To Water or Not?

An Experimental Study of Desert Bighorn Sheep

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Aldo Leopold, the "father" of wildlife management in North America, classified water as a potential limiting factor: something that can limit population numbers when not available in the proper proportion. Since then, wildlife managers, especially in the arid western United States, have developed water sources for wildlife where natural sources are considered scarce or unreliable.

Cain releasing radio-collared desert bighorn sheep.

Watering Desert Wildlife: a Widespread Practice

Some of the earliest water projects in the western United States were designed to benefit quail and mule deer. Popularity of these systems increased as new water sources were established for chukar, rabbits and hares, pronghorn, and other game species, including desert bighorn sheep. In the 1980s the focus for developed waters expanded beyond the potential enhancement of populations of game species. Water catchments were built to mitigate for water diversion, habitat loss, and other impacts resulting from widespread urban, agricultural, transportation, and industrial developments throughout the arid West. The practice of using water to mitigate for altered landscapes resulted in improved catchment designs that provided water for a variety of wildlife species. This management tool was further enhanced as state wildlife agencies partnered with land management agencies, sportsmen, and private organizations to increase levels of labor and capital investment. These partnerships also served a positive social and networking function by providing opportunities for hands-on wildlife management by professionals and the public.

The development of catchments continues to be a popular management tool across the western United States. By the late 1990s, wildlife agencies in 10 of 11 western states had active water catchment programs. These included approximately 6,000 guzzlers, modified tinijas (watering holes), developed springs, wells, and other methods of providing free-standing water to wildlife. Catchments are also maintained in wilderness areas in the West.

Controversy Seeps In

With more than a million dollars per year invested in this activity, you might suppose that the benefits of water developments for wildlife were well documented. Not so! Despite the


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considerable investments of time, money, and effort in developing catchments, very little funding is allocated for monitoring their influence on wildlife. Do supplemental water sources improve the condition of animals that use them? Does the number of births increase? Do more animals survive compared to those without access to man-made catchments? The lack of information to answer such fundamental questions has, in recent years, given rise to management uncertainty and even public controversy. Some critics question whether these costly developments offer any biological value to wildlife. Others object that man-made developments are incompatible with areas managed as wilderness. Still others suggest that man-made catchments may have negative consequences for wildlife.

The controversy has reduced the pace of catchment construction and maintenance on national wildlife refuges in Arizona. There is even pressure from some quarters to remove existing catchments from wilderness areas, monuments, and reserves even though these areas were established long after the catchments contained within them were built. Such demands are opposed by some sportsmen and state wildlife agencies concerned about adverse impacts to wildlife. Caught in the middle, agencies responsible for land management have limited scientific data to back up their decisions.

Like most controversies, the issues concerning man-made water catchments and desert wildlife are exacerbated by a lack of scientific information. Experimental studies to evaluate the importance of catchments are lacking. Some observational studies have produced conflicting results. As well, some populations of desert ungulates occupy areas that do not have perennial sources of free-standing water. Such uncertainties demonstrate a clear need for studies to scientifically examine how wildlife is influenced by the addition or removal of man-made water catchments.

A Place to Seek Answers

Supported in part by a conservation grant from the Boone and Crockett Club, we initiated an experimental study to examine the influence of water catchments on a population of desert bighorn sheep. Specifically, we set out to determine how man-made water catchments would influence the diet, foraging areas, movement and home range size, mortality, productivity, and recruitment of the sheep.

The study took place on the Cabeza Prieta National Wildlife Refuge (CPNWR) in southwestern Arizona. This refuge includes over 750,000 acres of rugged mountain ranges surrounded by large bajadas separated by wide alluvial valleys. This is ideal habitat for desert bighorn sheep. Fieldwork was conducted in the Sierra Pinta and Cabeza Prieta Mountains within the CPNWR. These mountain ranges are jagged, sharply crested, and dissected by steep and rugged canyons. The climate here is arid, with annual precipitation averaging about 4 inches, mostly in summer and winter. Average daily temperature in summer is 103 degrees and highs greater than 110 degrees are common. Our study began during the worst drought in southwestern Arizona in 107 years; September 2001–August 2002 was the driest on record for the region. Our study ended during an abnormally wet period; October 2004–September 2005 was the twenty-first-wettest period on record for the region.

Characteristic vegetation in these mountains includes ironwood, acacia, palo verde, creosotebush, white bursage, range ratany, brittlebush, elephant tree, buckwheat and mallow. In addition to desert bighorn sheep, the CPNWR supports desert mule deer, Sonoran pronghorn, and collared peccaries. Predatory species include coyotes, bobcats, mountain lions, and golden eagles. The CPNWR is managed

Desert Bighorn – Sierra Pinta

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Images from the authors during their field research.

Heart Tank – Sierra Pinta

Sierra Pinta – Spring 2005 (above normal precipitation)

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Sierra Pinta – Summer 2002 (

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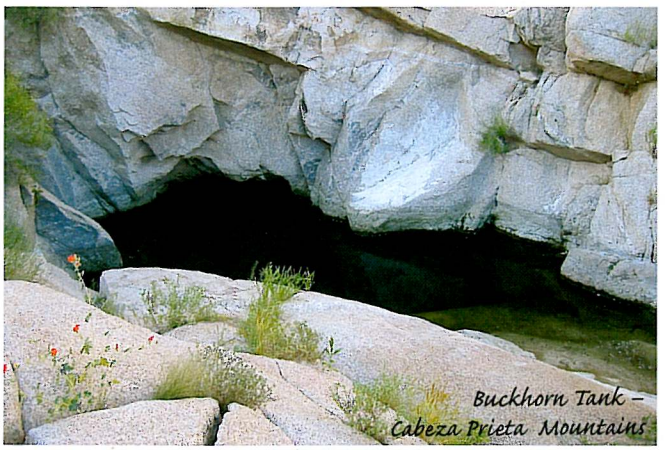
primarily for its wildlife and wilderness values, although military aircraft training occurs in the air space over the refuge.

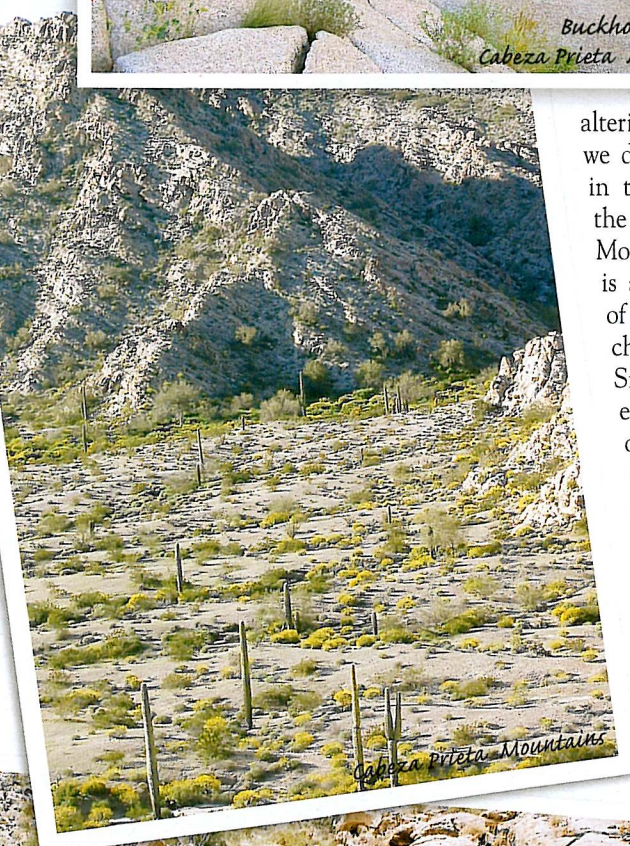
When we began our project there were three catchments in the Sierra Pinta Mountains and four in the Cabeza Prieta Mountains. These catchments provided the only known perennial sources of water.



Buckhorn Tank – Cabeza Prieta Mountains

An Experimental Approach

Our approach was to monitor female bighorn sheep for two years (2002–03) in both the Sierra Pinta and the Cabeza Prieta Mountains without altering any resources. Then, in 2004–05 we drained all of the water catchments in the Sierra Pintas but did not alter the available water in the Cabeza Prieta Mountains. We predicted that if water is a limiting factor, then the removal of water would alter the life history characteristics of bighorn sheep in the Sierra Pintas. For example, we would expect to see a higher consumption of succulent plants, larger movement and home range size, higher rates of mortality, and less productivity and recruitment compared to the Cabeza Prieta, where water remained available. We tested our ideas with a before-and-after, controlled study design.



Cabeza Prieta Mountains

What, specifically, did we want to find out?

First, we wanted to know whether the diet of sheep would change with water removal. For this investigation we examined particles of forage in fecal pellets to determine diet composition. We also measured the amounts of vegetation cover, cacti abundance, and plant moisture content in the area where sheep foraged.

Halfway Tank

Images from the authors during their field research.

Second, we wanted to determine whether sheep movement and home range size would be affected by water removal. To answer this question, we captured 37 female desert bighorn sheep and equipped them with Global Positioning System telemetry collars to determine if the removal of water catchments caused a change in movement rates, home range sizes, and distance to water catchments, especially in spring and summer.

Third, we wanted to determine if and how the removal of water catchments influenced sheep mortality, productivity, and recruitment. We monitored and contrasted these life history characteristics between periods with and without water in the mountain ranges. This required comparing adult survival, lamb-to-female ratios, and yearling-to-female ratios.

The Data Are In

Did the diets of bighorn sheep change in response to water removal? Overall, the diet did not change when water sources were removed from the Sierra Pintas. Browse made up the majority of diets (≥ 68%) followed by cacti, grass, and forbs. Our prediction that females in the Sierra Pintas would increase their consumption of succulents when water was removed was not supported by our data.

Similarly, our predictions that foraging areas used by female bighorn sheep in the Sierra Pintas would have more vegetative cover and succulents were not supported by our data. However, our data did support the prediction that areas used by sheep would have more thermal cover after the removal of water. This may reflect a behavioral response to water removal in which sheep sought to reduce heat loads and minimize water loss.

Were there responses in sheep movement and home range size? We found that home range size increased only in winter and autumn in the Sierra Pintas after water was removed. Home ranges increased by 35% in the Sierra Pintas but decreased by 24% in the Cabeza Prieta Mountains. These shifts were likely related to increased precipitation.

The distance from sheep to the nearest catchment decreased in winter by 25% in the Sierra Pintas but only by 9% in the range that had free-standing water. We did not document a change in the distance from sheep to water in the warmer summer and autumn seasons. The limited change

of home range sizes, movement rates, and distance to the nearest water catchment during hot, dry seasons after the removal of water suggested that other factors, such as forage conditions, played a larger role in determining home range area and movement rates during our study than did the presence or absence of water catchments.

Were there effects on sheep mortality, productivity, and recruitment? We documented 10 mortalities overall in the Sierra Pintas and eight in the Cabeza Prieta Mountains. In both mountain ranges, seven of these deaths occurred before water was removed. Most mortalities occurred in summer, and the average survival rate was lower in both mountain ranges before water was removed than after. The annual survival rates were positively associated with precipitation and negatively associated with the average daily temperature during winter. There was not a significant decrease in lamb-to-female and yearling-to-female ratios in the Sierra Pintas when water sources were removed.

We observed higher mortality rates during the drought when both mountain ranges had water. This suggested that the presence of these structures was not likely adequate to prevent mortalities of desert bighorn sheep during severe droughts. Poor forage quality and availability appeared to limit the population during this time. After water was removed, an increase in rains improved forage conditions including forage moisture, and the availability of natural water sources likely minimized any impact of removing water catchments on survival rates, lamb-to-female ratios, and yearling-to-female ratios.

The Results

In summary, the removal of water sources did not create the changes to life history characteristics of desert bighorn sheep that we predicted. Female desert bighorn sheep did use areas with more thermal cover, but their diet did not change, and other than thermal cover, the foraging areas were similar before and after the removal of water. During warmer months, when we would expect a response, we did not document changes in the distances from sheep to catchments. The limited changes created when water was removed suggest that forage plays a more important role than water in determining home range sizes, areas used, and movement rates. Because we did not document increased mortality after water was removed and we did not document a shift in lamb-to-female or yearling-to-female ratios with water removal, we concluded that water catchments were not as important as other resources, such as forage, in sustaining the desert bighorn sheep population.

To Provide Water or Not? The Verdict

The lack of significant changes following the removal of water suggested that during years with above-normal precipitation (as occurred during the period when we closed the water catchments in the Sierra Pintas), perennial sources of free-standing water may not be limiting to desert bighorn sheep in this area and may have little influence during times when forage moisture content is high. On the other hand, during periods of drought, forage quality and quantity are likely more limiting to ungulate populations in the southwestern United States than available water. During the period when both ranges had water, the area was also experiencing the worst drought on record but water catchments were not sufficient to prevent high adult mortality. Thus, providing water sources for ungulates during drought may do little to prevent the adverse consequences of scarce forage or other limiting factors.

Our study found that forage had a greater influence than water on female desert bighorn sheep in the Sierra Pintas. During periods of above-normal precipitation, high forage moisture and abundant natural sources of free-standing water may minimize the influence of man-made water catchments. Similarly, during periods of severe drought, forage conditions are likely the primary limiting force for desert bighorn sheep. Therefore, any influence of man-made water catchments on desert bighorn sheep populations likely occurs during years with weather conditions that are neither drought nor wet. The influence of water catchments in the Sierra Pinta Mountains is likely restricted to periods when forage is not limiting.

Although our study was limited to desert bighorn sheep, man-made water catchments are used by many other species. Thus far, the influence of catchments on population performance of other animals is unknown. Until long-term studies are completed (long enough to capture drought, wet, and normal years), the question of whether or not they should be constructed and maintained will continue to be controversial and largely a political matter. ■

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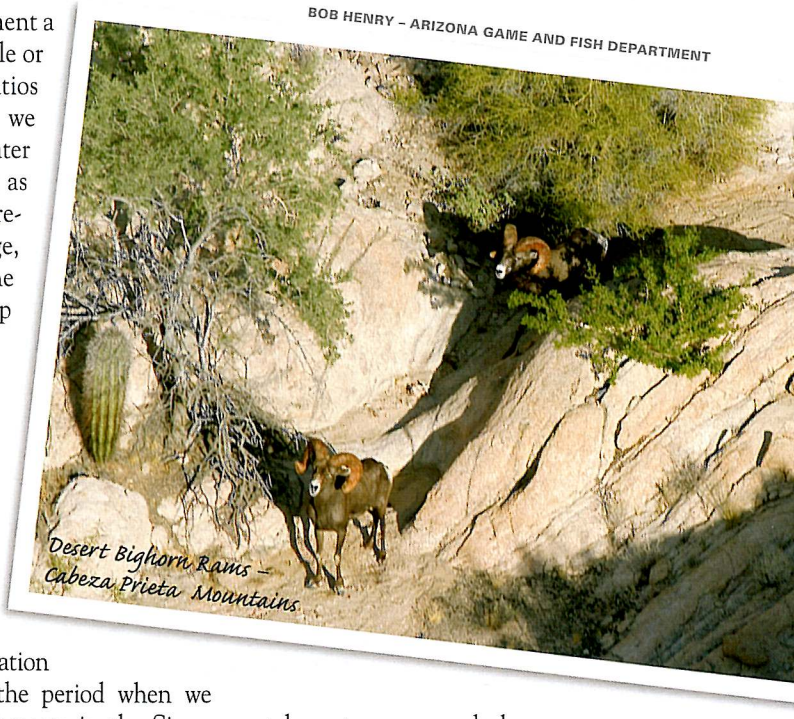

Desert Bighorn Rams – Cabeza Prieta Mountains

The doctoral research of James W. Cain III was supported in part by funding from the William I. Spencer Conservation Grants Program of the Boone and Crockett Club. Dr. Cain is now engaged in postdoctoral research at the Center for African Ecology, School of Animal, Plant, and Environmental Sciences, University of the Witwatersrand, South Africa.

The supervisor for his doctoral research, Dr. Paul R. Krausman, is a Professional Member of the Boone and Crockett Club and a professor at the University of Arizona, Tucson.

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