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STUDIES OF BIGHORN-BURRO INTERACTIONS IN DEATH VALLEY: PROGRESS TOWARD THE OBJECTIVES

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The Problem

Our studies of bighorn sheep and burros were undertaken in 1973 in response to management's need to understand the nature, severity, and potential consequences of burro-bighorn interactions in Death Valley. Considerable concern had been expressed about this problem by scientists and managers since formation of the Monument in the mid 1930s. Since burro control was stopped in the 1950s, the burro herd has increased at a steady rate while bighorn sheep appear to be decreasing commensurately. Burro impact on bighorn habitat is a degradative process that is insidious and severe. This process affects vegetative composition; it increases aridity by increasing erosional processes through soil compaction and surface disturbances; it reduces vegetative cover by overgrazing; and it adversely affects water sources by fouling and by usurption. Subtle changes in the ecosystem such as changes in soil organisms, possible losses of parts of the food web (especially insects, spiders and other invertebrates), changes in the small mammalian fauna, effects on ground-nesting birds, and the overall effects on nutrient recycling and energy exchange may never be understood. Perturbations of this magnitude reverberate throughout all parts of the system. Desert ecosystems are especially sensitive and vulnerable to such disturbances. If recovery is possible for a given desert system, such recovery may require centuries. However, enlightened management may be able to shorten the recovery period and to aid the system in approaching more natural conditions. The purpose of our studies is to gather sufficient information to support the development of appropriate management plans for the Death Valley bighorn and for restoration of their habitat.

Background Information

I have developed a long-term research program designed to clarify various aspects of burro-bighorn interactions in Death Valley. The questions to be answered by our research efforts appear deceptively simple. However, the research required to answer these questions is extremely complex, and frequently involves work in highly theoretical areas of biology that are only in their formative stages of development.

The burro-bighorn study is closely interrelated with other important studies such as the vegetational mapping projects currently underway. Because of these interrelationships which are not always intuitive to those in management, or to scientists who are not involved in the projects, I felt it would be helpful to clarify the long-term objectives of the major study, and how each separate study builds upon another to become more important to management than just the sum of their parts.

Since 1973, three Superintendents of Death Valley National Monument have regarded the burro-bighorn problem to be the highest natural science priority in the Monument. Our research program is designed to quantify various aspects of competition between burros and bighorn, and to document habitat alterations caused by burros. Our research will provide managers with options and with techniques for restoring more natural conditions to degraded bighorn habitat.

Our studies began in autumn of 1973 with a two-year telemetry and marking study of burro movements and distribution in the Wildrose area of DEVA. Population dynamics such as recruitment rate, seasonal movements, and size of home range areas were documented. In addition, browse impact on plants was documented in several widely separated parts of the study area (Norment and Douglas, 1977; Douglas and Norment, 1976a, 1977). An ancillary study by Tom Davis (Davis, 1975) was conducted concurrently with the Wildrose study, and clarified various aspects of burro physiology. These physiological parameters were important because they enabled us to do the following:

1. Identify the norm for various blood constituents, including enzymes, of healthy burros, thereby establishing a baseline for evaluating potential diseases that might prove useful for controlling burro numbers.
2. To run various clinical tests on serum in order to evaluate past exposure of burros to disease organisms, such as leptospirosis, toxoplasmosis, and Venezuelan equine encephalomyelitis, that might be useful for management of burro numbers.
3. To quantify basal metabolic rate in young and adult burros, which was then used to calculate energy demands of individuals, and of the herd. These data enabled us to calculate the amount of native forage necessary to support burros of different weight classes. These data were compared with data on vegetative growth in the Wildrose area, which allowed us to calculate carrying capacity for that area.

The Wildrose study area was chosen because of ease of access and because Patricia Moehlman (Moehlman, 1974) had just concluded a three-year study of burro behavior there. Two unforeseen circumstances affected the Wildrose study. Midway in the study, the NPS began trapping burros from the Wildrose area. This reduced the population size and provided interesting data on responses of a disturbed population. Unfortunately, our intent was not to study a disturbed population. The second circumstance was that bighorn were so scattered in the area that they could not be studied effectively at the same time. Because of these difficulties, we terminated the study at the end of two years, and selected a different study area.

Our second study area was Butte Valley, which was chosen for its isolation from disturbances, and because bighorn were thought to be more numerous there. We again used telemetry collars and marking collars for burros, and replicated parts of our research from the Wildrose area. This replication was important because conditions were significantly different in the Butte Valley area. Herd density was much higher, home ranges were highly constricted; enmigration of young animals was taking place; and the plant community and burro herd appear to have established an equilibrium condition. Thus, the two study areas represent opposite extremes and helped us establish the amount of variation present in Death Valley's burro population (White, 1980; White and Douglas, 1980; Douglas and White, 1980). The Butte Valley study required approximately two-and-a-half-years.

We found that bighorn were widely scattered and were not present in sufficient numbers in and around Butte Valley to be studied concurrently with burros. Consequently, bighorn studies were initiated in the Black and Funeral Mountains. Time-lapse cameras were used at waterholes, and aerial surveys of these ranges were conducted from fixed-wing plane and from helicopter.

We were curious about the extent of movements between burro groups from one end of the Panamint Mountains to the other. We had observed considerable variation in coat color of burros throughout Death Valley. Some segments of the population had dark gray coats, whereas others had various shades of gray or brown. Burros in some herds had coat colors ranging from white to dark black. We realized that it was important for management to know how extensively herd segments interacted, because if there was high interchange between groups, any effort to remove burros from one area could be negated by an influx of animals from adjacent areas.

In 1976, John Blake, one of my graduate students, initiated tests on burro serum. Gel electrophoresis was used to separate serum enzymes, which were then stained and analyzed for use in evaluating population genetics. The serum proteins chosen for genetic analysis were the transferrins, which are iron-binding molecules of the globulin fraction. Radioactive iron was used to mark these enzymes. Half of the gel was exposed to x-ray film following the electrophoretic run. The other half of the gel was stained to reveal the transferrin bands. By comparing the developed x-ray film and stained gel, even faintly stained bands could be identified with certainty.

The results of this study were very significant. We found that burros from five localities in the Panamint Mountains were largely isolated from each other, genetically. Even herds in adjacent canyons only a few miles apart operated as separate breeding units. This is explainable by the fact that the peak of breeding season coincides with the hottest months of summer, when burros are under the most water stress. Consequently, they remain near springs and breed with those individuals in the same canyon. In winter, when breeding is greatly reduced, adjacent herds intermingle, but apparently interbreed to a negligible extent.

These results have significant management consequences. They indicate that burros are faithful to their home range areas, and therefore probably can be removed from one small area with some assurance that the vacancy will not be immediately filled by other individuals (Blake, 1977; Blake & Douglas, 1978; Blake, Douglas & Thompson, in press).

In 1979, the Tin Mtn. - Quartz Spring area was chosen as a study area because it has both bighorns and burros in sufficient numbers to permit simultaneous study. We are now beginning to unravel some of the complexities of resource partitioning between these two species that have heretofore been impossible to clarify.

The six major objectives of the present, and past, studies in DEVA and their respective research techniques are as follows:

1. To define bighorn habitat quantitatively, and to assess its condition throughout Death Valley.
2. To define seasonal food habits and space partitioning of

bighorns and burros occupying the same area.

3. To determine status of diseases in the Death Valley bighorn herd.
4. To document the nature and extent of burro damage to bighorn range.
5. To evaluate bighorn response in the Tin Mountain area upon removal of burros.
6. To determine methods of restoring bighorn habitat so that isolated herds can be reunited.

Each of these objectives is elaborated upon in the following pages.

I OBJECTIVE: To analyze bighorn habitat, to define it quantitatively and to assess its condition throughout DEVA.

Part of resource partitioning concerns habitat. What constitutes optimum bighorn habitat? How can this be defined in a quantitative and qualitative manner that will aid managers in restoring damaged habitat and perpetuating high quality habitat?

WHAT HAS BEEN, OR IS BEING, ACCOMPLISHED?

1) Hansen's development of a bighorn habitat classification system was developed at the Desert Game Range, and later used at DEVA. This system is being evaluated in relationship to the NPS system (PATRIC) and other existing inventory systems, in order that the best system, or combination, can be used.

2) Vegetational mapping projects in the Black, Funeral, Grapevine, and N. Cottonwood Mtns. are underway. The Black and Grapevine projects are almost completed. Ultimately the entire Monument will have a detailed vegetation map, with quantitative evaluation of species composition in each vegetational community. These studies will provide important sets of data, such as the percentage of grass cover as opposed to

percentage of shrub cover. These data will enable us to better evaluate bighorn habitat, and the extent and condition of such habitat. The amount of available habitat indicates the potential number of sheep that could live there. The quality of the habitat dictates how many can live there.

3) Quantitative evaluations of vegetational communities have been completed in Wildrose Canyon and several nearby segments of that study area, as well as in Butte Valley. Quantitative evaluation of vegetation in the Tin Mtn. area is in progress. These data will aid in evaluating vegetational composition and diversity in bighorn areas.

4) Space partitioning between burros and bighorn is being studied in the Tin Mtn. area. This study area, as well as other ranges being studied, will have a detailed slope/aspect analysis to clarify the amount of terrain having a given facing at selected percentages of slope. The study will document the amount of time spent in each area by burros and bighorn, and the way such areas are used (e.g. lambing, summer foraging, etc.) This study will help quantify burro-bighorn competitive interactions.

II OBJECTIVE: To define seasonal food habits and space partitioning of bighorn and burros occupying the same area.

Ungulates are either selective feeders, or generalists, depending upon many variables and influences. It is likely that burros are more general in their food habits than bighorn, but this cannot be stated with certainty. Any competitive interaction between the two species probably involves food and water, since these are the limited resources in DEVA. Burros are larger and require much more food and water than bighorns. Burros also can exist on poorer quality forage because they are able to process it more rapidly. (Burros are able to vary the rate of gut clearance by continued eating, whereas ruminants do not have this option.)

Bighorn and burros appear to use some of the same terrain in the Tin

Mtn. study area. Bighorn, and bighorn sign, are frequently seen in areas heavily used by burros. Nevertheless, it is highly unlikely that both species use precisely the same parts of the habitat. There are indications that bighorn may use ridges and upper slopes more than burros do. There also is evidence to suggest that rams are less restricted by burros than are ewes and lambs. Knowledge of the nature of space partitioning between bighorn and burros is of considerable importance to documenting competitive interactions between these species.

WHAT HAS BEEN, OR IS BEING, ACCOMPLISHED?

1) Food items found in burro stomachs have been identified for 10 samples from Butte Valley, and 25 samples from Cottonwood Canyon. These samples provided information about burro food habits.

2) Food habits of both species are being analyzed microscopically, from droppings, on a monthly basis. Thus, we will learn what plants are eaten by burros and bighorn on a seasonal basis. Food resources are limited and competition for forage may vary with season. The ability of a ewe to raise a lamb through weaning depends upon obtaining adequate water and proper nutrition.

3) Nutrient content of major forage species is being studied in the Tin Mountain area so that nutrient content can be evaluated with respect to seasonal diets. In this way, periods of nutritional stress can be evaluated for bighorn and burros. Major competition for forage resources could occur during these stressful periods.

   Major forage species also were collected each month in Wildrose Canyon and Butte Valley. Energy (caloric) content was determined at UNLV by means of bomb calorimetry. Nutrient content (moisture, protein, fat, fiber, ash, nitrogen-free-extract, total digestible nutrients, potassium, phosphorus, calcium and magnesium) was determined for 70 samples from Wildrose, Skidoo and Emigrant Canyon and 53 from Butte Valley.

4) Fecal nitrogen is being analyzed from monthly samples of both species. Fecal nitrogen reflects availability of protein in ingested forage, and also reflects any periods of nitrogen stress for each species, and may help explain observed changes in food selection or movements during the year.

5) Space partitioning by bighorn and burros in the Tin Mtn. area is being studied by monitoring seasonal movements of animals equipped with marking- and radio-collars. Likewise, distributions of unmarked animals are recorded on topographic maps on a bi-weekly basis. Aerial monitoring flights and ground surveys are used to locate animals.

6) Locational data of bighorn and burros are being analyzed by elevations used, by vegetational communities occupied, by aspect and facing of slopes used, and by distance from water sources. These analyses will enable us to quantify any competitive overlap of use areas.

7) Trails of bighorn and of burros are being identified by observation, and by evidence of tracks, bedding sites, and scats. Trails are being mapped for the Tin Mtn. area. Knowledge of the trail systems will aid in identifying the extent of bighorn and burro use areas.

III OBJECTIVE: <u>To determine status of diseases in the DEVA bighorn herd.</u>

Any restoration of bighorn habitat, or water developments, will be of limited value if the herd segments are unhealthy. Monitoring of fecal collections and blood samples (when available) are means of directly assessing disease or parasite load.

<u>WHAT HAS BEEN, OR IS BEING, ACCOMPLISHED?</u>

1) Dr. Tom Bunch, Utah State Univ., recently examined skulls of bighorn sheep from DEVA and reported a moderate incidence of chronic sinusitus (Bunch, personal communication). There

probably is no management action that can be taken to resolve this problem. This widespread problem is being investigated by Bunch and associates.

2) Autopsies are performed on dead sheep as conditions permit by California Fish & Game veterinarians.

3) Blood samples from sheep trapped at Quartz Spring are being screened for a wide variety of disease organisms by Cal. F&G. Results are not yet available.

4) Droppings will be screened for parasite eggs.

IV OBJECTIVE: To document the nature and extent of burro damage to bighorn range

WHAT HAS BEEN, OR IS BEING, ACCOMPLISHED?

1) Our studies in Wildrose and Butte Valley documented the amount of browse impact on perennial species at various distances from waterholes.

2) Our earlier studies document that several species of plants are selectively removed from the plant community by overgrazing of burros.

3) Studies of plants in exclosures (Wildrose, Butte, A Canyon) indicate more species diversity of annuals and more biomass of perennials inside exclosures than outside.

4) Soil compaction is being studied by Drs. Dennis Fenn and C. Douglas in Butte Valley.

5) The effects of burro trailing on soil crusts and on growth of desert annuals is being investigated. Crusting helps reduce wind erosion and conserves soil moisture, which are beneficial effects in desert environments. Soil crusts are present inside the Butte Valley exclosure, but not outside. Weedy annuals are abundant outside the exclosure; but there are

practically none inside the exclosure. Although there are higher numbers of annuals outside the exclosure, there is higher species diversity inside, and plants are more robust than those outside. Dr. K. Bell plans to investigate moisture conditions of plants inside and outside the exclosure to clarify reasons for these observations.

6) Identifications of soil crustal organisms. The Dept. of Microbiology, at Univ. California, Davis, has agreed to identify crustal organisms of Death Valley soils. Trampling and disturbance of the soil surface by burros may reduce numbers and kinds of soil organisms. These organisms are very important for soil development and for nutrient and energy recycling in the ecosystem.

V OBJECTIVE: To evaluate bighorn response in the Tin Mountain area upon removal of burros.

Competition between ungulates is difficult to prove to the satisfaction of critics. Documenting precisely what happens in competition between burros and bighorn would be possible if burros were introduced into pristine bighorn habitat, and resource partitioning studied as habitat degradation occurred. This is, of course, unacceptable in a Park Service area. Another method is to study both species in an area, then remove burros and document the response of bighorn. It is our intention to study the distribution and seasonal use areas of marked bighorns and burros for about 2 years in the Tin Mtn. area, then remove burros and document the responses of bighorn. It might be anticipated that bighorn will expand their home ranges and use areas. This outcome is not certain, owing to intangibles such as length of time the bighorn range has been constricted, and the possibility that degraded vegetation adjacent to the present bighorn habitat may not be able to support bighorn at this time.

VI OBJECTIVE: To determine methods for restoring bighorn habitat so that isolated herds can be reunited.

Arid lands are highly sensitive to disturbances such as overgrazing, pumping of ground water, wind and water erosion of topsoil, and vagaries of climatic change. Overgrazing, poaching, and man's meddling with springs probably have caused most of the problems for bighorn over the past 100 years in Death Valley. It is difficult to evaluate conditions bighorn lived under in DEVA before man or his livestock started modifying the landscape. Throughout California, and most of Death Valley, bighorn currently exist in habitat islands that are remnants of former range. Populations have been fragmented by changes in the vegetation by overgrazing, by road construction, and by disappearance of traditional watering sources.

Small remnant herds of sheep numbering fewer than 50 animals almost surely will not survive indefinitely. The smaller the herd, the greater the effects of inbreeding depression, which results in reduced heterozygosity, and leads to lowered immune responses, and reduced vitality. One of the more obvious signs of such problems is reduced survival of lambs. Diseases present special and severe threats to small groups of animals. Some diseases that decimate bighorn herds are known to have been introduced by domestic sheep. All, or most, members of a small group of social animals, such as bighorn, may succumb to disease that in a larger group might kill a few animals but scarcely affect the total population. There are historic precedents for this concern. Some herds have died out in California during recent times; others presently are showing almost no survival of offspring. Fortunately, a few herds are doing extremely well.

If management in DEVA is to preserve bighorn sheep for more than another 100 years, or so, the isolated remnants of the herd must be encouraged to rejoin one another as a panmictic (interbreeding) entity.

It is estimated that a minimum population size of 50 individuals is necessary to keep inbreeding at a 1% level. If a population remains at only 50 animals for 20 to 30 generations, about 25% of their genetic variation will be lost. A herd of 25 animals can experience a 25% lowering of reproduction within five years (Soule, 1980). Many herds in California, and in DEVA, contain fewer than 50 animals. Some have fewer than 25, which makes them extremely vulnerable to extinction.

WHAT HAS BEEN, OR IS BEING, ACCOMPLISHED?

1) Time-lapse cameras were used in the summer of 1975 to monitor bighorn use at water sources in the Black and Funeral Mtns. Time-lapse cameras were used in the summer of 1980 at all springs in the Grapevine Mountains. These records aid in establishing numbers and age groups of sheep using various water sources.

2) Aerial surveys of bighorn by helicopter and fixed-wing plane have been conducted in the Black, Funeral, and N. Cottonwood Mountains. This type of survey will be conducted prior to preparing management recommendations for each mountain range.

3) Evaluations of spring condition and bighorn use have been prepared for the Black Mountains, Grapevine Mountains, and N. Cottonwood Mountains.

4) Upon completion of vegetational mapping in a given mountain range, bighorn habitat will be evaluated by the most precise methods available. These will include slope/aspect analyses, evaluation of vegetational distributions, quantitative evaluation of plants in each vegetational community (as a reflection of habitat quality), the amount of space occupied by each community, delineation of bighorn habitat based on site records, aerial surveys, topography, and proximity of springs. This presently is being done for the Grapevine Mountains.

5) Threats to the herd within each mountain range will be clearly defined.

6) Habitat degradation and other threats will be assessed and management options presented for correcting the situation.

7) Methods for revegetating with native grasses and other bighorn staple foods will be investigated.

8) Restoration of burro impacted areas should result from experiments in #7 above. These experimental restorations will require monitoring to determine effectiveness of the method.

9) Restoration of corridors between isolates should follow, or accompany #8.

OTHER REFLECTIONS ON OBJECTIVE VI.

All restoration of bighorn habitat and reconnection of isolates of habitat by means of corridors depends upon removing burros from DEVA. Without burro removal, any habitat restoration for bighorn is likely to also enhance that habitat for burros.

Other innovative and aggressive management options for aiding bighorn in DEVA may include any of the following, or a combination of items:

1) Restoration of native grasses in overgrazed habitats, especially in corridors between isolated herds.

2) Restoration of springs and development of artificial water sources.

3) Reseeding and installation of guzzlers in corridors between isolates.

4) Prescribed burning and reseeding to return shrubland to native grassland.

5) Introduction of sheep from other herds (e.g. River Mountain herd of LAME) into small herds in DEVA, thereby reducing effects of inbreeding and buying some time pending habitat restoration efforts.

6) Transplanting bighorn from LAME into suitable (restored or native) habitat between isolates in circumstances where the transplanted group would provide an avenue for reuniting the isolates.

Aggressive management techniques such as these probably will be difficult to accomplish. The methodology required is new and untried in large part. Managers could be accused of trying to raise as many bighorn as possible. Likewise, placement of a guzzler in a corridor might be difficult to justify on the basis of overgrazing alone. Prescribed burning of shrubland has not been experimented with in NPS desert parks, and would be controversial.

This report presents a condensed overview of research being conducted on bighorn sheep and feral burros in Death Valley. The findings to date, and apparent trends of our research, indicate that restoration of burro-impacted areas in bighorn habitat will require a long-term commitment. It is hoped that this overview report will enable the reader to understand how research is addressing various problems, and how research is providing information to management that can lead to aggressive action programs. Promoting the welfare and long-term survival of Death Valley bighorn is an important and challenging task for both managers and researchers.

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