. North. Wild Sheep and Goat Council. 3:287-313). Pertinent information on horses and domestic goats was very meager.

We attempted to include as many citations as possible but undoubtedly missed some important papers. Many of the papers we cited treat livestock or human disturbance anecdotally. It was not possible to detect all such references. Especially difficult to locate were unpublished theses and dissertations and in-house research reports from state and federal agencies. Accordingly, we focused our efforts on the refereed, professional literature and on the various symposium proceedings likely to carry articles on bighorns. Among the latter, we examined complete runs (through 1986) of: (1) Desert Bighorn Council Transactions, (2) Transactions of the North American Wild Sheep Conference, (3) Proceedings of the Northern Wild Sheep Council, (4) Proceedings of the Northern Wild Sheep and Goat Council, and (5) Proceedings of the California Bighorn Sheep Workshop. We made no effort to track down unpublished information from Pittman-Robertson reports.

USING THE BIBLIOGRAPHY

Wherever possible, each annotation consists of (1) the citation, (2) a taxonomic reference, (3) a subject reference, (4) a geographic reference, and (5) the text of the annotation. Annotations of papers of a general nature may contain fewer than five parts because subject and/or geographic references could not be assigned. Annotations are listed alphabetically by author and are indexed by taxonomic, subject, and geographic references and by author(s).

The taxonomic reference consists of the type of bighorn under consideration: California (Ovis canadensis californiana); Desert (O. c. nelsoni, O. c. mexicana, O. c. weemsi, O. c. cremnobates); Rocky Mountain (O. c. canadensis); and a single reference to Stone's sheep (O. dalli stonei). If the paper was not directed at any one group of bighorns, the taxonomic reference was listed as "General."

The subject reference consists of two levels. Major headings are "burros," "cattle," "livestock," and "human disturbance." Minor headings within "burros," "cattle," and "livestock" are either "competition" or "disease." In many cases, authors inferred competition without actually presenting proper evidence that competition was or was not occurring. We use the term "competition" only for convenience. Minor headings within "human disturbance" are "aircraft," "construction," "encroachment," "experimental," "oil and gas," "recreation," and "research." "Encroachment" is a general term for human development, including roads and urbanization.

Studies that tested the response of bighorns to disturbance are listed "Experimental." "Research" refers to the handful of studies that assessed the effects of researchers on the animals that they studied. The geographic reference lists the state or province in which the research was conducted.

By design, most of the annotations are brief. Annotations copied verbatim from abstracts are followed by "Author's abstract." Annotations excerpted from abstracts are followed by "From author's abstract." Except for certain plant species, scientific names are not included in annotations, even if they were present in the author's abstract.

001. Albrechtsen, B. R., & J. B. Reese. 1970. Problem analysis of habitat management for desert bighorn sheep. Desert Bighorn Council. Trans. 14:63-65.

Desert; human disturbance, recreation; cattle, competition; Nevada

Preliminary results suggested that bighorns could not tolerate the presence of domestic livestock. Mining and recreational activity were suggested as additional limiting factors.

002. Andryk, T. A., & L. R. Irby. 1986. Population characteristics and habitat use by mountain sheep prior to a pneumonia dieoff. Proc. North. Wild Sheep and Goat Council. 5:272-289.

Rocky Mountain; human disturbance, oil and gas exploration; Montana

Radio-collared bighorns moved 4-6 km one day after seismic exploration began on a lambing area. Ewe groups returned to the area within 16 days after seismic activity ceased and remained there for the rest of the summer.

003. Bailey, J. A. 1980. Desert bighorn, forage competition, and zoogeography. Wildl. Soc. Bull. 8:208-216.

Desert; livestock, competition

Suggests that desert bighorns are Pleistocene relicts that are poorly adapted to arid environments. Competition for forage with exotic ungulates that are better adapted to desert environments is partly responsible for the decline of desert bighorn populations. Control of domestic livestock and exotic ungulates on critical sheep range is essential to maintaining desert bighorns. (See 032, 038, 065, and 095)

004. Bailey, J. A. 1986. The increase and dieoff of Waterton Canyon bighorn sheep: biology, management and dismanagement. Proc. North. Wild Sheep and Goat Council. 5:325-340.

Rocky Mountain; human disturbance, construction; Colorado

An all-age dieoff of bighorn sheep during construction of the Strontia Springs Dam was attributed to bronchopneumonia. The dieoff may have been stress-related. Potential human-caused stressors included the construction activities, traffic, dust, and the research itself. There remains a need to identify and quantify the various stressors operating on a bighorn herd.

005. Bodie, W. L., & W. O. Hickey. 1980. Response of wintering bighorn sheep to a rest-rotation grazing system in central Idaho. Proc. North. Wild Sheep and Goat Council. 2:60-69.

Rocky Mountain; cattle, competition; Idaho

A change from season long domestic livestock grazing to a rest-rotation grazing system occurred in 1973 on the Morgan Creek bighorn sheep winter ranges in central Idaho. Sex and age of bighorns were recorded and the location of each group was plotted on maps annually from 1973-1979. Comparisons of changes in sex and age in the population, use of individual pastures, and use by livestock grazing treatment were made. Although the population increased, the number of breeding ewes remained static. Under a season-long grazing system, bighorns preferred to use areas not grazed by domestic livestock. After four years of rest-rotation grazing, bighorns shifted from an area closed to livestock grazing to the livestock use pastures. Bighorns appeared to prefer the late-use pasture over early-use or rest treatments. Results are preliminary, as use shifts appear to continue. (Authors' abstract)

006. Boyle, S. A., & F. B. Samson. 1985. Effects of nonconsumptive recreation on wildlife: a review. *Wildl. Soc. Bull.* 13:110-116.

General; human disturbance, recreation

Only a general reference to bighorns. Makes the important point that "Changes in wildlife distribution, habitat use, or survival are difficult to attribute to specific causes without experimentation."

007. Buechmer, H. K. 1960. The bighorn sheep in the United States, its past, present, and future. *Wildl. Monogr.* 4. 174 pp.

General; cattle, burros, competition

A comprehensive review of the status of bighorn sheep. Reviews unpublished studies of cattle and burro abuse of bighorn ranges. Suggests that competition from domestic livestock was a factor in the decline of bighorns late in the 19th century.

008. Campbell, B., & R. Remington. 1981. Influence of construction activities on water-use patterns of desert bighorn sheep. *Wildl. Soc. Bull.* 9:63-65.

Desert; human disturbance, construction; Arizona

Time-lapse photography was used to monitor frequency of bighorn visits to artificial guzzlers from June-August before (1978) and after (1979) intensive construction activities on a water project in the Buckskin Mountains, Arizona. Bighorns visited water less frequently and watered earlier in the morning and later in the evening in 1979 than in 1978. Watering visits in 1979 were timed to avoid construction activity, peaking before construction began in the morning and after it ended in the evening. Lower visitation rates in 1979 suggested a

shift from frequent, opportunistic use of water before construction to brief, infrequent use of water during the peak of construction activity. Changes in water-use patterns could have long-term adverse effects on the bighorn population.

009. Cleary, E. 1973. Selective exclusion fencing in wild burro and bighorn sheep management. Desert Bighorn Council. Trans. 17: 106-109.

Desert; burros, competition; California

Interspecific competition for water by wild burros and bighorn sheep in the Wood's Mountains was eliminated by use of a steel-pipe fence. The fence enclosed Wood's Spring, the only permanent water source in the area, in such a manner as to deny water to the burro without denying water to the bighorn sheep. Without water, the burros were forced to seek both water and food outside of the Wood's Mountains. Thus, fencing indirectly eliminated competition for food and directly eliminated competition for water between these two species. (Author's abstract)

010. Cunningham, S. C., & R. D. Ohmart. 1986. Aspects of the ecology of desert bighorn sheep in Carrizo Canyon, California. Desert Bighorn Council. Trans. 30:14-19.

Desert; cattle, competition; California

Bighorns were found primarily in rocky desert scrub and cattle in mixed chaparral. Bighorns foraged primarily on steep slopes whereas cattle foraged mostly in canyon bottoms. Because of this habitat separation, plant species used by bighorns were seldom used by cattle. Dietary overlap between the two species averaged only 15.4% and was lowest during summer (12%) and highest during autumn and spring (18.2%).

011. DeForge, J. R. 1972. Man's invasion into the bighorn's habitat. Desert Bighorn Council. Trans. 16:112-116.

Desert; human disturbance, recreation; California

Presents evidence that bighorns stopped using an area when recreationists trespassed on a closed road.

012. DeForge, J. R. 1976. Stress: is it limiting bighorn? Desert Bighorn Council. Trans. 20:30-31.

Desert; human disturbance, encroachment; cattle, burros, competition

Theorizes that the major factor limiting bighorn populations is the

stress that results from the cumulative effects of habitat loss, livestock overgrazing, competition from burros, and human encroachment.

013. DeForge, J. R. 1981. Stress: changing environments and the effects on desert bighorn sheep. Desert Bighorn Council. Trans. 25:15-16.

Desert; human disturbance, encroachment

Argues that large and sudden die-offs of bighorns could be related to stress brought about by environmental degradation.

014. Demarchi, D. A., & H. B. Mitchell. 1973. The Chilcotin River bighorn population. Can. Field-Nat. 87:433-454.

California; cattle, competition; British Columbia

The population dynamics and biology of the California bighorn sheep occurring in the Chilcotin River area are documented. The grassland ecology is related to historical records and present grazing by domestic cattle and bighorn sheep. The area of the bighorn sheep range has been used by horses since the first white explorers visited the area, and for the past 100 years the area has been used to graze domestic livestock. The grasslands have ultimately been overgrazed and a community of needle-and-thread grass and Sandberg bluegrass occurs over most of the area that could support a climax community of bluebunch wheatgrass and Sandberg bluegrass. The use of particular terraces, gullies, and cliffs is given in detail for bighorn sheep and cattle. During the winter of 1968-69, the deep snows coupled with the overgrazed ranges caused an abnormal reduction in bighorn sheep: rams were reduced from 80 to 50 animals, ewes from 200 to 140 animals, and lambs from 81 to 35 animals. There has been some population recruitment since that time, but the number of observed animals is lower than in the summer of 1968. (Authors' abstract)

015. Dodd, N. L., & W. W. Brady. 1986. Cattle grazing influences on vegetation of a sympatric desert bighorn range in Arizona. Desert Bighorn Council. Trans. 30:8-13.

Desert; cattle, competition; Arizona

Vegetation was sampled in a 45-ha bighorn sheep enclosure ungrazed by cattle for 26 years and a comparable grazed area to assess vegetation differences attributable to cattle grazing. Sampling was stratified by slope: level, moderate, and steep. Specific differences in grass and shrub composition were assessed. Significant differences with cattle grazing in perennial grass, annual grass, forb, total vegetation, and bare ground cover were detected on level slope only. Cattle favored level slopes while bighorns predominantly used steep slopes. Direct correlations between observed cattle use by slope and vegetation cover differences (excluding shrubs) were significant ($P <$

0.05). Cattle fed primarily on grasses while bighorns used a wide variety of shrubs. Direct correlation between the cattle diet and the observed vegetation cover differences (excluding shrubs) was also significant. (Authors' abstract)

016. Douglas, C. L. 1976. Coordination of bighorn research and management in Joshua Tree National Monument. Trans. N. Am. Wild Sheep Conf. 2:1-15.

Desert; human disturbance, recreation; California

Owing to prolonged drought, watering sources for desert bighorns are in short supply in Joshua Tree National Monument. The problem has been exacerbated by increased human use in the Monument. In some cases, recreationists have inadvertently excluded bighorns from critical sources of water.

017. Douglas, C. L., & C. Norment. 1977. Habitat damage by feral burros in Death Valley. Desert Bighorn Counc. Trans. 21:23-25.

Desert; burros, competition; California

This report presents results of an analysis of browse impact upon vegetation in four contiguous areas in the northern Panamint Mountains, Death Valley National Monument, California. Browse impact was evaluated by the Vesey-Fitzgerald method. The analyses demonstrate that browsing by burros is altering the composition of the vegetational community in Wildrose Canyon. Of all shrubs in Wildrose Canyon, 45.7% exhibit some evidence of having been browsed, while the survival of 12.2% is threatened by severe browsing. Acamptopappus shockleyi and Ambrosia dumosa were the species most affected by browsing. Burros inhabit Wildrose Canyon and vicinity for about 6 months each year. Vegetation in the three other locations is utilized only sporadically by burros and is less damaged. (Authors' abstract)

018. Drewek, J., Jr. 1970. Population characteristics and behavior of introduced bighorn sheep in Owyhee County, Idaho. M.S. Thesis, Univ. Idaho, Moscow. 46 pp.

California; cattle, competition; Idaho

Cattle occupied most of the areas used by bighorns, but the presence of cattle did not seem to disturb bighorns.

019. Dunaway, D. J. 1971. Bighorn sheep habitat management on the Inyo National Forest, a new approach. Desert Bighorn Counc. Trans. 15: 18-23.

California; human disturbance, recreation; California

Suggests that human disturbance has been the major factor in the decline of bighorns on the Inyo National Forest. Recommends the establishment of a California Bighorn Sheep Zoological Area for the Inyo forest. Management efforts should focus on (1) protection of bighorn habitat and (2) regulation of human use in critical bighorn use areas. Livestock grazing should also be prohibited.

020. Dunaway, D. J. 1971. Human disturbance as a limiting factor of Sierra Nevada bighorn sheep. Trans. N. Am. Wild Sheep Conf. 1:165-173.

California; human disturbance, recreation; California

Suggests that the decline of some California bighorn herds is due to increased recreational use.

021. Dunn, W. C., & C. L. Douglas. 1982. Interactions between desert bighorn sheep and feral burros at spring areas in Death Valley. Desert Bighorn Council. Trans. 26:87-96.

Desert; burros, competition; California

Use of springs by desert bighorn sheep and feral burros was examined as part of a study on resource partitioning between these species. Spring use by ewe groups was almost entirely restricted to a spring not used by burros, while ram group use was not affected by the presence of burros. The number of burros present affected sheep use of springs, although the impact varied with different intensities of burro use. Evidence also suggests that temporal shifts in drinking times of bighorns may occur at springs used by burros. The potential adverse impacts of limiting use of springs by ewe groups are discussed. (Authors' abstract)

022. Elder, J. M. 1977. Human interactions with Sierra Nevada bighorn sheep: the Mount Baxter herd. M.S. Thesis, Univ. Michigan, Ann Arbor. 93 pp.

California; human disturbance, recreation; California

See 042.

023. Elliot, N. 1959. Effects of wild burros on range conditions. Desert Bighorn Council. Trans. 3:9-10.

Desert; burros, competition; California

Uncontrolled burro populations have exceeded the carrying capacity of the range, seriously depleting rangeland vegetation and outcompeting game species (i.e., desert bighorns) in some areas.

024. Estes, R. D. 1979. Ecological aspects of bighorn sheep populations in southeastern Washington. M.S. Thesis, Washington State Univ., Pullman. 124 pp.

California, Rocky Mountain; cattle, competition; Washington

Although bighorns visited areas used by cattle, the two species were never seen together. Differences in habitat use and diet resulted in little potential for competition between bighorns and cattle.

025. Ferrier, G. J. 1974. Bighorn sheep along the lower Colorado River: 1974 and 2050. Desert Bighorn Council. Trans. 18:40-45.

Desert; human disturbance, encroachment, recreation; Arizona, California

Impacts of recent urbanization and increasing recreational activities have caused significant losses of bighorn habitat and numbers along the Lower Colorado River. The natural ecology of the bighorn in this area is being destroyed. Traditional migration routes are being lost to an expanding human population. New patterns of use are emerging as herds are becoming isolated and restricted to smaller habitats. While it is expected that some additional bighorn habitats will be lost, substantial amounts of habitat are expected to be perpetuated and managed for bighorns. (Author's abstract)

026. Ferrier, G. J., & W. G. Bradley. 1970. Bighorn habitat evaluation in the highland range of southern Nevada. Desert Bighorn Council. Trans. 14:66-93.

Desert; cattle, competition; Nevada

During hot, dry periods, bighorns and cattle come into contact at springs and are in direct competition for water and forage.

027. Follows, D. S. 1969. Desert bighorn in Canyonlands National Park, Utah. Desert Bighorn Council. Trans. 13:33-42.

Desert; cattle, competition; Utah

Documents bighorns suddenly moving out of an area after cattle were introduced.

028. Gallizioli, S. 1977. Overgrazing on desert bighorn ranges. Desert Bighorn Council. Trans. 21:21-23.

Desert; cattle, competition

Overgrazing by livestock has been recognized by many as one of the more important factors in the early decline of populations of desert bighorn sheep in the Southwest. There is evidence that overgrazing, and perhaps even the mere presence of cattle in desert bighorn sheep ranges, continues to be a major reason for continuing declines of some desert bighorn populations and for the failure of others to increase. In Arizona, overgrazed ranges are also the main stumbling block to the reintroduction of desert sheep to historic ranges. (Author's abstract)

029. Ganskopp, D. C. 1983. Habitat use and spatial interactions of cattle, wild horses, mule deer, and California bighorn sheep in the Owyhee Breaks of southeast Oregon. Ph.D. Diss., Oregon State Univ., Corvallis. 194 pp.

California; cattle, competition; Oregon

Points out that competition between bighorns and cattle has been reported but not clearly proven in any instance. In southeastern Oregon, there was very little overlap between bighorns and cattle in the use of slope and of vegetation types. Bighorns required escape cover (i.e., steep, rocky areas) in close proximity to food and water, whereas cattle avoided such areas.

030. Ganskopp, D., & M. Vavra. 1987. Slope use by cattle, feral horses, deer, and bighorn sheep. Northwest Sci. 61:74-81.

California; cattle, competition; Oregon

Bighorns used slopes from 0-70% (10% intervals) in proportion to availability and overused 70-80% slopes relative to availability. Cattle used slopes from 0-20% in proportion to availability and significantly avoided slopes steeper than 20%. (See 029)

031. Geist, V. 1971. Mountain sheep. A study in behavior and evolution. Univ. Chicago Press, Chicago, Ill. 383 pp.

Stone's; human disturbance, recreation; British Columbia

Documents three cases where Stone's sheep deserted home ranges after disturbance by hunters. Geist concludes that "If hunting causes sheep to vacate their accustomed areas and seek refuge on terrain where they would normally be rarely found, then we can expect deleterious effects on the sheep population as a whole."

032. Geist, V. 1985. On Pleistocene bighorn sheep: some problems of adaptation, and relevance to today's American megafauna. Wildl. Soc. Bull. 13:351-359.

General

The latest word on Bailey's (see 003) "Pleistocene relict" hypothesis, including updated information on the fossil record of bighorns.

033. Ginnett, T. F., & C. L. Douglas. 1982. Food habits of feral burros and desert bighorn sheep in Death Valley National Monument. Desert Bighorn Council. Trans. 26:81-87.

Desert; burros, competition; California

Burros and bighorns use many of the same forage species, resulting in "moderate" dietary overlap. The two species are potential competitors for forage. Because they are more opportunistic, burros should be expected to outcompete desert bighorns when forage is limiting.

034. Golden, F. H., & R. D. Ohmart. 1976. Summer observations on desert bighorn sheep in the Bill Williams Mountains, Arizona. Desert Bighorn Council. Trans. 20:42-48.

Desert; cattle, burros, competition; Arizona

Especially near water, bighorns were observed near cattle and burros. Although no interspecific interactions were seen, bighorns "seemed to wait for the cattle to move away from the pond before coming down to water."

035. Graham, H. 1971. Environmental analysis procedures for bighorn in the San Gabriel Mountains. Desert Bighorn Council. Trans. 15:38-45.

Desert; human disturbance, recreation; California

Bighorns avoided areas that received > 500 visitor days/year. Light use by humans (< 100 visitor days/year) did not appear to affect bighorn use.

036. Hamilton, K., S. A. Holl, & C. L. Douglas. 1982. An evaluation of the effects of recreational activity on bighorn sheep in the San Gabriel Mountains, California. Desert Bighorn Council. Trans. 26: 50-55.

Desert; human disturbance, recreation; California

The effect of human disturbance on bighorn sheep was studied in the San Gabriel Mountains, California. The hypothesis that bighorns were abandoning habitat receiving high levels of human use was tested. Bighorns using the Narrows mineral lick in South Fork Lytle Creek were not displaced by the presence of people in the canyon. The greatest proportion of sheep use of the lick and people use of the canyon

occurred during midday hours. There was no correlation between numbers of people using the canyon and numbers of bighorns using the lick. Frequency of people traveling near the lick was important since sheep did not use it when people were in the immediate vicinity. Bighorns did not avoid the lick; they used it only when no humans were in the immediate vicinity. The presence of large numbers of hikers on the Devil's Backbone trail, located in sheep summer range, did not cause sheep to abandon adjacent habitat. There was no significant difference in sheep distribution between the Devil's Backbone trail (heavy recreational use) and the Cucamonga Peak trail (light recreational use). (Authors' abstract)

037. Hansen, C. G. 1971. Overpopulation as a factor in reducing desert bighorn populations. Desert Bighorn Council. Trans. 15:46-52.

Desert; human disturbance, encroachment

Human encroachment has induced stress and overcrowding in desert bighorn populations by modifying habitat and restricting daily and seasonal movement patterns.

038. Hansen, M. C. 1982. Desert bighorn sheep: another view. Wildl. Soc. Bull. 10:133-140.

Desert; human disturbance, encroachment; livestock, competition

Desert bighorn populations are declining not because they are Pleistocene relicts (see 003), but because of environmental perturbations caused by modern man. One of the most important problems is livestock grazing, which has caused gross changes in the vegetative composition of rangelands, particularly the conversion of grass/forb communities to those dominated by shrubs. To reduce the adverse effects that humans have had on desert bighorns, managers should strive to: (1) improve rangeland condition, (2) provide adequate sources of water, (3) develop habitat near escape terrain, (4) reduce human disturbance, (5) minimize the potential for competition with exotic ungulates, (6) control sources of exotic diseases and parasites, and (7) allow bighorns unrestricted access to adjacent areas of suitable habitat.

039. Hass, W. L. 1979. Ecology of an introduced herd of Rocky Mountain bighorn sheep in southcentral Wyoming. M.S. Thesis, Colorado State Univ., Fort Collins. 343 pp.

Rocky Mountain; cattle, competition; Wyoming

Data on habitat use and food habits suggested that cattle and bighorns were potential competitors for forage.

040. Hass, W. L., & E. Decker. 1980. A study of a recently introduced bighorn herd. Proc. North. Wild Sheep and Goat Counc. 2:143-167.

Rocky Mountain; cattle, competition; Wyoming

Dietary overlap between cattle and bighorns averaged 36%. Next to elk, cattle were the most significant competitors with bighorns "...because they utilized ridgetop forage which would otherwise be available to bighorns...during winter."

041. Hicks, L. L. 1977. Human disturbance of the Mt. Baxter herd of Sierra Nevada bighorn sheep. M.S. Thesis, Univ. Michigan, Ann Arbor. 57 pp.

California; human disturbance, recreation; California

See 042.

042. Hicks, L. L., & J. M. Elder. 1979. Human disturbance of Sierra Nevada bighorn sheep. J. Wildl. Manage. 43:909-915.

California; human disturbance, recreation; California

California bighorn sheep and recreationists were studied in the Sierra Nevada Mountains of California from May through August 1976. Direct observation of sheep and people, pellet transects, and hiker interviews were used to assess overlap in areas of use and nature of interactions. Distance, juxtaposition, age and sex composition, and herd size are important factors in reaction of bighorns to humans. Meadows used by humans were inherently poor meadows for bighorn sheep, based on vegetation analysis. Use of meadows by sheep was correlated with amount of preferred forage species and vegetative cover. Hiker foot-trails did not affect sheep movements in the summer range. Bighorn-human encounters were limited to specific locations and were not adversely affecting the bighorn population. Nevertheless, regulations should continue to limit use of the study area by humans. (Authors' abstract)

043. Hook, D. L. 1986. Impacts of seismic activity on bighorn movements and habitat use. Proc. North. Wild Sheep and Goat Counc. 5: 292-296.

Rocky Mountain; human disturbance, oil and gas exploration; Montana

In April 1982, eight bighorn sheep were radio-collared on the Ford Creek winter range. This range is utilized by the southern segment of the Sun River population. As part of a continuing effort to evaluate effects of gas and oil development on big game populations along the Rocky Mountain Front, the year-round movements of these sheep were

monitored for four years. In the fall of 1983, three seismic lines (helicopter porta-drills) were run concurrently across the Ford-Fairview plateaus, which represents the major portion of this herd's fall-winter range. In September-October 1982, prior to disturbance, 71% (10 of 14) of the radio locations occurred on the Ford-Fairview plateaus. During the September-October 1983 seismic activity, no relocations occurred on the plateaus. Instead, 100% (17) of the sheep relocations were to the south along the Crown Mountain-Wood Lake Hogback, which is part of their summer range. In September-October 1984, post disturbance, 45% (5 of 11) of the relocations were again on the Ford-Fairview plateaus. In 1983, average annual home range size declined 28% from 25.9 square miles in 1982 to 18.6 square miles. Following disturbance in 1984, it increased to 29.7 square miles. Data on habitat use for three years are presented. (Author's abstract)

044. Horejsi, B. 1976. Some thoughts and observations on harassment and bighorn sheep. Proc. N. Wild Sheep Council. 1:149-155.

Rocky Mountain; human disturbance, encroachment, recreation

Both passive and active human harassment of bighorns can have significant impacts on individuals and populations. Specifically, harassment of bighorns may (1) increase mortality, (2) affect growth and development, (3) cause abandonment of some ranges, and (4) alter activity and behavioral patterns.

045. Horejsi, B. L. 1986. Bighorn sheep, Mount Allan, and the 1988 Winter Olympics: political and biological realities. Proc. North. Wild Sheep and Goat Council. 5:313-324.

Rocky Mountain; human disturbance, encroachment; Alberta

In November 1982, the government of Alberta announced that the alpine skiing events of the recently awarded 1988 Olympic Winter Games would be held on Mount Allan, about 90 road km west of Calgary. Mount Allan is part of a mountain complex that supports a population of about 300 bighorn sheep. In proceeding with the development of Mount Allan, former Premier Peter Lougheed and his colleagues contravened provincial, national, and international agreements respecting the wildlife resource. The ecology of the sheep population is not well known. Human activity on sheep range is becoming intensive and will escalate. Provincial policies that reflect a strong anti-wildlife philosophy, and the kinds of developments completed or underway in the Mount Allan area are identified. The sheep population, hitherto problem free, is endangered. (Authors's abstract)

046. Jessup, D. J. 1985. Diseases of domestic livestock which threaten bighorn sheep populations. Desert Bighorn Council. Trans. 29:29-33.

General; cattle, disease

Bighorn sheep are among the most sensitive North American wild ungulates to common livestock diseases. Cattle may be a source of some of these diseases, including bluetongue, paratuberculosis, pink eye, and respiratory syncytial virus. "At present, the best management strategy is to maintain bighorn herds at optimal nutritional planes, at or below carrying capacity and as widely separated as possible from domestic livestock." (Note: also published in the 1985 Proc. California Bighorn Workshop, pp. 57-71)

047. Jorgensen, P. 1974. Vehicle use at a desert bighorn watering area. Desert Bighorn Counc. Trans. 18:18-24.

Desert; human disturbance, recreation; California

Desert bighorn and human activity were observed during June 1973 at the Middle Willows watering area in the Anza Borrego Desert State Park, California, where an unpaved road crossed a creek utilized by bighorn as a source of water. Bighorn activity decreased roughly 50% on days with vehicle traffic, as compared to days without vehicle activity. It also was observed that vehicles and bighorns normally utilized the water source at the same time of day. (Author's abstract)

048. King, M. M. 1985. Behavioral response of desert bighorn sheep to human harassment: a comparison of disturbed and undisturbed populations. Ph.D. Diss., Utah State Univ., Logan. 137 pp.

Desert; human disturbance, experimental, recreation; Utah

Desert bighorn sheep response to human disturbance was evaluated in southeastern Utah from 1981-1983. Bighorn response was compared between the Red Canyon area, an area with relatively high levels of human disturbance, and the White Canyon area, an area with relatively low levels of human disturbance. Bighorns were deliberately harassed by vehicles and hikers and immediate response and distance fled were recorded. When bighorns remained in the presence of the harassing stimuli, actual time spent in and proportion of animals engaged in various behaviors were recorded to determine group wariness and activity budgets under harassed conditions. Bighorns were also observed under unharassed conditions to compare behavior between harassed and unharassed conditions. Red Canyon bighorns responded more severely to harassment trials than White Canyon bighorns. Response by Red Canyon bighorns was generally running flight whereas White Canyon bighorns responded most often with non-flight behaviors. Group wariness was greater for Red Canyon bighorns than White Canyon bighorns when bighorns were exposed to continuous harassment. Activity budgets of unharassed bighorns were similar between areas; however, activity budgets of harassed animals differed significantly between areas particularly with respect to attention and feeding

behaviors. Red Canyon bighorns were at attention longer and fed less than White Canyon bighorns under harassed conditions. Energy-nutrient relationships, hunting ramifications, and management implications as they relate to harassment of desert bighorn sheep in southeastern Utah are discussed. (Author's abstract)

049. King, M. M., & G. W. Workman. 1984. Cattle grazing in desert bighorn sheep habitat. *Desert Bighorn Counc. Trans.* 28:18-22.

Desert; cattle, competition; Utah

Cattle and desert bighorns differed in use of topographic features and in diet. Bighorns used higher, steeper slopes than did cattle, which used mostly lower, gentler slopes and valley floors. Dietary overlap between the two species was only 23%. Cattle were primarily grazers, whereas bighorns were almost exclusively browsers. There was no evidence that bighorns used habitats differently when cattle were on vs. off the range.

050. King, M. M., & G. W. Workman. 1984. Ecological relationships between desert bighorn sheep and domestic cattle in southeastern Utah. *Proc. North. Wild Sheep and Goat Counc.* 4:167-179.

Desert; cattle, competition; Utah

Ecological relationships between desert bighorn sheep and domestic cattle were investigated in the White Canyon area of southeastern Utah. Cattle and bighorn sheep utilized different topographic types and had significant differences in diet composition during the winter grazing season. Bighorn failed to move into and use areas vacated by cattle when cattle were moved to summer ranges. At present there are insufficient data to conclusively ascribe failure of bighorn to use areas used by cattle to social intolerance or to differential habitat preferences. Critical management issues with respect to bighorn-cattle interactions in Utah are discussed. (Authors' abstract)

051. King, M. M., & G. W. Workman. 1986. Response of desert bighorn sheep to human harassment: management implications. *Trans. North Am. Wildl. Nat. Res. Conf.* 51:74-85.

Desert; human disturbance, experimental, recreation; Utah

Eighty-three percent of harassment trials illicit flight responses from Red Canyon bighorns compared to 46% for White Canyon bighorns. Average distance fled as a result of harassment was approximately 2.75 times greater for Red Canyon bighorns than for White Canyon bighorns. Group wariness was exhibited at more intense levels by Red Canyon bighorns than by White Canyon bighorns when they remained in the presence of harassing stimuli. Activity budgets of unharassed

bighorns were similar between areas. However, activity budgets of harassed animals differed significantly between areas particularly with respect to attention and feeding behaviors. Under harassed conditions, Red Canyon bighorns were at attention longer and fed less than did White Canyon bighorns. Behavioral response of desert bighorns to encounters with humans were more severe and thus more energy costly for animals that had been historically exposed to relatively high levels of human disturbance. Wildlife and land managers should include evaluation of past disturbance history in bighorn habitat and plan to minimize potentially harassing human activities in crucial habitat particularly if bighorns have been exposed to high levels of human disturbance. Further research is needed to determine physiological and demographical impacts of human disturbance on desert bighorn sheep. Until such data are available, desert bighorn populations should be managed conservatively. (From authors' summary)(See 048)

052. Kornet, C. A. 1978. Status and habitat use of California bighorn sheep on Hart Mountain, Oregon. M.S. Thesis, Oregon State Univ., Corvallis. 49 pp.

California; cattle, competition; human disturbance, research; Oregon

Competition between cattle and bighorns seemed to be minimal. However, bighorns tended to avoid cattle when the two species were in close proximity, and bighorns did not mingle with cattle as they did with mule deer. In seven of nine instances of human disturbance of large groups (> 40 sheep), bighorns did not revisit the area for at least 1.5 days.

053. Kovach, S. D. 1979. An ecological survey of the White Mountain Peak bighorn. Desert Bighorn Counc. Trans. 23:57-61.

Desert; human disturbance, recreation; California

Bighorns tolerated humans that "ignored" them but would not tolerate humans that directly approached them or appeared above them. Bighorns fled when humans approached to within about 300 m.

054. Krausman, P. R., & J. J. Hervert. 1983. Mountain sheep responses to aerial surveys. Wildl. Soc. Bull. 11:372-375.

Desert; human disturbance, aircraft, research; Arizona

The authors monitored the reactions of bighorns to 32 low-level flights of a fixed-wing airplane (either a Cessna 172 or 182). All flights less than 50 m above ground greatly disturbed sheep, whereas flights at 50-100 m usually did not disturb sheep. Different age and sex classes responded similarly to low-flying aircraft.

055. Krausman, P. R., W. W. Shaw, & J. L. Stair. 1979. Bighorn sheep in the Pusch Ridge Wilderness Area, Arizona. Desert Bighorn Council. Trans. 23:40-46.

Desert; cattle, competition; human disturbance, recreation; Arizona

Although researchers have claimed that competition from livestock and disturbance from recreationists have adversely influenced bighorn populations, they don't always collect the data needed to properly assess competition, nor do they understand the exact conditions under which bighorns will not tolerate humans.

056. Lauer, J. L., & J. M. Peek. 1976. Big game-livestock relationships on the bighorn sheep winter range East Fork Salmon River Idaho. Univ. Idaho, For., Wildl. & Range Exp. Sta. Bull. No. 12. 44 pp.

Rocky Mountain; cattle, competition; Idaho

An historical record, description of habitat, and outline of winter range use patterns and relationships of bighorn sheep to mule deer and livestock are presented for the East Fork Salmon River, Idaho. The bighorn sheep population in winter 1974-1975 was estimated at a minimum of 46 individuals. Three vegetation types and one phase in which big sagebrush dominated were delineated on the bighorn sheep winter range: a Wyoming big sagebrush/bluebunch wheatgrass community, with a Wyoming big sagebrush/bluebunch wheatgrass-Sandberg bluegrass phase, a mountain big sagebrush/bluebunch wheatgrass community, and a Douglas-fir/mountain big sagebrush community. A distinct preference for use of the Wyoming big sagebrush/bluebunch wheatgrass community by bighorns existed during December 1974 through May 1975. Competition among bighorn sheep, mule deer, and cattle appeared to exist for bluebunch wheatgrass on the Wyoming big sagebrush/bluebunch wheatgrass community based on assessment of food habits, plant utilization, and range use overlap. Improvement of the current range condition to enhance the bighorn sheep population could be accomplished through modification of current grazing practices and either artificial revegetation of specific sites where grasses are lacking or controlled burning of specific sites where grasses are more prevalent. Such vegetation manipulation should enhance range condition and promote increased use by bighorn sheep. (From authors' abstract)

057. Leslie, D. M., Jr., & C. L. Douglas. 1980. Human disturbance at water sources of desert bighorn sheep. Wildl. Soc. Bull. 8: 284-290.

Desert; human disturbance, construction; Nevada

Alterations of behavior and movement of desert bighorn sheep in the River Mountains, Nevada, were coincident with construction activities near the population's primary watering site. The juxtaposition of

construction efforts and summer water dependence of bighorn sheep caused a significant shift in use of artificial water sources. Nine of 17 marked ewes altered their watering patterns in response to construction activities. Productivity during construction did not depart from the long-term population mean; however, lamb survival may have been affected. Responses of the River Mountain herd to construction activities were dampened by a high degree of habituation to man. (Authors' abstract)

058. Light, J. T., Jr. 1971. An ecological view of bighorn habitat on Mt. San Antonio. Trans. N. Am. Wild Sheep Conf. 1:150-157.

Desert; human disturbance, recreation; California

A study of the influence of summer hikers on the distribution of bighorns revealed that bighorns vacate areas of high human use (> 500 visitor days/year). "Occasional" human visitors are tolerated, but continued use "...creates stress conditions and the bighorn begin to avoid these areas of heavy human visitation."

059. Light, J. T., Jr. 1973. Analysis of bighorn habitat in the San Gabriel Mountains. Desert Bighorn Council. Trans. 17:53-58.

Desert; human disturbance, recreation; California

Proposes guidelines for recreational use within desert bighorn ranges based on three years of research.

060. MacArthur, R. A., R. H. Johnston, & V. Geist. 1979. Factors influencing heart rate in free-ranging bighorn sheep: a physiological approach to the study of wildlife harassment. Can. J. Zool. 57:2010-2021.

Rocky Mountain; human disturbance, aircraft, experimental; Alberta

The telemetered heart rates (HR) of unrestrained female bighorn sheep were recorded under various behavioral and environmental circumstances. In all ewes HR varied positively with activity level and inversely with distance to a road traversing the study area. The HR recorded from animals moving at night or through timber by day were higher than during daytime movement across open slopes. Responses to transient stimuli varied greatly. The appearance of free-ranging canids evoked maximal increases in HR in all ewes. Vehicular traffic and aircraft elicited HR responses only at close range (< 200 m). Most (78.1%) HR responses to disturbing stimuli preceded or occurred in the absence of overt behavioral reactions. HR usually peaked within 60 sec of the onset of the response and recovered to predisturbance base line in less than 200 sec. The appearance and continued presence (1-10 min) of a human within 50 m of the sheep resulted in a 20% rise in mean HR.

The behavior, ecology and bioenergetics of bighorn sheep were discussed. (Authors' abstract)

061. MacArthur, R. A., V. Geist, & R. H. Johnston. 1982. Cardiac and behavioral responses of mountain sheep to human disturbance. *J. Wildl. Manage.* 46:351-358.

Rocky Mountain; human disturbance, aircraft, experimental; Alberta

Telemetered heart rates (HR) and behavioral responses of mountain sheep reacting to human disturbance in the Sheep River Wildlife Sanctuary, southwestern Alberta, were recorded. Cardiac and behavioral responses of sheep (4 ewes, 1 ram) to an approaching human were greatest when the person was accompanied by a dog or approached sheep from over a ridge. Reactions to road traffic were minimal as only 8.8% of vehicle passes elicited HR responses. No reactions to helicopters or fixed-wing aircraft were observed at distances exceeding 400 m from sheep. Responses to disturbance were detected using HR telemetry that were not evident from behavioral cues alone. However, mean duration of HR response (138.6 sec) was not greater ($P > 0.05$) than mean period of the behavioral reaction when sheep were alert or withdrawing from harassing stimuli (112.4 sec). Use of HR telemetry in harassment research is discussed. (Authors' abstract)

062. Mackie, R. J. 1978. Impacts of livestock grazing on wild ungulates. *Trans. North Am. Wildl. Nat. Res. Conf.* 43:462-476.

General; livestock, competition

Although this review mentions bighorn sheep, it is concerned mostly with deer and elk. The following was taken from the Conclusions. "Clearly, there are many negative or potentially negative impacts associated with the presence of cattle, sheep, goats, horses, mules, burros, and even hogs on rangelands. Some will be inherent in the presence of the domestic animal on the range; others may depend upon the nature of the grazing or the husbandry or other management practices applied or upon the particular wild ungulate and/or domestic animal involved. In total, however, they seem sufficient to indicate that the probability of conflict is always high and at least some negative impact may be inescapable whenever livestock grazing occurs on rangelands occupied by wild ungulates."

063. McCollough, S. A., A. Y. Cooperrider, & J. A. Bailey. 1980. Impact of cattle grazing on bighorn sheep habitat at Trickle Mountain, Colorado. *Proc. North. Wild Sheep and Goat Counc.* 2:42-59.

Rocky Mountain; cattle, competition; Colorado

Distribution, diet, and habitat use by cattle during May-October were

compared to similar measurements for bighorn sheep during winter and spring. Cattle used only about 4% of bighorn winter-spring range. Although cattle and bighorn used similar vegetative types and aspects, cattle avoided the steep slopes inhabited by bighorn. Cattle distribution was also restricted by a limited water supply. Both cattle and bighorns were primarily grazers, but bighorns consumed considerable browse. Dietary overlap was moderate. Forage abundance and percent utilization were estimated on 21 areas identified as critical bighorn winter-spring habitat. Cattle use of bighorn critical areas on two grazing allotments was slight. Greatest impact was found on one allotment where about 35% of the forage was removed from bighorn critical areas by cattle during summer. Dietary and/or spatial overlaps between cattle and bighorn do not necessarily indicate forage competition. Yet competition can occur with little overlap in these two parameters. Limiting forage resources must be identified to verify competition. Methods useful in verification of competition are discussed. (Authors' abstract)

064. McCullough, D. R., & E. R. Schmeegas. 1966. Winter observations on the Sierra Nevada bighorn sheep. Calif. Fish and Game 52: 68-84.

California; cattle, competition; California

Ranges of cattle barely overlapped those of bighorns, and forage competition was absent.

065. McCutchen, H. E. 1981. Desert bighorn zoogeography and adaptation in relation to historic land use. Wildl. Soc. Bull. 9:171-179.

Desert; human disturbance, encroachment; livestock, competition

Rather than being Pleistocene relicts (see 003), desert bighorns are secondary relicts owing to the impacts of European settlement. Such impacts include unrestricted hunting, mining, fence and road construction, and the introduction of domestic livestock. Desert bighorns are vulnerable to competition because they evolved in the absence of other large grazing ungulates.

066. McKnight, T. L. 1958. The feral burro in the United States: distribution and problems. J. Wildl. Manage. 22:163-179.

Desert; burros, competition

A comprehensive (albeit dated) review of the distribution and habits of Equus asinus in the western United States. Includes a discussion of bighorn-burro interactions and potential competition for forage, water, and space.

067. McMichael, T. J. 1964. Studies of the relationship between desert bighorn and feral burro in the Black Mountains of northwestern Arizona. M.S. Thesis, Univ. Arizona, Tucson. 38 pp.

Desert; burros, competition; Arizona

This study of the relationships between desert bighorn sheep and feral burros was conducted in Warm Springs Canyon of the Black Mountains, Mohave County, Arizona from July 1962 to September 1963. Bighorns and burros were located and observed to determine their feeding and watering patterns, daily movements, and seasonal distribution. Samples of the contents of eight bighorn stomachs were collected during the 1962 and 1963 hunting seasons. Bighorns and burros were frequently found near springs during summer. Here they fed on the same plant species, drank at the same times of day, and used the same shade to avoid the heat. Although no direct harm to the bighorns could be attributed to the burros, under limiting conditions burros could have a negative effect on bighorns. (From author's abstract)

068. McQuivey, R. P. 1978. The desert bighorn sheep of Nevada. Nevada Dep. Wildl., Biol. Bull. No. 6. 81 pp.

Desert; human disturbance, encroachment; cattle, competition; Nevada

Overgrazing and competition with cattle for forage is considered the "...most important factor affecting the disappearance of bighorn sheep from northern and central Nevada and in localized areas of southern Nevada." Areas grazed by cattle had 0.88 bighorns/mi², whereas those not grazed by cattle had 2.54 bighorns/mi², a significant difference. Although desert bighorns seem to tolerate human presence, recreational development and urbanization have adversely affected bighorn populations in some parts of the state.

069. Mensch, J. L. 1970. Survey of bighorn sheep in California. Desert Bighorn Counc. Trans. 14:123-126.

Desert; human disturbance, encroachment; burros, competition; California

Bighorns declined by 60% after burros entered an area. Bighorn habitat was also lost to housing developments and highway construction.

070. Miller, G., & E. L. Smith. 1985. Human activity in desert bighorn habitat: what disturbs sheep? Desert Bighorn Counc. Trans. 29: 4-7.

Desert; human disturbance, experimental; Arizona

During a six-year study of desert bighorn sheep in western Arizona, we observed 1,766 groups of sheep. During many of the observations (N =

1,150), sheep were confronted by the presence of people or other potential disturbances (e.g., trucks, airplanes, helicopters, or other animal species). Behavioral reactions of sheep, if any, to the potential disturbances were recorded for each observation. Sheep exhibited stronger reactions to one or two humans on the ground than to parked vehicles or a light airplane circling overhead. The closer sheep were to a disturbance the farther they were likely to move away. Similarly, large groups tended to move farther away than small groups when disturbed by a single person. These observations corroborate earlier studies. (Authors' abstract)

071. Monson, G., & L. Sumner (eds.). 1980. The desert bighorn: its life history, ecology, and management. Univ. Arizona Press, Tucson. 370 pp.

Desert; cattle, burros, competition; human disturbance, recreation, encroachment

Includes review chapters on competition between bighorns and exotic ungulates (Chapter 14 by F. L. Jones) and on the impacts of modern man on bighorns (Chapter 19 by H. Graham).

072. Packard, F. M. 1946. An ecological study of the bighorn sheep in Rocky Mountain National Park. J. Mammal. 27:3-28.

Rocky Mountain; human disturbance, recreation; Colorado

Mentions that camera-toting recreationists were displacing bighorns.

073. Purdy, K. G., & W. W. Shaw. 1980. Progress report: recreational use of desert bighorn habitat in Pusch Ridge Wilderness. Desert Bighorn Council. Trans. 24:52-56.

Desert; human disturbance, recreation; Arizona

Includes a review of previous human disturbance studies.

074. Purdy, K. G., & W. W. Shaw. 1981. An analysis of recreational use patterns in desert bighorn habitat: the Pusch Ridge Wilderness case. Desert Bighorn Council. Trans. 25:1-5.

Desert; human disturbance, recreation; Arizona

Recreational use of the Pusch Ridge Wilderness, Arizona, may present disturbances to mountain sheep. This report examines the recreational uses and users of bighorn habitat in the wilderness area. Photoelectric trail traffic counters, unmanned survey stations, self-administered questionnaires, telephone surveys, and direct

observations were used to obtain patterns of recreational use and activity data, to determine the significance of sheep to recreators, and to assess potential bighorn disturbances. Findings indicate that use patterns can be broadly described by two types of visitors: lower canyon visitors and backcountry visitors. The majority of users are lower canyon visitors and appear to present little threat of bighorn disturbances. While less than 10% of the total users can be considered backcountry visitors, their activities and lengths of stay may pose a greater threat to the bighorns. Backcountry visitors generally believe their activities do not adversely affect the bighorns. However, they do favor recreational use restrictions if necessary for the welfare of the sheep population. Several recommendations are made as safeguards against human/bighorn sheep conflicts in the wilderness area. (Authors' abstract)

075. Russo, J. P. 1956. The desert bighorn sheep in Arizona. Arizona Game and Fish Dep. 153 pp.

Desert; cattle, burros, competition; Arizona

Especially near water sources, cattle and burros have damaged vegetation within bighorn sheep use areas.

076. Seegmiller, R. F. 1976. Feral burro-desert bighorn sheep relationships, Bill Williams Mountains, Arizona. Trans. N. Am. Wild Sheep Conf. 2:35-37.

Desert; burros, competition; Arizona

Eight months, spanning one year, were spent observing and photographing feral burros and desert bighorn sheep in the Bill Williams Mountains, Arizona. Movements of both burros and bighorns during the cooler months extended farther from the Bill Williams River and generally encompassed a larger area than during the warmer months. Greatest interspecific overlap in habitat use occurred during January through March on long steep slopes extending from high mesas, peaks, and ridges and during April through June in foothill habitat. Forage observations and fecal composition analysis showed considerable interspecific overlap. Burro-bighorn interactions at watering sites in summer and during bighorn lambing season were not observed, although both were seen in close association shortly after lambing, with young lambs present. Estimates of burro population numbers and annual reproduction rates exceeded those of bighorn sheep. (Author's abstract)

077. Seegmiller, R. F., & R. D. Ohmart. 1975. Feral burros within desert bighorn habitat. Desert Bighorn Counc. Trans. 19:45.

Desert; burros, competition; Arizona

Burro movements varied seasonally. In summer they were within 4-6 km of the river, and in winter they ranged as far as 13 km from the river. No burro-bighorn interactions were seen during the summer at water or during the lambing season, although both species were seen in close association. Based on field observations, diets of burros and bighorns overlapped markedly in all seasons. Both species relied principally upon the annual herbaceous layer, especially Plantago insularis. (From authors' abstract)

078. Seegmiller, R. F., & R. D. Ohmart. 1981. Ecological relationships of feral burros and desert bighorn sheep. Wildl. Monogr. 78. 58 pp.

Desert; burros, competition; Arizona

An estimated 60-90 burros co-occurred with about 17 desert bighorns in the Bill Williams Mountains, Arizona. Movements and distributions of both species were closely tied to permanent water during the warmer months; both species moved farther from water during cooler months. Dietary and habitat overlap averaged 47% and 51%, respectively. In shared ranges, burros consumed 1.5 to 2 times as much forage as did bighorns. No interference interactions were observed. In some cases, burros and bighorns foraged within 10 m of one another with no apparent conflict. Because it was not known what factors were limiting the populations, it could not be concluded that burros and bighorns were competing for food. However, if these species are limited by the availability of vegetative biomass of "sufficient nutritive value," then exploitation competition between them "either was occurring or was imminent." Burros are expected to further degrade southwestern rangelands, and they should be removed from all habitats suitable for desert bighorns.

079. Stanger, M. C., J. Cresto, G. W. Workman, & T. D. Bunch. 1986. Desert bighorn sheep-riverboat interactions in Cataract Canyon, Utah. Desert Bighorn Counc. Trans. 30:5-7.

Desert; human disturbance, recreation; Utah

The precipitous slopes of Cataract Canyon adjacent to the Colorado River provide important habitat for desert bighorn sheep. The effects of riverboat use in Cataract Canyon on movement and behavior of five radio-collared ewes and associated animals were studied in 1985. Desert bighorn sheep behavior in spring prior to riverboat use of the area was compared with behavior during summer riverboat use. No significant differences were found. For the desert bighorn sheep observed, 58% showed no response, 39% showed a minor response, and 3% showed a moderate response to riverboats. No long-term detrimental effects of riverboats were observed. (Authors' abstract)

080. Stevens, D. R. 1982. Bighorn sheep management in Rocky Mountain National Park. Proc. North. Wild Sheep and Goat Counc. 3:244-253.

Rocky Mountain; human disturbance, recreation; Colorado

Bighorns increased their use of a lambing area and a mineral lick after human use was restricted with trail closures and traffic regulation.

081. St. John, K. P., Jr. 1965. Competition between desert bighorn sheep and feral burros for forage in the Death Valley National Monument. Desert Bighorn Council. Trans. 9:89-92.

Desert; burros, competition; California

Suggests that burros and bighorns compete directly for forage.

082. Sugden, L. G. 1961. The California bighorn in British Columbia with particular reference to the Churn Creek herd. British Columbia Dep. Rec. and Conserv., Queen's Printer, Victoria, B.C. 58 pp.

California; cattle, competition; human disturbance, encroachment; British Columbia

Human encroachment and overgrazing by cattle are contributing factors in the decline of California bighorns in British Columbia.

083. Sumner, L. 1959. Effects of wild burros on bighorn in Death Valley National Monument. Desert Bighorn Council. Trans. 3:4-8.

Desert; burros, competition; California

Bighorns in Death Valley have dwindled or disappeared wherever burros have increased in number. Although much of the burro-bighorn conflict occurs at water sources, burros have also devastated native vegetation and caused soil erosion.

084. Tevis, L., Jr. 1959. Man's effect on bighorn in the San Jacinto-Santa Rosa Mountains. Desert Bighorn Council. Trans. 3:69-75.

Desert; human disturbance, encroachment; California

The largest contiguous population of desert bighorns in California occurs next to the subdivisions and developments of the Palm Springs resort area. Most of the land occupied by bighorns is in private ownership, and the potential for disturbance to the bighorns is great. Tevis recommends that the bighorn herd be publicized to increase local interest in the animals. At the same time, research projects should be initiated to evaluate the effects of human encroachment on the bighorn population.

085. Trefethen, J. B. (ed.). 1975. The wild sheep in modern North America. Proc. Workshop Manage. Biol. North Am. Wild Sheep. Boone & Crockett Club, Winchester Press, New York, N.Y. 302 pp.

General; cattle, competition; human disturbance, recreation

A collection of status reports and management recommendations from throughout the range of North American wild sheep. Contains anecdotal information on bighorn-livestock interactions (pp. 103-104).

086. Van Dyke, W. A., A. Sands, J. Yoakum, A. Polenz, & J. Blaisdell. 1986. Bighorn sheep. Wildlife habitats in managed rangelands--the Great Basin of southeastern Oregon. U. S. For. Serv. Genl. Tech. Rep. PNW-159 (2nd ed.). 37 pp.

General; cattle, competition; human disturbance, encroachment, recreation

Even in suitable habitat, excessive human use can reduce the number of bighorns that use an area. This report includes a brief review of the influences of human activity and cattle on bighorn populations.

087. Vaske, J. J., A. R. Graefe, & F. R. Kuss. 1983. Recreation impacts: a synthesis of ecological and social research. Trans. North Am. Wildl. Nat. Res. Conf. 48:96-107.

General; human disturbance, recreation

A brief review of the ecological and social impacts of outdoor recreation on wildlife.

088. Wagner, F. H. 1983. Status of wild horse and burro management on public rangelands. Trans. North Am. Wildl. Nat. Res. Conf. 48: 116-133.

Desert; burros, competition

Outlines the history of the wild horse and burro issue, including a review of the management-related ecological findings from the National Academy of Sciences and the Bureau of Land Management/Forest Service studies.

089. Wagner, F. H., G. L. Achterman, J. L. Artz, W. H. Blackburn, W. H. Conley, L. L. Eberhardt, S. K. Fairfax, W. E. Johnston, S. R. Kellert, J. C. Malechek, P. D. Moehlman, U. S. Seal, & J. W. Swan. 1982. Wild and free-roaming horses and burros. Final report. Comm. Wild Free-Roaming Horses and Burros, Board Agricult. Nat. Resour., Natl. Res. Counc., Natl. Acad. Press, Washington, D.C. 80 pp.

Desert; burros, competition

A comprehensive final report on the National Academy of Sciences study. Although past studies and contemporary researchers have implied or suspected that burros compete with desert bighorns, current evidence for competition is circumstantial.

090. Walters, J. E., & R. M. Hansen. 1978. Evidence of feral burro competition with desert bighorn sheep in Grand Canyon National Park. Desert Bighorn Counc. Trans. 22:10-16.

Desert; burros, competition; Arizona

Based on fecal samples, dietary overlap between burros and desert bighorns averaged 52% (range = 29.6-61.1%). Evidence for competition between the two species at water sources was equivocal.

091. Weaver, R. A. 1959. Effects of burro on desert water supplies. Desert Bighorn Counc. Trans. 3:1-3.

Desert; burros, competition; California

Burros may totally usurp water at small springs and have destroyed artificial water developments provided for wildlife. The simplest solution to these problems is to eliminate or reduce burro populations.

092. Weaver, R. A. 1973. Burro versus bighorn. Desert Bighorn Counc. Trans. 17:90-97.

Desert; burros, competition; California

Seven of 14 bighorn study areas in California have feral burro populations. In each of these areas, burros compete directly with bighorns for food, space, and water if it is in short supply. Burros have damaged the vegetation and soil and have had a detrimental effect on the entire biota. (From author's abstract)

093. Webb, P. M. 1972. Status of desert bighorn sheep in Arizona. Desert Bighorn Counc. Trans. 16:105-111.

Desert; human disturbance, encroachment; cattle, competition; Arizona

A general review stating that most desert bighorn habitat losses result from (1) dam building and water projects, (2) land development, (3) highway and road construction, (4) recreational activity and development, or (5) competition from livestock.

094. Wehausen, J. D. 1980. Sierra Nevada bighorn sheep: history and population ecology. Ph.D. Diss., Univ. Michigan, Ann Arbor. 250 pp.

California; human disturbance, recreation; California

Human disturbance of ewe-lamb groups was investigated in summer. There was no evidence that long-term spatial displacement was occurring in the Mount Baxter herd. Also, with its increasing population trend, it could not be argued that disturbance from humans was adversely affecting reproduction. A small sample of interactions with the Mount Williamson herd suggested greater wariness than the Baxter herd. Human use of Mount Williamson has increased exponentially since World War II. Coincident with this increase has been a loss of bighorn summer range. The current summer range boundaries coincide with regular routes of human use; a causal relationship may be involved. (From author's abstract)

095. Wehausen, J. D. 1984. Comment on desert bighorns as relicts: further considerations. Wildl. Soc. Bull. 12:82-85.

Desert

The third in a series of rebuttals to Bailey (003), this paper undermines the "Pleistocene relict" hypothesis by pointing out that Bailey's arguments lack "...plausibility from the point of view of natural selection." Although it does not deal directly with human disturbance or livestock, this paper should be consulted after reading Bailey (003), Hansen (038), and McCutchen (065).

096. Wehausen, J. D., V. C. Bleich, B. Blong, & T. L. Russi. 1987. Recruitment dynamics in a southern California mountain sheep population. J. Wildl. Manage. 51:86-98.

Desert; cattle, disease; California

Cattle could be long-term reservoirs for disease (e.g., bluetongue and epizootic hemorrhagic disease) in bighorns in the Santa Rosa Mountains. These diseases may have been responsible for a severe decline in recruitment rates that began in 1977. Removal of cattle from the sheep range would provide an ideal opportunity to determine whether cattle serve as reservoirs of infection for diseases that influence bighorn sheep mortality.

097. Wehausen, J. D., L. L. Hicks, D. P. Garber, & J. Elder. 1977. Bighorn sheep management in the Sierra Nevada. Desert Bighorn Counc. Trans. 21:30-32.

California; human disturbance, recreation; California

Bighorn sheep in the Sierra Nevada have recently received the benefit of conservation management based on the hypothesis that human disturbance has had a significant negative influence on sheep populations. Testing of ramifications of this hypothesis indicates that human disturbance is not an important factor, and management policies are being revised accordingly. Where a resource such as bighorn sheep is potentially threatened, timely management action based on hypothesis is an important management tool, but carries with it an obligation to subject that hypothesis to critical test, and to alter management in accordance with the results of such testing. (From authors' abstract)

098. Welles, R. E., & F. B. Welles. 1961. The bighorn of Death Valley. U.S. Natl. Park Serv. Fauna Ser. No. 6. 242 pp.

Desert; burros, competition; human disturbance, encroachment; California

A comprehensive report on the life history of desert bighorns. Includes descriptions of the responses of bighorns to researchers, park visitors, and automobiles. In contrast to many other reports, bighorns and burros in Death Valley seem to coexist without conflict.

099. Welles, R., & F. Welles. 1961. The feral burro in Death Valley. Desert Bighorn Council Trans. 5:32-33.

Desert; burros, competition; California

Research conducted from February to 30 June 1960 indicated that (1) food habits and behavior of burros are not as directly competitive with bighorns as was previously believed; (2) in its preferred habitat, the burro is not in "significant conflict" with bighorns; (3) forage competition is reduced because the two species prefer different plants; (4) topographic barriers often separate the two species' foraging areas; (5) burros do not always destroy cover at springs nor destroy installations at water sources; and (6) burros seldom, if ever foul water sources to the extent that other animals will not use them.

100. Whitfield, M. B., & B. L. Keller. 1984. Bighorn sheep of the Teton Range, Wyoming: ecology of a remnant population. Proc. North. Wild Sheep and Goat Council. 4:120-136.

Rocky Mountain; human disturbance, recreation; Wyoming

Bighorns avoided areas of concentrated recreational use.

101. Wilson, L. O., et al. (Desert Bighorn Council Technical Staff) 1980. Desert bighorn habitat requirements and management recommendations. Desert Bighorn Council Trans. 24:1-7.

Desert; cattle, competition; human disturbance, recreation

This is the Desert Bighorn Council Technical Staff's review of habitat requirements and management recommendations for desert bighorns. It includes guidelines for managing cattle grazing and recreational use within bighorn ranges.

102. Wilson, L. O. 1968. Distribution and ecology of the desert bighorn sheep in southeastern Utah. M.S. Thesis, Utah State Univ., Logan. 221 pp. (Also published as Utah Dep. Natl. Res. Publ. 68-5)

Desert; cattle, competition; human disturbance, encroachment; Utah

Bighorns and cattle were never sighted together during two years of study. The distance between bighorns and cattle averaged 10.2 km and ranged from 4.6-15.8 km. Bighorns seemed to avoid an area (Red Canyon) that was overused by 40 cattle throughout the study period, but occupied a nearby ungrazed area that was similar in all other respects. There was no strong trend in the way bighorns reacted to a state highway that passed through their range.

103. Wilson, L. O. 1969. The forgotten desert bighorn habitat requirement. Desert Bighorn Council Trans. 13:108-113.

Desert; human disturbance, encroachment; cattle, competition

Despite anecdotal observations to the contrary, desert bighorns tend to be intolerant of disturbances from people and livestock. Simply put, the "forgotten" habitat requirement of desert bighorns is space.

104. Wylie, T. C., & J. W. Bates. 1979. Status of desert bighorn sheep in Canyonlands National Park-1978. Desert Bighorn Council Trans. 23:79-80.

Desert; cattle, competition; Utah

An apparent population increase is attributed in part to the elimination of cattle grazing in 1975.

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