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The Recreational Impact of Reducing the "Laughing Waters" of Aravaipa Creek, Arizona

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ABSTRACT: The paper describes analyses that were conducted to determine the importance of water as an attribute of the recreational setting at Aravaipa Canyon Wilderness, Arizona, and the influence that reduced flows in Aravaipa Creek would have on visitors' perceptions of water quantity and quality. Water was rated by visitors as the most important attribute of the wilderness area. Also, visitors were able to perceive small changes in the flow of Aravaipa Creek and possibly attributed diminished water quality to reduced flows. The presentation of results is framed with a discussion of legal aspects of instream flows and wilderness, a description of pertinent social issues, and an explanation of the techniques used in the analyses.

KEY WORDS: Instream flows, water rights, federal reserved water rights, wilderness recreation.

Aravaipa is an Apache name (some say Pima, some say Papago) and the commonly accepted meaning is "laughing waters." The name fits. (Abbey 1982:155)

Aravaipa Creek, the main feature of Aravaipa Canyon Wilderness, is a relic. Many, if not most, perennial desert streams in southern Arizona have disappeared or been radically changed during the past century by grazing, irrigation projects, watershed and vegetation management, urbanization, flood control developments, and groundwater pumping in excess of recharge (Johnson and Carothers 1982). But Aravaipa Creek still flows and supports a gentle, verdant riparian oasis in the midst of a scenic desert canyon. Seven native fish species—including two threatened species (U.S. Bureau of Land Management 1988a)—inhabit the creek, seeking food and shelter among boulders and mats of watercress. Lining the banks of the creek are mature and renewing stands of cottonwood, Arizona walnut, alder, willow, mesquite and box elder. These trees and other vegetation help provide habitat for more than 200 species of birds, 46 species of mammals, 46 reptilian species, and 8 amphibian species that reside in the wilderness area (U.S. Bureau of Land Management 1988a).

In addition to these natural features, the uniqueness of a perennial stream in the Sonoran Desert makes Aravaipa a popular recreation attraction. Between 1974 and 1986, 43,708 people visited the area, spending more than 111,000 visitor-days (a visitor-day equals one visit for 12 hours). Dur-

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ing the peak year of 1982, 14,072 visitor-days were spent in the wilderness area by 4,490 visitors (U.S. Bureau of Land Management 1988a). Based on these figures, one can calculate that, during "average" years, 3,362 people visit Aravaipa Canyon Wilderness and accumulate 8,568 visitor-days. Nearly all of this use is focused on Aravaipa Creek and its banks, a linear corridor approximately 11 miles long and rarely wider than 320 feet (Minckley 1981).

To protect the creek from depletion by surface water diversion or groundwater overdraft, the Bureau of Land Management (BLM) applied in 1981 to the Arizona Department of Water Resources (ADWR) for an Application for Permit to Appropriate Water (Application Number 33-87114). Slightly more than 4,000 acres of Aravaipa Canyon were at that time in Primitive Area status (an administrative designation similar to wilderness), which included 11.5 of 17 miles of perennial surface flow of Aravaipa Creek. In 1984, Congress designated 6,699 acres of the Canyon and surrounding area a wilderness area (P.L. 98-406, 98 Stat. 1485). Recently, in the spring of 1989, ADWR approved the instream flow permit (Number 33-87114), the third in Arizona's history. The actions of the BLM to protect Aravaipa's waters are significant because they represent an important means of protecting free-flowing waters in designated wilderness areas.

Recent court decisions have affirmed that federal agencies have a duty to protect waters in wilderness areas (Marks 1987; *Sierra Club v. Andrus* 487 F. Supp. 443 [D.D.C. 1980]; *Sierra Club v. Block*, 622 F. Supp. 842 [D. Colo. 1985]). Asserting federal reserved water rights through general stream adjudications or state water rights through state permitting systems are two methods of protecting wilderness waters. Federal reserved water rights are based on the idea that ". . . Congress . . . intended to reserve water rights for public lands that have been withdrawn from the public domain and reserved for a particular purpose" (Vasallo 1986:384). The purpose of wilderness, according to the Wilderness Act of 1964 (P.L. 88-577; 16 U.S.C. 1131), is to withdraw ". . . undeveloped Federal Land retaining its primeval character and influence" (sec. 2[c]), preserve and protect designated areas "in their natural condition" (sec. 2[a]), and provide for ". . . recreational, scenic, educational, conservation, and historical use" (sec. 4[b]). As Vasallo (1986) argued, these public purposes could form the basis of preserving historical flows in wilderness.

Last year, however, the Office of Solicitor, United States Department of the Interior, issued a Supplemental Opinion indicating that wilderness designation does not carry with it reserved water rights (M-36914 [Supp. III]). The opinion concluded that Congress intended wilderness purposes to be secondary to the purposes of the public lands from which wilderness areas were created. Thus, federal reserved water rights, which exist to the extent necessary to accomplish the primary purposes of National Parks, Forests, Wildlife Preserves, and other federal lands, do not exist to accomplish the purposes of secondary reservations such as wilderness. In a letter to the Secretary of the Interior (E. Meese, memo to D. P. Hodel, 1988), the Attorney General concurred with this opinion and further stated that the Department of Justice will not assert reserved wilderness water rights on behalf of the United States. For the time being, then, wilderness resource managers in the BLM (and potentially the Forest Service) may only use state permitting systems to secure instream flow rights. Instream flows for wilderness areas which are claimed as appropriative water rights in a state system must be quantified for beneficial uses as defined by the state.

The Arizona water code states that fish and wildlife and recreation are the beneficial uses of surface waters for which an applicant may apply to obtain an instream flow right. When the BLM initially applied for an instream flow permit (Application Number 33-87114), time constraints forced them to rely on relatively little data to estimate the monthly flows necessary to satisfy these legal purposes (D. Drobka, personal communication). The BLM estimated that an average monthly flow of 15 cubic feet per second (cfs) would be required, 10 cfs for fish and wildlife purposes and 5 cfs for recreation.

Several years later, to substantiate its claims, the BLM published a detailed study of its flow needs (U.S. Bureau of Land Management 1988b). Data from a report submitted to the U.S. Fish and Wildlife Service (USFWS) were used to determine monthly

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flows necessary to sustain the natural aquatic habitat of two Federally Threatened fishes inhabiting the stream (Turner and Tafanelli 1983). Additionally, an expert on Southwestern fishes recommended that monthly flows can vary between 25 and 10 cfs while maintaining an average of 15 cfs (Minckley 1981). To support the recreational portion of the application, the BLM needed information on the impact that reduced streamflows would have on its ability to continue providing recreation opportunities under a policy of nondegradation in Aravaipa Canyon Wilderness. A central feature of the BLM wilderness management policy is the principle of nondegradation. This policy requires "... that wilderness areas will be managed to provide for the protection and perpetuation of the values of the wilderness resource ..." and that "... conditions generally prevailing in each wilderness at the time of congressional designation" will be used as a benchmark for future management (U.S. Bureau of Land Management 1981:8). Consequently, degradation of natural conditions in the wilderness area caused by reductions in the flow of Aravaipa Creek would be illegal under agency policy.

In this paper, we describe analyses conducted to determine the impact that reduced flows in Aravaipa Creek would have on the recreational setting at Aravaipa Canyon Wilderness. These analyses were provided to the BLM to include in a study supporting the instream flow application (U.S. Bureau of Land Management 1988b). We first present statistical evidence of the importance of water as a component of the wilderness setting. Second, logistic regression equations are described that model relationships between visitors' perceptions of water quantity and quality in the creek and actual streamflows. The reader is referred to Grizzle et al. (1973) and SAS Institute (1985) for detailed descriptions of logistic regression. After describing these analyses, we discuss the significance of the results and arrive at a conclusion.

DATA COLLECTION METHODS

The data for the analyses presented in this paper resulted from a comprehensive sociological evaluation of recreation in Aravaipa Canyon Wilderness (Moore et al. 1989). From March 1987 to February 1988, we mailed questionnaires to 800 people who had secured permits to visit Aravaipa. Each month, a random sample of permit requesters was selected. In this manner, a stratified random sample of an annual cross-section of visitors was compiled. So that each month's strata could be included in the data set and so that each respondent was given an equal probability of being included in the survey, responses were weighted according to methods outlined in Moore et al. (1989). Reminders and replacement questionnaires were sent to people who did not respond to the initial and subsequent mailings. Six hundred and sixty-five people responded to the survey, constituting an 83 percent response rate.

Only some of the 58 questions from the mail survey were used in the following analyses. The questionnaire probed a variety of topics, including the respondents' perceptions of physical and biological attributes of the wilderness setting. Of relevance to this paper were questions that explored the importance of water as a component of the ecological setting and the abundance of water in comparison to respondents' preferences. See Moore et al. (1989) for a reproduction of the questionnaire in its entirety.

To model the impact of reduced streamflows on the perceptions of visitors, streamflow data were also used. These data were obtained from the Safford District Office of the Bureau of Land Management. The agency maintains streamflow gauges at the mouth and head of Aravaipa Canyon. Because Aravaipa Creek is unregulated, flows used in our analysis represented natural variations over the sampling period.

RESULTS

As noted above, information provided for the instream flow application was divided into two sections: (1) documentation of the importance of water to recreational

TABLE 1
Ranking of the most important elements of Aravaipa Canyon.

	%	Rank
Water	33.4	1
Peace and quiet	23.2	2
Solitude	16.4	3
Wildlife	8.7	4
Geology	6.9	5
Challenge	3.0	6
Vegetation	2.6	7
Ease of hiking	2.3	8
Good campsites	1.6	9
Shade	1.4	10
Safety from natural hazards	0.4	11
Archeology	0.2	12
Meeting other visitors	0.0	13
$n = 545$		

visitors at Aravaipa Canyon Wilderness and (2) analysis of how reduced flows influenced the perceptions of visitors.

Importance of Water to Recreation

To estimate the importance of water to recreational visitors, we asked survey respondents to rank, in order of importance, thirteen elements of Aravaipa Canyon and rate the importance of various water-related activities. Possibly reflecting the uniqueness of a free-flowing stream in a desert region, water was most frequently ranked the most important element of the wilderness area, followed by peace and quiet, solitude, wildlife, and geology (Table 1).

Two water-based activities—hiking and swimming—were highly rated by the respondents. Besides aesthetic enjoyment, these activities are the primary ways that people enjoy water in Aravaipa Canyon Wilderness. Nearly all the respondents (94.7 percent) reported that they liked or strongly liked hiking in Aravaipa Creek. This result is important because the creek is the only travel route through the wilderness area and visitors must repeatedly cross and walk through the creek. If the respondents were not pre-disposed to enjoy the water, they might report lower levels of enjoyment from hiking in the creek. Seventy-eight percent of the respondents reported that they liked or strongly liked swimming in Aravaipa Creek. Although a smaller percentage (42 percent) reported actually swimming in Aravaipa Creek during their most recent visit, a strong preference for close contact with water in the wilderness area was apparent from the results.

In addition to activities directly related to water were pursuits derived from the riparian zone supported by the creek. Because Aravaipa is a prime ecological area, most visitors who come to the area engage in some form of nature study. In one question of the survey, for example, respondents were asked how much they would like to engage in various activities related to nature study on their next trip (Table 2). Ninety-seven percent responded that they would like or strongly like to observe and identify mammals; 87 percent, observe and identify reptiles and amphibians; 84 percent, observe and identify birds; 82 percent, identify plants; and 70 percent, observe and identify fish. In addition to hiking, camping, exploring, and relaxing, nature study activities form the recreational core of the wilderness area. Hunting is generally excluded from the watered part of the wilderness area because of a ban on discharge of firearms in the canyon bottoms (Arizona Game and Fish Commission Order R12-4-109). The lack of sport fish excludes recreational fishing, and, with an average annual flow of 18–25 cfs (U.S. Bureau of Land Management 1988a), the creek is not suitable for boating.

Perceptions of Water Quantity and Quality

Most visitors were satisfied with current streamflows: Eighty-eight percent reported that the flow they encountered was at the preferred amount. Approximately four percent indicated that they saw more water than they preferred. Voluntary comments on the questionnaire demonstrated that these visitors had been exposed to minor flooding events that are common in Aravaipa Canyon.

Approximately eight percent of the visitors reported that they encountered less water than they prefer. To determine whether or not their perceptions were related to actual streamflows, we modeled the relationship with a logistic regression, spline function. The function presented below is a refinement of analyses submitted for U.S. Bureau of Land Management

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TABLE 2

Attitudes toward water related activities and attributes of Aravaipa Canyon Wilderness.

	Strongly dislike	Dislike	Neutral	Like	Strongly like	*n*
Observing and identifying fish	0.0	1.3	28.7	36.4	33.6	656
Swimming in Aravaipa Creek	1.2	1.9	18.6	31.5	46.7	655
Identifying plants	0.0	0.9	17.3	41.0	40.7	658
Observing and identifying birds	0.3	0.5	15.4	35.5	48.4	657
Observing and identifying reptiles and amphibians	0.0	1.1	11.6	41.0	46.3	656
Walking in Aravaipa Creek	0.3	1.5	3.5	18.1	76.6	658
Observing and identifying mammals	0.0	0.1	3.2	30.4	66.3	657

(1988b), but the conclusions are identical to those provided to the BLM. Three regression parameters were estimated: one for daily flows less than or equal to 23 cfs; one for daily flows greater than 23 cfs and less than or equal to 25 cfs; and another for flows greater than 25 cfs but less than or equal to 150 cfs. Accordingly, in the following equation, FLOW1 corresponds to daily flows over the range of 18.4 to 23 cfs (18.4 cfs was the minimum flow recorded during the study period); FLOW2 for flows greater than 23 cfs and less than or equal to 25 cfs; and FLOW3 for flows over 25 cfs.

The spline function was modeled to reflect flow regimes normally experienced by visitors. Normally observed flows for Aravaipa Creek are best represented by median and modal flows, the median flow over the survey period ($n = 362$) being 22.7 cfs and the modal flow, 24.2 cfs. Seventy-five percent of the flows of Aravaipa Creek, which ranged between 18.4 cfs and 241 cfs during the study period, were under 25 cfs. The mean annual flow, at 27.5 cfs (95% C.I. = ±2.2 cfs), is less representative of flows typically encountered by visitors because it is skewed toward higher flow values associated with infrequent flooding events.

Using the median and modal flows as approximations of typical flows, then, FLOW1 modeled the statistical relationship between visitors' perceptions and below normal streamflows; FLOW2, which covers the cluster of flow values about the mode, modeled the relationship for normal flows; and FLOW3 modeled the relationship for above normal flows.

The logistic regression model provided a significant improvement in fit over a model with only an intercept (change in $L^2 = 18.74$, change in df = 6, and $P < 0.01$) and produced the following parameters:

$$\ln(<\text{preferred}/\text{about as preferred}) = -1.09^{a} - .37^{b}\text{FLOW1} + .51^{c}\text{FLOW2} - .14^{d}\text{FLOW3},$$

where ln(<preferred/about as preferred) = the log-odds of indicating less than preferred as opposed to acceptable amounts of water and FLOW1, FLOW2, and FLOW3 are as described above ([a]parameter significant at $P = 0.006$; [b]parameter significant at $P = 0.01$; [c]parameter not significant [$P = 0.12$]); and [d]parameter not significant [$P = 0.30$]). To interpret the above model, note that FLOW1 = daily flows − 18.4 over the range of 18.4–23 cfs and FLOW1 = 4.6 otherwise. FLOW2 = 0 for daily flows less than or equal to 23 cfs; FLOW2 = daily flows − 23 for flows greater than 23 cfs and less than or equal to 25 cfs; and FLOW2 = 2 otherwise. And, FLOW3 = 0 when daily flows are less than or equal to 25 cfs and FLOW3 = daily flows − 25 for flows greater than 25 cfs.

The model demonstrates that perceptions of streamflows may be grounded in reality: for each cfs drop in streamflow (below 23 cfs), the odds of indicating that one saw less water than preferred versus acceptable amounts of water increased by 45 percent. (The term "odds" is commonly used in loglinear, logit, and logistic regression modeling to refer to ". . . the frequency [or probability] of one category of a variable compared to the frequency [or probability] of another" [Alba 1988:260]). In simpler terms, as streamflows decreased, people became much more likely to indicate that flows were less than preferred. At 23 cfs, for example, a visitor had 0.06 odds

(approximately 1:13) of indicating the less than preferred category (95% C.I. = 0.04–0.08). At 18.4 cfs, the odds had increased to 0.34 (approximately 1:3) (95% C.I. = 0.15–0.74).

The regression model relating perceptions of water quantity to actual streamflows indicates that even small reductions in the normal flow of the creek are noticeable to at least some visitors. Most likely, reduced streamflows had three adverse effects on recreational visitors. First, with lower streamflows, swimming holes became increasingly shallow and less useful for swimming and wading. Second, as the water receded from the shoreline, mats of dead and drying algae and other aquatic plants were exposed. Also, some pools became disconnected from the creek, stopped receiving influxes of fresh water, and, eventually, became stagnant. Third, possibly after encountering stagnant pools and decaying vegetation, visitors might have assumed that the water quality of the creek had declined.

We tested this third hypothesis—that perceptions of water quality were related to streamflows—by comparing visitors' ratings of water quality for Aravaipa Creek against actual, daily streamflows. This hypothesis was tested during the spring of 1989. Accordingly, the results were not included in U.S. Bureau of Land Management (1988b). No relationship was found ($P < 0.05$), but when we compared a behavioral measure—purification of drinking water—to streamflow, a relationship was uncovered. As flows decreased below 23 cfs, visitors became more likely to purify water from Aravaipa Creek. The logistic regression model used to describe this relationship provided a significant improvement in fit over a model with only an intercept (change in $L^2 = 6.88$, df = 2, and $P < 0.05$) and produced the following parameters:

$$\ln(\text{purify water/did not purify}) = 3.96^{a} - 0.59^{b}\text{FLOW1} + 0.23^{c}\text{FLOW2},$$

where ln(purify water/did not purify) = the log-odds of purifying as opposed to not purifying water from Aravaipa Creek; FLOW1 = daily flows − 18.4 for flows over the range of 18.4–23 cfs; FLOW1 = 4.6 for flows greater than 23 cfs; FLOW2 = 0 for daily flows less than or equal to 23 cfs; and FLOW2 = daily flows − 23 for daily flows greater than 23 cfs ([a]parameter significant at $P = 0.0002$; [b]parameter significant at $P = 0.04$; [c]parameter not significant [$P = 0.26$]). This function is based solely on the 154 visitors who reported that they drank water from Aravaipa Creek. Because of the small size of this population, a three variable spline function could not be estimated. The two variable function presented above does, however, test the hypothesis that visitors encountering flows below normal are more likely to purify water from the creek.

This model indicates that the odds of purifying versus not purifying creek water decreased from 52.5:1 (95% C.I. = 6.4:1–435:1), at 18.4 cfs, to 3.5:1 (95% C.I. = 2.6:1–4.7:1), at 23 cfs. Note, however, that these results do not imply an actual relationship between streamflows and water quality. Numerous variables can affect water quality conditions, including peak and sustained flows, sediment type(s), point and non-point pollution sources, and multiple uses of the immediate and upstream watershed.

DISCUSSION

Originally, the BLM believed that protecting the native, endangered fishes of Aravaipa Canyon Wilderness would be the primary purpose of securing an instream flow permit (D. Drobka, personal communication). In Arizona, other applicants filing for permits for fish and wildlife and recreation purposes rely principally on models designed to quantify flows for fisheries. The underlying assumption is that these flow requirements will serve recreation and other needs (such as riparian habitat and aesthetic values) and therefore adequately protect those uses (J. Perry, personal communication).

What managers at Aravaipa Canyon Wilderness discovered, however, was that the timing of peak flows required to sustain fisheries habitats do not coincide with the prime hiking seasons. The natural flow regimes under which endemic Southwest fishes had evolved peak during the spring runoff season (typically from January to March) and during the summer monsoons

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(June through August). But April, May, September and October are the most popular months for hiking the wilderness. Consequently, an instream flow permit based solely on fish and wildlife considerations may not have adequately covered recreational needs.

Our research indicated the recreational need for maintaining flows during the spring and fall months and thus provided the principal source of data that helped the BLM verify recreation as a beneficial use by law. According to a deputy counsel with the ADWR, the BLM's 1988 study is considered to be a model that other applicants might follow to hasten the permitting process and increase the likelihood of permit approval (H. Kopp, personal communication). The results substantiated the recreational importance of water in Aravaipa Canyon Wilderness: without water, or the vegetation and wildlife associated with water, most of the recreational attractiveness of the wilderness area would be sacrificed. Concurrent with such a loss, the BLM would be unable to provide legally mandated opportunities for recreation. Although Aravaipa Canyon is a spectacular geologic resource, water is the lifeblood of the wilderness area.

The results also demonstrated that visitors could perceive small changes in the flow of Aravaipa Creek and possibly attributed diminished water quality to reduced flows. Such attribution probably stemmed from encounters with the stagnant pools and decaying vegetation that are associated with low streamflows.

CONCLUSION

The approval of the BLM permit application represents an important step in the implementation of instream flow rights in Arizona: It paved the way for incorporation of social research data into future applications. Equally important was the recognition of the importance of a free-flowing stream to the recreational value of Aravaipa Canyon Wilderness. In short, the state bureaucracy acknowledged the good humor that the "laughing waters" of Aravaipa Creek bring to the arid lands of southern Arizona.

ACKNOWLEDGMENT

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