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Developed Waters for Wildlife: Science, Perception, Values, and Controversy

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Abstract

Human-made or -modified water sources (i.e., catchments) are widely used for wildlife management in the arid western United States, where thousands of such catchments have been built to enhance wildlife populations and mitigate for the loss of natural water sources. For decades, the need for and value of catchments to wildlife was unquestioned. Recently, however, the use of catchments has become controversial, particularly on public lands. Impacts to wildlife populations and wildlife habitats have been central to the debate, which has, in large part, been fueled by a paucity of scientific information. Value-based conflicts over management practices on public lands also have played a significant role. (WILDLIFE SOCIETY BULLETIN 34(3):563–569; 2006)

Key words

catchments, Southwest, water, wildlife.

A Brief History of Wildlife Water Development in the Arid West

Water is a welfare factor (Leopold 1933) and, when not in the proper proportion, can be a limiting factor to populations. For over half a century, humans in the arid western United States have provided water for wildlife. Where water was perceived to be limiting because of the scarcity or unreliability of natural sources, early resource managers focused considerable attention on developing water for wildlife. Such developments were first described in the 1940s, intended to benefit quail (*Callipepla* spp.; Glading 1943) and later mule deer (*Odocoileus hemionus*; Glading 1947, Wright 1959). The popularity of these systems increased as new designs were developed and established for chukar (*Alectoris chukar*; Benolkin 1990), lagomorphs (Cooke 1982), bighorn sheep (*Ovis canadensis*; Halloran and Deming 1958, Blong and Pollard 1968), pronghorn (*Antilocapra americana*; Sundstrom 1968), and other game species. In the 1980s, the focus for wildlife catchments expanded beyond enhancing populations of game species. Widespread urban, agricultural, transportation, and industrial developments across the arid West provided an incentive to use developed water sources to mitigate the loss of naturally occurring water sources (deVos et al. 1983, Messing 1990, Krausman and Etchberger 1995, Rosenstock et al. 1999). Along with this mitigation function was the need for catchment designs that were more reliable and accessible to the variety of wildlife species using natural free-water sources (Gunn 1990, Lesicka and Hervert 1995). To bolster wildlife water-catchment programs, state wildlife agencies partnered with federal land management agencies, sportsmen, and private organizations that could provide additional labor and capital investment. Such collaborations also served a social and networking function, providing opportunities for hands-on participation in projects of mutual interest (Broyles 1998). Wildlife water catchments remain a popular management tool across the western United States. In 1997, 10 of 11 western state wildlife agencies had ongoing water catchment programs, that collectively represented nearly 6,000 water developments (precipitation catchments [guzzlers], modified natural rock basins [tinajas], developed springs, and wells) and annual expenditures of >$1 million (Rosenstock et al. 1999).

The Controversy over Wildlife Waters

For decades, the benefits of developed water sources to wildlife were unquestioned. Unfortunately, despite the tremendous capital investment in water catchments, relatively few resources were devoted to monitoring and studying their effects. Predictably, the absence of data created fertile ground for management uncertainty and, ultimately, public controversy. Sanchez and Haderlie (1990) noted that the pace of water development on U.S. Fish and Wildlife Service (USFWS) refuges in Arizona, USA, had slowed, in part because of concerns that overabundant water supplies could adversely affect wildlife populations and habitats. This was supported by Broyles (1995) who questioned the benefits of wildlife water developments and hypothesized various negative impacts that could be caused by these facilities. Similar cautionary notes were raised by Brown (1998). Broyles and Cutler (1999) further challenged the efficacy of water catchments for desert bighorn sheep and stimulated a vigorous exchange in the literature (Broyles and Cutler 2001, Rosenstock et al. 2001, Krausman et al. 2003). Range managers have established numerous livestock water sources that also may be used by wildlife (Vallentine 1980), and these facilities, likewise, have been controversial (Scott 1998).

Concurrent to the debate in the scientific literature, water catchments on public lands received greater scrutiny by interest groups and members of the public. Projects involving installation of new waters or renovation of existing systems frequently were challenged because of hypothesized biological impacts (Broyles 1995), economic costs and benefits (Brown 1998, Broyles 1998), and perceived incompatibility with areas managed for wilderness characteristics (Czech and Krausman 1999, Bleich 2005). Some

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wilderness advocates further maintained that existing wildlife waters should be removed from special-status federal lands (e.g., wilderness, monuments, and preserves) that were established long after catchments were built. These actions were opposed by sportsmen's groups and state wildlife agencies concerned about adverse impacts to wildlife populations. Federal agencies administering the lands in question were often caught in the middle, faced with conflicting or vague policy directives covering catchments.

One favorable outgrowth of this controversy was the initiation of numerous studies that have expanded our understanding of the biological effects of wildlife water developments in the arid West. This special section contains papers from a November 2004 symposium at Arizona State University, "Wildlife Water Development Workshop: a Review of the Science, Policy, and Human Dimensions." Highlights from these papers and recent studies published elsewhere are presented below.

The free-water requirements of many wildlife species in the arid West are poorly understood. Existing information indicates considerable variability among species and is sometimes equivocal.—Water constitutes 99% of all molecules within an animal (MacFarlane and Howard 1972) and is critical for physiological processes (e.g., hydrolytic reactions, thermal control, transportation of metabolic products, excretion, lubrication of skeletal joints, sensory transmission within ears and eyes; Robinson 1957). The importance of free (surface) water varies among wildlife species found in the arid West (Payne and Bryant 1998, Rosenstock et al. 1999). Free water is required by some birds and mammals, although xeric-adapted species can exist solely on metabolic and preformed water sources (Table 1). The need for free water has often been inferred from observational data on animal distribution and resource use rather than physiological studies. It is, therefore, not surprising that the literature remains equivocal with respect to free-water requirements of many wildlife species. Mechanisms of thermoregulation and water balance have been studied in domestic and wild ungulates from Africa and the Middle East, but comparatively little is known about desert bighorn sheep and other North American ungulates that are focal species for catchment programs (Cain et al. 2006). Critical questions remain concerning the relative importance of preformed versus free-water sources and the physiological benefits provided by the latter during critical periods (Cain et al. 2006).

Wildlife water developments are used by a diverse array of species and do not appear to present a high risk of predation for animals that visit them.—There is a widespread perception that wildlife water developments are used primarily by game species; however, recent studies present a different picture. Catchments in southwestern Arizona, USA, were used by >34 species, and the visitation rate of nongame species far exceeded that of game animals (O'Brien et al. 2006). Contrary to popular perceptions of high predation rates at human-made water catchments, relatively few predation events ($n = 8$) were observed (O'Brien et al. 2006). Catchments in the Sonoran Desert received little use by passerine birds during spring migration but were heavily used by resident bird species, particularly during drought (Lynn et al. 2006). Although wildlife use of free-water sources may be opportunistic and does not by itself indicate a need for that resource, these studies imply greater conservation benefits from catchments than previously recognized.

Water development design has a strong influence on wildlife use, and in some cases, modifications may be needed to achieve management objectives.—Older gallinaceous-guzzler designs may not be accessible to larger mammals and can pose a risk of entrapment to animals that are able to enter. Bleich et al. (2006*b*) present a retrofitting approach for such facilities. Waters developed for other purposes (e.g., livestock) may not be designed to accommodate wildlife but can provide a critical resource. Tuttle et al. (2006) provide experimental evidence demonstrating how structural modifications and water surface area of livestock watering troughs can affect accessibility to bats.

The availability of natural and human-made water sources affects habitat use, though other factors can be more important. Ungulate foraging appears to have negligible impact on plant communities near developed waters.—Patterns of habitat use with respect to water sources have been described for ungulates and other game species expected to benefit from water developments, leading to recommendations for the spacing of these facilities (Table 1). However, the influence of developed water sources on habitat use varies. Previous studies have found mule deer in proximity to water sources, including catchments, during dry periods (Rautenstrauch and Krausman 1989, Boroski and Mossman 1996). When denied access to catchments, females moved outside their known home ranges to locate alternate water sources (Hervert and Krausman 1986). In contrast, Marshal et al. (2006*a*) found that forage quality and other factors had a greater influence on deer distribution than did the proximity of catchments. The influence of catchments on habitat use by deer was greatest during hot, dry periods and varied among individuals (Marshal et al. 2006*a*). Mule deer were relatively slow to use new water sources; use of washes near catchments was greatest where these wildlife waters had been in place >3 years (Marshal et al. 2006*b*). Coyotes (*Canis latrans*) are frequent visitors to desert water catchments (O'Brien et al. 2006), but habitat use was not concentrated in areas closer to water, even during summer months (R. Waddell, Arizona Game and Fish Department, unpublished data). During spring migration, passerine bird density and species composition did not differ between xeroriparian habitats with and without water developments (Lynn et al. 2006).

Despite heavy use of developed waters by wild ungulates (O'Brien et al. 2006), impacts to adjacent plant communities (i.e., piosphere effects; Andrew 1988) have not been documented. Forage biomass did not differ between control washes and washes with catchments used by mule deer and desert bighorn sheep (Marshal et al. 2006*b*). The presence of natural and other human-made water sources affects wildlife use of water catchments (Marshal et al. 2006*a*). However, the rugged and remote nature of the arid West can make locating natural water sources difficult. Bronson et al. (2006) describe a test of remote-sensing techniques for locating such water sources.

Water quality at catchments is comparable to natural sources and unlikely to adversely affect animal health.—A common criticism of wildlife water catchments is that they

Table 1. Importance of free-standing water to selected wildlife in the southwestern United States (adapted from Payne and Bryant [1998], Rosenstock et al. [1999], and others).

Species	Need for free-standing water	Movements relative to known water sources (km)	Optimum spacing of water developments (km)	References
Game birds				
California quail (*Callipepla californica*)	Might need, if succulent vegetation unavailable	0.4–1.2	≤1.6	Leopold (1977)
Chukar partridge (*Alectoris chukar*)	Required when succulent forage unavailable, 44 ml/d			Degen et al. (1983, 1984)
	Influences distribution; 2,800 L/covey/yr		0.8–1.6	Christensen (1954), Mackie and Buechner (1963)
	Increased existing populations and facilitated establishment of new populations			Benolkin (1990)
Gambel's quail (*Callipepla gambelii*)	Required, if succulent vegetation unavailable			MacGregor (1950), Hungerford (1960, 1962)
	Use of catchments varies with regional rainfall patterns	1.6–3.2	1.6–3.2	Campbell (1961)
Gray partridge (*Perdix perdix*)	Might need, if succulent vegetation unavailable	0.4–1.6	0.8–1.6	Porter (1950)
Mountain quail (*Oreortyx pictus*)	Might need, if succulent vegetation unavailable	3.2	1.6–3.2	MacGregor (1950)
Mourning and white-winged dove (*Zenaida macroura*, *Z. asiatica*)	Could increase populations			Elder (1956)
		3.7 (loafing sites), 1.8 (nests)	<6.0	Howe and Flake (1988)
Northern bobwhite (*Colinus virginianus*)	Used in hot dry periods; succulent vegetation usually adequate	0.4–1.2	≤1.6	Prasad and Guthery (1986), Koerth and Guthery (1990), Goodwin and Hungerford (1977), McNabb (1969)
Scaled quail (*Callipepla squamata*)	Succulent vegetation might be adequate	0.4–2.4	1.6	Schemnitz (1961, 1994), Campbell et al. (1973)
Wild turkey (*Meleagris gallopavo*)	1,900 L/flock/summer	0.8–1.6	1.6–3.2	Payne and Copes (1988)
	Populations increase with water		2.6	Shaw and Mollohan (1992), Hoffman et al. (1993)
Game mammals				
Collared peccary (*Pecari tajacu*)	Limited reliance on free-water			Zervanos and Day (1977)
White-tailed deer (*Odocoileus virginianus*)	May be required in some habitats			Lautier et al. (1988)
	16–31 ml/kg			Boyd et al. (1986)
Coues white-tailed deer (*Odocoileus virginianus couesi*)	May obtain water from succulent vegetation			Severson and Medina (1983)
Desert bighorn (*Ovis canadensis*)	Required during summer			Turner (1973)
	Dependable water required	1.6–2.4	2.0–8.0	Graff (1980), Boyd et al. (1986), Halloran and Deming (1958)
	Some populations may exist without free-standing water; obtain moisture from vegetation			Krausman and Etchberger (1995), Warrick and Krausman (1989)
Desert mule deer (*Odocoileus hemionus*)	100–200 ml/kg	0.8–5.0	<3.2–4.8	Hanson and McCulloch (1955), Roberts (1977), Severson and Medina (1983), Elder (1954)
	Dependent on water, especially in dry periods			Rautenstruach and Krausman (1989), Boroksi and Mossman (1996), Hervert and Krausman (1986)
Elk (*Cervus elaphus*)	42–63 ml/kg		1.6–3.2 km	Mackie (1970), Roberts (1977)
	Water developments played a role in expansion			Skovlin (1982)
Pronghorn (*Antilocapra americana*)	Need for free water equivocal, varies among regions and subspecies			Yoakum (1994)
	Can meet requirements from preformed or metabolic water	4.8–6.4 km	1.6–8.0 km	Boyd et al. (1986), Beale and Smith (1970), Robbins (1983), Sundstrom (1968), Yoakum (1978), Deblinger and Alldredge (1991)
	May be important in habitat management for Sonoran subspecies	1.6–3.0	1.6–3.2	Morgart et al. (2005)
Nongame species				
Ringtail cat (*Bassariscus astutus*)	Can likely meet needs from preformed water			Chevalier (1984)
Coyote (*Canis latrans*)	Can likely meet needs from preformed water			Golightly and Ohmart (1984)

Table 1. continued.

Species	Need for free-standing water	Movements relative to known water sources (km)	Optimum spacing of water developments (km)	References
Kit fox (*Vulpes macrotis*)	Can likely meet needs from preformed water			Golightly and Ohmart (1984)
Black-tailed jackrabbit (*Lepus californicus*)	Free water not required when forage moisture sufficient			Nagy et al. (1976)
Small mammals	No apparent need			Mares (1983)
Bats	Required during lactation (*Myotis lucifugus*)			Kurta et al. (1989)
	Required by some species, developed water sources influence distribution			Geluso (1978)
Harris' hawk (*Parabuteo unicinctus*)	Required, increased distribution			Dawson and Mannan (1991)
House finch (*Carpodacus mexicanus*)	Required, influences distribution			Bartholomew and Cade (1956), MacMillen and Hinds (1998)
Verdin (*Auriparus flaviceps*)	Not required			Webster and Weathers (2000)
Black-throated sparrow (*Amphispiza bilineata*)	Not required, but access to free-water increases clutch size			Coe and Rotenberry (2003)
Ground dove (*Columbina passerina*)	9.7% of body weight/day			Willoughby (1966)

promote poor water quality that may pose a health risk to animals that use them (Kubly 1990, Broyles 1995). During critical summer periods, water at these sources is often unappealing to human visitors but not to wildlife (O'Brien et al. 2006). There were few differences in water quality parameters between natural tinajas and 2 different types of catchments in southeastern California, USA (Bleich et al. 2006*a*). Differences observed were related to design features of catchments. Water quality was within recommended guidelines (Bleich et al. 2006*a*), findings that paralleled a similar study in southwestern Arizona, USA (Rosenstock et al. 2005).

Where Do We Go from Here?

The use of catchments as a wildlife management tool likely will remain controversial. Value-driven issues related to wildlife management in wilderness (Bleich 1999) and, more fundamentally, active manipulation of natural systems (Caughley and Sinclair 1994) will remain a source of debate. Dolan (2006) makes the case for continued use of water catchments to benefit desert bighorn sheep, noting the lack of documented adverse impacts and the threats posed to desert bighorn sheep populations by development, climate change, habitat fragmentation, and water diversion. Indeed, recent studies presented in this special section and elsewhere (Rosenstock et al. 2004, 2005), do not support hypothesized negative biological impacts of catchments and do suggest potential benefits to a wide array of species. As portions of the arid West continue to experience explosive growth of human populations and recurrent drought, the potential mitigation value of water developments likely will increase.

From a scientific standpoint, however, lingering questions remain concerning the ultimate benefits of catchments to wildlife populations. Although useful tools for meeting management objectives, catchments have not always yielded the expected benefits. Most importantly, our understanding of the effects of water developments on population performance (i.e., reproduction, recruitment, and survival) rests largely on anecdotal observations and a few correlative studies. The need for long-term, experimental studies has been previously articulated (Broyles 1995, Brown 1998, deVos et al. 1998, Rosenstock et al. 1999), but such studies have yet to be undertaken, largely because of daunting logistical and other challenges. For focal species (e.g., mule deer and desert bighorn) that occur at low densities and have large home ranges, experiments would need to be conducted at a very large (i.e., landscape) scale. Because most wildlife water developments are located on federal lands, extensive manipulation of water sources (i.e., addition or removal) likely would require environmental review through the National Environmental Policy Act process and amendment of existing land management plans. A further complication is that many potential study areas are located on lands designated or managed as wilderness or having restricted public access. Citizen groups, state wildlife agencies, and other interested parties almost certainly would challenge any large-scale addition or removal of water sources on public lands, potentially causing years of delay during ensuing administrative reviews and litigation. Once underway, such an experiment would need to span multiple wet–dry periods, which could take a decade or longer. The cost of such research would be enormous or perhaps

prohibitive, especially if a community-level approach (Burkett and Thompson 1994) was used. Researchers, managers, and stakeholders will have to collaborate in new and creative ways to overcome these obstacles. Until such large-scale, experimental studies are undertaken, we encourage researchers to continue "chipping away" at the remaining questions as funding and opportunities present themselves. For some species such as desert ungulates, laboratory studies under simulated environmental conditions (Cain et al. 2006) may be a viable alternative to experiments in natural setting.

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Desert bighorn sheep entering water catchment trough, southwestern Arizona, USA. Photo by Arizona Game and Fish Department.