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Water Developments and Desert Bighorn Sheep: Implications for Conservation

BRIAN F. DOLAN,[1] *Arizona Desert Bighorn Sheep Society, Mesa, AZ 85277, USA*

Abstract

*In recent times the construction and maintenance of wildlife water developments for the stated purpose of conserving desert bighorn sheep (*Ovis canadensis*) populations has been controversial, especially within sensitive lands of the southwestern United States. A major portion of the controversy is whether wildlife water developments provide a benefit to populations of desert bighorn sheep and whether the associated incursion into the naturalness of an area is justified. Desert bighorn sheep are a valued natural resource and they exist today in small, isolated populations threatened with a variety of human-related impacts (e.g., disease, development, climate change, habitat fragmentation, water diversion). In this article I summarize the available published literature related to desert bighorn sheep and wildlife water developments and review the effects and consequences of water developments in desert bighorn sheep conservation. Based on my review, I contend that recent criticism of water developments has failed to adequately consider anthropogenic factors that can influence wildlife populations and their habitats. My review found that desert bighorn sheep benefit from water developments and that the role of active management of wildlife habitat, including the development of free-standing water for bighorn sheep where this component is unavailable, is justified as a means of mitigating negative anthropogenic influences in an otherwise natural setting.* (WILDLIFE SOCIETY BULLETIN 34(3):642–646; 2006)

Key words

Arizona, conservation, desert bighorn sheep, management, Ovis canadensis, *water developments.*

The Arizona Game and Fish Department (AGFD) began constructing water developments for wildlife in 1946 (AGFD 1997). Initially designed to benefit game bird populations, water developments have been constructed to benefit other wildlife populations in areas where free water may be a limiting factor (Wright 1959), mitigate the loss of natural sources (Wright 1959, deVos et al. 1983), and enhance amphibian populations (AGFD 1997, Rosen and Schwalbe 1998, Sredl and Saylol 1998) The value of human-made water structures to desert bighorn sheep (*Ovis canadensis*) has been questioned (Broyles 1995, 1997). Some of the controversy appears to have originated because desert bighorn sheep have been found in areas without permanent free water (Seton 1929, O'Conner 1939, Brown 1984, 1997).

My objective was to review and synthesize published literature and case histories that report the consequences of wildlife water developments in the southwestern United States to desert bighorn sheep and other ungulates. Based on my review, I contend that recent criticism of water developments has failed to consider anthropogenic factors that can influence wildlife populations and their habitats. These factors include impacts associated with long-term changes in climate (Hanski 1999, Walther et al. 2002), extensive fragmentation of bighorn sheep habitat, the small size of extant bighorn sheep populations (Berger 1990), and the implications of small population size and increased potential for extinction caused by population and environmental stochasticity (Gilpin and Soulé 1986, Berger 1990, Belovsky et al. 1994). I summarize some of the recent literature on these factors in an effort to demonstrate the need for active management of wildlife habitat including the development of free-standing water for bighorn sheep where this component is missing as a means of mitigating other negative influences. Throughout this discussion I use the term "water development" to describe a perennial source of water for wildlife, either a human-made water source or a natural water source that has some form of human intervention (e.g., supplemental water hauling, evaporation control, sediment removal). Without intervention, most natural waterholes are ephemeral pools.

The Controversy

Several authors cite the potential negative impacts of water developments to desert bighorn sheep (Broyles 1995, 1997, Broyles and Cutler 1999). Potential adverse effects of water developments include increased predation at water sources (Bourliere 1963, Monson 1965, Cunningham and deVos 1992, Krausman and Etchberger 1992), drowning or starvation as a result of being trapped in the water development (Mensch 1969, Allen 1980, Baber 1983), disease transmission and poor water quality (Witham et al. 1982, deVos and Clarkson 1990, Kubly 1990, Schmidt and DeStefano 1996, Swift et al. 2000), introduction and expansion of nonnative species (Broyles 1995, Manseau et al. 1996), and soil compaction and overgrazing adjacent to water developments (Ayeni 1975, Tolsma et al. 1987).

However, others (Leslie and Douglas 1979, Krausman and Etchberger 1995, Krausman 2002) have documented the role of water developments in conserving desert bighorn sheep populations. Although desert bighorn sheep use habitat near water sources, water developments have not always resulted in increased sheep populations (Ballard et al. 1998). deVos et al. (1998) suggested that much of the controversy regarding the effects of water developments on desert bighorn sheep may be attributed to study design problems. Some of the specific problems they identified included studies that were primarily descriptive or anecdotal, short in duration, limited in design, restricted to a few species, and influenced by weather extremes.

Water and Desert Bighorn Distributions

Although all ungulates are capable of obtaining water from forage (Skovlin 1982), desert bighorn sheep distribution appears to be correlated with its proximity to free water. Leslie and Douglas

[1] *E-mail: bfd@dakotacom.net*

Table 1. Mortalities of desert bighorn sheep and other wildlife reported at dry water sources in the southwestern United States.

Location	Date	Observer	Loss	Additional remarks
Mojave Tanks, Trigo Mountains, Arizona	1934	H. Morrow	23 bighorn sheep	Kofa National Wildlife Refuge report
Little White Tanks, Castle Dome Mountains, Arizona	1943	Lt. Hatfield	1 ram, 5 mule deer	Kofa National Wildlife Refuge report
Stubbe Spring Guzzler, Joshua Tree Nat. Mon., California	ca. 1968	L. Lutz	2 rams	Water later developed
Butterfly Tank Facility, Estrella Mountains, Arizona	July 1987	J. Gunn[a]	1 ram, 1 ewe	Facility renovated in 1990
Lazarus Tank, Plomosa Mountains, Arizona	July 1983	J. Witham	2 bighorn sheep	5 live dehydrated sheep
Little Bones Cave, Plomosa Mountains, Arizona	July 1983	J. Witham	5 bighorn sheep	Pothole went dry
Muddy Mountains Guzzler #5, Muddy Mountains, Nevada	July 1994	P. Cummings	2 ewes	Dry ephemeral development
Trigo Tinajas, Trigo Mountains, Arizona	ca. 1994	G. Searles	Several bighorn sheep	Pothole went dry
Vermin Tank Guzzler, Old Dad Mountains, California	August 1995	A. Pauli[b]	3 bighorn sheep	See Swift et al. (2000)
Old Dad Peak Guzzler, Old Dad Mountains, California	August 1995	A. Pauli[b]	42 bighorn sheep	See Swift et al. (2000)
Suds Hole Guzzler, Sheep Hole Mountains, California	July 2000	J. Anderson	6 bighorn sheep	Development failure
Bear Claw Guzzler, Sheep Hole Mountains, California	July 2000	J. Anderson	Several bighorn sheep	Development failure
Catchment #933, Plomosa Mountains, Arizona	August 2000	D. Pfleger[a]	2 bighorn sheep, 3 mule deer, 1 coyote	Development went dry
North Pinta Tank Cabeza Prieta National Wildlife Refuge	August 2004	J. Cain[c]	1 ewe	Waters turned off Jan 2004

[a] Arizona Game and Fish Department.
[b] California Department of Fish and Game.
[c] University of Arizona.

(1979) reported that 84% of the desert bighorn sheep found in their Nevada, USA, study area during the summer months were within 1.9 km of water sources. Olech (1979), Cunningham (1982), and Bristow et al. (1996) documented similar summer aggregations of desert bighorn sheep around natural and human-made water sources. Turner et al. (2004) studied habitat use for Nelson's desert bighorn sheep (*O. c. nelsoni*) in California, USA, and determined that 97% of 12,411 observations were within 3.2 km of perennial water.

Desert bighorn sheep are widely distributed in areas such as the Central Nevada Ranges, where water is not a limiting factor. Several dry ranges in Nevada support desert bighorn sheep during cooler months but not during summer (McQuivey 1978). Water developments allowed desert bighorn sheep to remain on desert range during the summer (McQuivey 1978). Prior to the water developments, the herd would move to more mesic higher elevations during the summer (McQuivey 1978). McQuivey (1978) also reported that 82% of 488 desert bighorn sheep on his study area were found within a 3.2-km radius of known water sources in summer. This reduced the amount of habitat available for desert bighorn sheep to 15–20% of the existing range.

Desert Bighorn Sheep–Water Interactions

Desert bighorn sheep, mule deer (*Odocoileus hemionus*), and other wildlife mortalities have been reported at natural and human-made water developments where all water evaporated, was lost, or was not replenished (Table 1). Swift et al. (2000) documented the largest loss of desert bighorn sheep in 1995 at 2 wildlife water developments in California, USA. In that incident, 45 bighorn sheep died at the Old Dad and Vermin water developments after they dried up.

Monson (1965) documented 4 events involving ≥20 desert bighorn sheep mortalities near wildlife water sources during summer. The sources documented by Monson (1965) are now considered important for desert bighorn sheep because of management actions that made them more dependable (J. Hervert and D. Conrad, AGFD, personal communication). For water sources to be considered dependable for desert bighorn sheep, they must be perennial and located in favorable habitats that are isolated or part of a local cluster of water sources >5 km from the nearest alternative water source (Halloran and Deming 1958, Blong and Pollard 1968).

Anthropogenic Influences

The effects of an expanding human population on wildlife habitat may be the greatest challenges that wildlife managers face. Some human-related effects are obvious (e.g., the development of travel corridors or the direct loss of habitat to urbanization). Other factors that can influence wildlife populations are less obvious and include global climate change or variations in precipitation patterns (Turner et al. 2003, 2004).

Climate Change: Long-Term Consequences for Bighorn Sheep

Most studies on water use by desert bighorn sheep have been designed to address other questions and have not addressed the role of climate (deVos et al. 1998). Temperature and precipitation changes can affect both the plants and animals in the Southwest (Turner et al. 2003). Global warming has drawn considerable attention as a major influence on the environment. Walther et al. (2002) documented changes in plant phenology, species composition, and abundance of many species as a result of recent warming trends. Hanski (1999) suggested that climate change can decrease habitat quality and lead to extirpation of populations when small, interconnected populations exist, as is the case with bighorn sheep.

Although the southwestern United States has been undergoing changes in flora and fauna as the region has become warmer and drier in the last 12,000 years (Lowe and Brown 1994), the greatest rate of change has occurred in the last 150 years (Fredrickson et al. 1998). Burning of fossil fuels increases carbon dioxide (Fredrickson et al. 1998, Turner et al. 2003), a possible cause of accelerated desertification in the Southwest.

Turner et al. (2003) suggest that the climate of the Southwest is affected by the global climate system as a whole and indicate that wind patterns in the northern hemisphere play an important role in regional precipitation. Since the 1960s wind patterns have been classified as meridional, which results in great variability in precipitation in a region (Turner et al. 2003). As a measure of the great interannual variation in precipitation that occurs in the Sonoran Desert, these authors calculated coefficients of variation for several weather stations in the Sonoran Desert and found that the western portion of the Sonoran Desert was highly variable; extremely wet and dry periods occur. Yuma, Arizona, USA, on the western edge of the Sonoran Desert, demonstrates this extreme; only 0.6 cm of rainfall occurred in 1956, yet 28.9 cm of rainfall occurred in 1905. Although desert climates are and always have been highly variable, increased aridity and temperatures can have a negative effect on desert bighorn sheep when free-standing waters are not available to this species (Epps et al. 2004).

Much of the attention on the cause of extirpation of bighorn sheep populations has focused on patch size (Berger 1990, Krausman et al. 1996*a*, Wehausen 1999); however, Epps et al. (2004) investigated the role of climate change on bighorn sheep and concluded that increased temperature and decreased precipitation in the late 1900s was an important factor in bighorn sheep population extirpations in California, USA. Although bighorn sheep occur in hot, dry regions, the increases in aridity (Turner et al. 2003) and temperatures (Lane et al. 1994, Turner et al. 2003) have been particularly severe and have adversely impacted desert bighorn sheep populations (Epps et al. 2004). These factors in concert may present the greatest challenges to bighorn sheep survival, particularly in lower-elevation ranges (<1,490 m; Epps et al. 2004), which includes most of the occupied desert bighorn sheep range in the Southwest.

Managing Small, Isolated Populations

There has been a decline in the distribution and numbers of bighorn sheep throughout their range. Many extant populations are isolated from occupied ranges that were once connected (Buechner 1960). Cooperrider (1985) and Valdez (1988) both estimated that >500,000 bighorn sheep occupied North America prior to European settlement. Fewer than 12,000 persisted after more than a century of human-caused declines (Monson and Sumner 1980).

Historic records for bighorn sheep from Arizona, USA, indicate this species occurred in most mountainous regions of Arizona but by the mid-1950s was absent from the San Francisco Peaks and Bill Williams Mountains (northern Arizona), most of the Verde River drainage (central Arizona), and many isolated mountains in southern Arizona (Russo 1956). Aggressive conservation activities and translocations occurred over the past 40 years, and numerous populations have been reestablished in Arizona. However, most populations in Arizona are small in size (<100 individuals), isolated from other populations, and are at risk of extirpation (Belovsky et al. 1994).

Although there was disagreement between these studies regarding the actual number of bighorn sheep required to ensure survival, it is important to point out that all of these studies documented extinctions occurring in small, isolated bighorn sheep populations. Belovsky et al. (1994) point out that the dynamics of small populations are well documented and there is no guarantee of persistence in any situation where small, isolated populations exist, as is the case for desert bighorn sheep throughout their range. Small populations experience decreased genetic diversity (Frankham 1996), as undesirable mutations can build up over many generations when effective population size is <100 individuals (Lynch et al. 1995). Singer et al. (2001) and McKinney et al. (2004) noted that patch size is also an important factor for population persistence. Diamond (1972) proposed that patch size alone was the most important variable in determining the rate of population collapse. Bighorn sheep are at risk because of small population size, the small, isolated habitat patch sizes they occupy, and the increased aridity and ambient temperatures occurring in the Southwest (Turner et al. 2003).

Water Developments: Active Management to Mitigate the Effect of Change

Soulé et al. (1979) reported that benign neglect (lack of active management) will lead to faunal collapse. Given the changes that have occurred in the Southwest, including increasing desertification, increasing habitat fragmentation, and the resulting decreasing net effective size of most bighorn sheep populations, I believe that active management (as it relates to the construction and maintenance of water developments) will be needed to reduce the extirpation risks for localized bighorn sheep populations. The need for increased management has been proposed by other authors (Berger 1990, Belovsky et al. 1994, Krausman et al. 1996*b*) to avoid population extinctions.

Desert bighorn sheep are an important component of the southwestern wildlife community and their populations have declined throughout their range. The factors related to these declines are the result of human-related impacts (e.g., climatic changes, habitat loss and fragmentation, water diversions, introduction of livestock diseases) and are not likely to be reversed in the future as the human population in the Southwest continues to grow. Therefore, I believe it is important to recognize that a hands-off, preservationist approach to the maintenance of biological diversity (Belovsky et al. 1994) may no longer be a feasible option for wildlife managers, particularly when the focus of management is a species, such as desert bighorn sheep, whose small population sizes have resulted from human-related impacts. To assist with mitigating these impacts or when water is recognized as a limiting factor for the health of a desert bighorn sheep population, and in the absence of documented adverse impacts of water developments, I believe water developments should be a component of bighorn sheep management; to do otherwise will place bighorn sheep populations at increased risk of extirpation.

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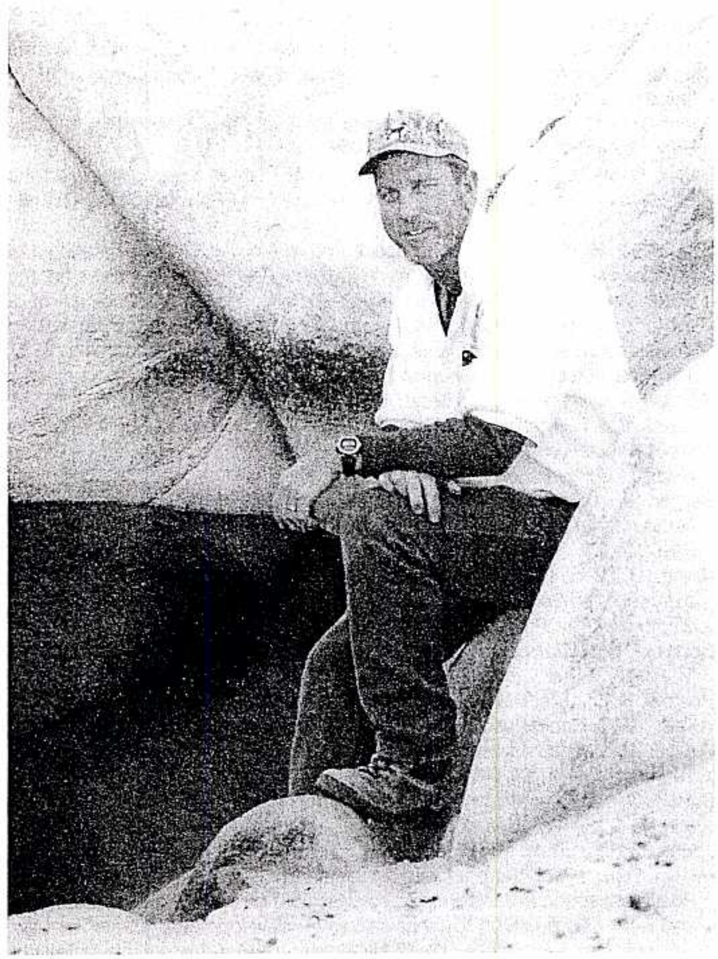

Brian F. Dolan is a past-president of the Arizona Desert Bighorn Sheep Society and a member of several other regional and national wildlife conservation organizations. He is a second generation Arizonan who has spent a lifetime exploring the deserts of the Southwest, pursuing his passions for wildlife and the outdoors. Over the past 14 years he has been actively involved in the conservation of desert bighorn sheep and other wildlife in Arizona. In 2001 the Arizona Game and Fish Commission recognized him as their Volunteer of the Year. He earned a B.S. in civil engineering at the University of Arizona and is employed as a licensed professional engineer and construction manager.

Special Section Associate Editor: Krausman.