Water for Wilderness Areas: Instream Flow Needs, Protection, and Economic Value

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ABSTRACT: This paper reviews what is known about wilderness water needs, examines options for protecting water for wilderness areas, and summarizes available economic estimates of the value of instream flow. Studies of instream flow needs indicate that recreation and conservation purposes often require considerably less than virgin flows, but such purposes do not include the "naturalness" goals of wilderness areas. There is no consensus on how much of the naturally occurring streamflow is needed to maintain the natural character of a wilderness area, or on the value the public assigns to instream flow in wilderness areas. The courts have yet to quantify reserved rights for a designated wilderness area. Recent economic studies of the value of instream flow indicate that recreation value alone is generally insufficient to justify reservation of all but minimum flows. If wilderness designation implies that more than minimum flows are needed, economic justification must lie in preservation or existence value. The few studies that have addressed the existence value of instream flow suggest significant economic value, but provide little specific guidance for decisions about water flow in wilderness areas.

KEY WORDS: Economic value, instream flow, water rights, wilderness.

INTRODUCTION

Protecting streamflow for wilderness areas was not a major issue prior to the 1980's, largely because most wilderness areas were at headwaters. Water conflicts were unusual for headwaters wilderness areas because of the lack of upstream appropriators, although the opportunity for conflict existed if owners of private inholdings attempted to divert water out of the wilderness area, or if other appropriators, such as cities, applied to divert water out of the wilderness area, perhaps to another basin.

The wilderness water issue was formally raised by the Sierra Club in a 1984 legal action that attempted to force the federal government to assert federal reserved rights for wilderness areas in Colorado (Marks 1987). Water issues went on to tie up Colorado wilderness legislation throughout the 1980's and into the 1990's. The conflict is between wilderness advocates who want to obtain federal reserved water rights for wilderness areas, and water use interests who want to protect past investments and future development opportunities and insist that wilderness water claims be handled by purchase or as an instream flow water right under state law.

The wilderness water issue promises to grow in importance as more areas downstream of current or potential diversions (such as areas managed by the Bureau of Land Management) are considered for wilderness designation. Such designation places controls on management within the wilderness boundary, but has little effect on what happens outside the boundary, where much of the water flowing through a downstream wilderness area originates. Land and water management in that upstream area may affect both the quantity and quality of water entering the wilderness.

Wilderness designation raises three questions that are addressed in this paper: (1) how much water is needed to fulfill the purposes of wilderness designation, (2) how can that required amount of water be protected from withdrawal by upstream appropriators, and (3) what is the value of water in wilderness areas?

INSTREAM FLOW NEEDS IN WILDERNESS AREAS

The 1964 Wilderness Act (16 U.S.C. 1131–1136), in addition to specifying the six management purposes of recreation, scenery, education, conservation, science, and history, directs the administering agency to preserve "the wilderness character of the area" (section 4[b]), where wilderness is defined in part as an area "retaining its primeval character" and "protected and managed so as to preserve its natural conditions" (section 2[c]). However, the Act also allows the President, in wilderness areas in national forests, to "authorize prospecting for water resources, the establishment . . . of reservoirs . . . and other facilities needed in the public interest . . ." and asserts that "nothing in this Act shall constitute an . . . exemption from State water laws" (section 4[d]).

This vague and potentially contradictory direction allows for considerable disagreement about what flows are implied by wilderness designation. At one extreme, one might focus on the six management purposes mentioned in the Act, requesting just enough flow to satisfy the specific purposes that were most important in a given wilderness area. For example, the conservation purpose could support sufficient flows to assure the survival of fish and other aquatic organisms, and the recreation and scenic purposes could support sufficient flows for fishing, floating, viewing, and other activities. Additional flows would be requested if the conservation purpose also supported stream channel maintenance. Still more flows would be needed if optimum rather than minimum flows were requested for these management purposes. At the other extreme, one might argue that "natural conditions" imply virgin flows, that is, all flows that would exist in the absence of land or water management upstream of and within the wilderness area. As Vassallo (1986:392) summarizes this position, "the minimum is natural flow."

Instream flow needs for fish and other aquatic organisms differ by species and by type of river channel, and the timing of flows can be critical. Nevertheless, several authors have suggested rules of thumb (Stalnaker 1980; Wesche and Rechard 1980) for estimating fish flow needs. For example, Tennant (1976) concluded, based on observations of many rivers, that fish habitat would be "good" if winter (October to March) flows were never below 20% of mean annual flow and summer (April to September) flows were never below 40% of mean annual flow. Similarly, fish habitat would be "excellent" if at least 30% and 50% of mean annual flow were maintained during these two seasons, "outstanding" if 40% and 60% of mean annual flow were maintained, and "optimum" if from 60% to 100% of mean annual flow were maintained. Tennant certainly suggests that fish do not require complete virgin flows to thrive. Furthermore, fish habitat simulation models in current use today (Lamb 1989), while not producing instream flow standards or recommendations, still indicate that flows below virgin levels will support viable fish populations.

Tennant's (1976) and other guidelines are not explicit about the effect on fish populations of flows above the recommended levels, except to recommend periodic flood flows for channel maintenance. It may be reasonable to assume that full virgin flow at any given time is not detrimental to fish habitat, and that the marginal value of instream flow for fish habitat gradually drops as flow reaches its maximum, as in Figure 1. The figure illustrates the general principle of diminishing marginal returns to flow, which may apply at any one time, or over an entire year assuming a favorable time distribution of flows within the year. However, Nehring (1988) has found in several Colorado streams that unusually high natural flows in the spring tend to wash young fish downstream, lowering populations. At such times, the value of flow for fish habitat is better represented by the relationship shown in Figure 2.

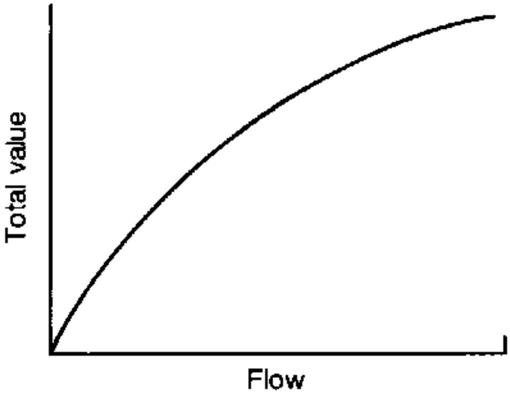

FIGURE 1. ***Diminishing marginal returns to flow.***

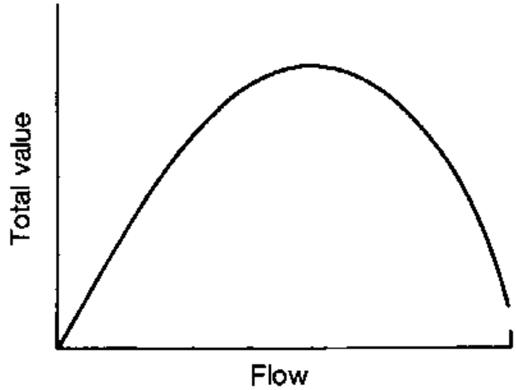

FIGURE 2. ***Positive, then negative, marginal returns to flow.***

Instream flow needs for recreation have received considerable attention. Shelby et al. (1992:table 2) lists 28 studies that report on the relationship of streamflow quantity to recreation quality or value. A few of these studies focus only on the minimum flows needed to make certain recreation activities possible (such as Corbett's [1990] multiriver assessment of minimum flows for canoeing), but most studies go beyond minimum flows to look at the full relation of flow to recreation quality. Nearly all of these studies indicate that flow, whether for fishing, boating, or streamside use, positively contributes to the recreation experience up to some maximum flow level, beyond which additional flow detracts from the experience, as in Figure 2. The flow level at which recreation quality or value is maximized differs among activities (with rafters, for example, preferring more flow than anglers), but too much flow is always a possibility. Of course, as the total value of flow reaches a maximum, the marginal value (indicated by the slope of the total value curve) reaches zero, with additional contributions of flow assigned a negative value.

Clearly, flows desired for recreation may be above or below the flows naturally occurring at any given time. For example, in the Rocky Mountains, flows during the spring snow melt are often above those desired by recreationists, and flows in the late summer and fall are typically lower than those desired for many activities. Thus, recreation alone may not require virgin flow levels, at least during part of the year.

Channel maintenance requires base flows, plus occasional flows at much higher levels than are generally needed by fish or most types of recreation (Richards 1982). During those occasional times when flood-level flows are required, the value of flows for channel maintenance can perhaps be depicted as in Figure 3, where the value of flow is minimal until flow approaches the maximum potential level.

The U.S. Forest Service has claimed a reserved right to sufficient flows to maintain stream channels in good hydrologic condition. The agency first tested this approach in the 1982 adjudication of the Big Horn River in Wyoming, in which it estimated that about 78% of mean annual flow was needed for channel maintenance. The Forest Service settled out of court for considerably less, perhaps because of a concern that the measurement method it used was not ready to withstand a court test (Romm and Bartoloni 1985). More recently, in preparation for a Colorado case, the Forest Service quantified and requested channel maintenance flows for many stream reaches in forests of the Platte River watershed along the Front Range of the Rocky Mountains (this case may be decided by the Water Court sometime in 1992 but will most likely be appealed to the state Supreme Court, and possibly to the U.S. Supreme Court, delaying any guidance for wilderness issues). Requested flows for 16 carefully studied stream reaches varied from 24% to 56% of mean annual virgin flows (James Maxwell, USFS Region 2, personal communication, 1991). Requests var-

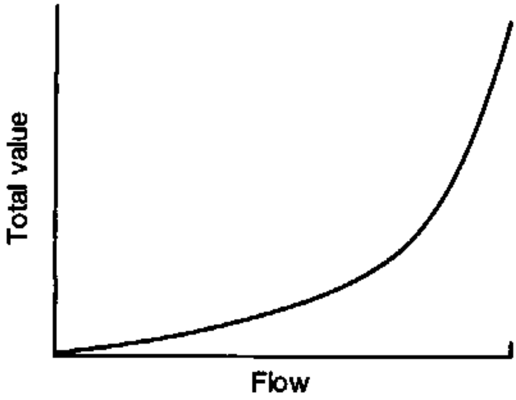

FIGURE 3. *Increasing marginal returns to flow.*

ied among rivers depending on stream morphology and flow timing, and on all rivers a greater proportion of flow was requested in wet years than in dry years. Although these flows would not be identical to those needed for fish habitat or recreation, there would be considerable overlap, suggesting that combined flows for conservation and recreational purposes would be less than virgin flows.

The Bureau of Land Management recently conducted four interdisciplinary studies that indicate the flows necessary to provide good conditions for a mix of uses (Jackson et al. 1989):

1. On Beaver Creek, a tributary of the Yukon River in Alaska and a congressionally designated National Wild River, the study team focused on fish survival, recreational boating, and camping in recommending the following minimum instream flows: 100% of virgin winter flows to maintain the fishery, 80% of virgin spring flows for channel maintenance (especially to maintain gravel bars and pools to facilitate camping and viewing), and 90% of the lesser of actual or mean monthly summer flows to keep boating portages down to a reasonable number for recreationists (Van Haveren et al. 1987). On an average annual basis, this amounts to a minimum flow request of roughly 80% to 90% of virgin flows.
2. In a study of the Gulkana River, another National Wild River in Alaska, minimum flow requests, primarily for boating, fish habitat, and channel maintenance, equaled mean monthly flows for all but the high flow months of May to July when less than mean monthly flows were considered acceptable except for periodic flood flows for channel maintenance (Shelby et al. 1990). On an average annual basis, roughly 60% of virgin flows were requested.
3. On the Dolores River below McPhee Dam in Colorado, proposed flows for recreation, fish habitat, and channel maintenance equaled, on an average annual basis, roughly 35% of virgin flows (Vandas et al. 1990). The proposal was constrained by the existence of substantial upstream diversions.
4. On a stretch of the San Pedro River in Arizona, now dedicated as a National Conservation Area, flow recommendations focused on fish and wildlife habitat, riparian vegetation, and aesthetics. During the winter, spring, and fall periods, the lesser of median daily or actual flow was requested; during the summer period flows equal to median winter flows, plus 60% of flood flows, were requested (Jackson et al. 1987). On average this amounts to a recommended minimum flow of roughly 30% of virgin flows.

These four studies indicate that flow recommendations can vary significantly, depending on physical (hydrologic and morphologic) characteristics as well as featured instream flow uses, and that complete virgin flows are not necessarily required for satisfying multicriterion instream needs.

The role of streamflow in maintaining "natural conditions" and preserving the "wilderness character" within wilderness areas may differ from its role in providing for fish habitat, recreation, or stream channel maintenance. If the term "natural conditions" implies full virgin flows, then perhaps it is unreasonable to assume that different increments in flow are of different value. Rather, as Figure 4 indicates, the value of flow in wilderness may be constant, with each increment of flow contributing equally to the natural character of the wilderness. Or, to take an extreme preservationist interpretation, perhaps flows are worth little unless most of the naturally occurring flow is maintained (Figure 3). Alternatively, it may be reasonable to assume that the law of diminishing returns applies also to naturalness, and that Figure 1 best depicts the overall value of flow in wilderness. Other possibilities, not depicted in the figures, include discontinuous relationships, perhaps where the marginal value rises with flow to a point and is zero for all higher levels. In any case, it should be noted that if some quantity short of complete virgin flow is obtained, it will matter just as much when those flows are available as how much of the virgin flow is available.

PROTECTION OF FLOWS FOR WILDERNESS AREAS

Applications for water diversions must be filed with appropriate agencies. The guidelines that most states and pertinent federal agencies use to review such applications include considerations for instream flow (Shupe 1989a). The permitting process could be used to protect downstream wilderness areas from unreasonable reductions in streamflow. However, the possibility of denial of water diversion applications during the permit review process does not offer the same security as a dedicated water right. Such a right is necessary if instream flow is to enjoy the same legal footing as consumptive use for such purposes as irrigation and municipal withdrawals.

There are basically two approaches to obtaining legal entitlement to instream flow for downstream wilderness areas: (1) filing for a new water right, and (2) transferring existing water rights to instream uses.

New Water Rights

State instream flow laws and the federal reserved rights doctrine offer two approaches for protecting instream flows. Over the past 20 years, many states have altered their water laws to include instream flow as a beneficial use of water, allowing individuals, private groups, or state agencies (depending on the state) to hold instream flow rights (Tarlock 1978; MacDonnell et al. 1989). For example, Colorado's 1973 instream flow law empowers the Colorado Water Conservation Board to hold instream flow water rights on behalf of the public (Shupe 1989b) and Alaska's 1980 amendments to the state's Water Use Act allow government agencies or private persons or groups to file for and hold reservations for instream flow (Harle 1989).

While instream flow rights offer a viable option for instream flow protection in many locations, and are a welcome alteration to the historic "use it or lose it" philosophy of water law in states following the doctrine of prior appropriation, there are three limitations of such rights for protecting water for wilderness areas. First, instream flow rights, when authorized, are junior to already existing rights, and thus are of little use in streams that are already fully appropriated. However, they are useful when helping to avoid flow-reducing transfers of senior rights via the appropriation doctrine rule that entitles junior users to have the stream remain in the condition in which they found it. On partially appropriated streams, instream flow rights are least effective—especially during dry years when instream flow protection is most needed. Second, most instream flow rights allow protection of only the minimum flow needed for specific purposes, and such minimum flows may represent a small fraction of natural flows. Third, not all states recognize instream flow rights and existing instream flow laws may not cover all

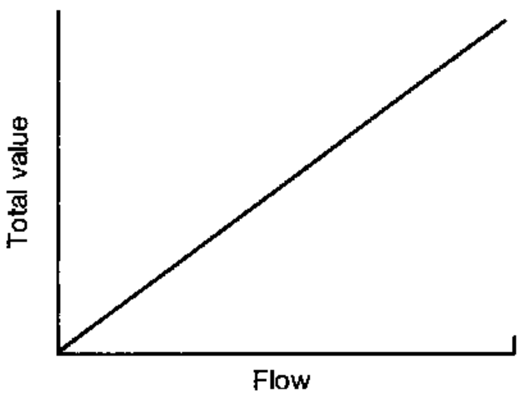

FIGURE 4. *Constant marginal returns to flow.*

instream uses (McKinney and Taylor 1988; MacDonnell and Rice 1989; Reiser et al., 1989; Shelby et al. 1992).

Federal reserved rights are sometimes obtainable for land areas specially set aside by Congress. Reserved water rights were first asserted for Indian reservations, but have been expanded, following the U.S. Supreme Court decision in *Arizona v. California* (373 U.S. 546 [1963]), to other federal reservations, including national parks and forests (Brooks 1979; Wilkinson and Anderson 1985; Mead 1986; Tarlock 1986; Marks 1987).

Before the late 1980's, reserved rights were not mentioned in laws establishing wilderness areas. However, in three recent additions to the wilderness system, Congress expressly reserved water for instream flows. Each statute used different language to indicate the amount of flow needed to fulfill the purpose of wilderness designation. Congress reserved "sufficient" flows in Nevada (P.L. 101–195, 103 Stat. 1784), "minimum" flows in New Mexico (P.L. 100–225, 101 Stat. 1539), and "necessary" flows in Washington (P.L. 100-668, 1.2 Stat. 3961). Meanwhile, two 1991 Congressional wilderness proposals for Colorado (the Allard/Schaeffer Bill H.R. 1369 and the Wirth/Brown Bill S. 1029) expressly denied the possibility of federal reserved rights for federal wilderness areas.

Reserved rights claims for non-Indian federal reservations are often unsuccessful. Examples of court denials include the National Park Service's request of reserved rights to "natural flows" for Dinosaur National Monument (Bassin 1985), the Forest Service's Rio Mimbres case in New Mexico (Brooks 1979), and the Forest Service's Big Horn claims in Wyoming (Mead 1986). However, reserved rights were granted for the minimum flow necessary to protect an endangered pupfish in a Nevada national monument (*Cappaert v. United States*, 426 U.S. 128 [1976]), and for natural flows in their entirety for Middle Creek in Yellowstone National Park as part of the Big Horn adjudication (Mead 1986).

Claims for federal reserved rights often encounter stiff opposition for several reasons. First, such rights, when awarded to existing reservations, are retroactive to the date of the reservation, thereby possibly usurping rights that have been established since the reservation. A reserved right for an existing wilderness area obtained pursuant to the wilderness designation could have a priority date as far back as 1964 if it was one of the original wilderness areas designated by Congress (although the impact of such a right on other users would generally be little, if any, for headwaters wilderness areas). Second, reserved rights can interfere with transfers of senior rights from downstream to upstream of a reservation, because such a transfer would diminish the flow through the reservation (Marks 1987). Finally, reserved rights could preclude future upstream claims. Federal reserved rights and state instream flow rights have similar implications by limiting transfers and precluding future claims. However, the impact of federal reserved rights would be greater if they reserve more flow than is possible under state instream flow laws.

Reserved rights for a designated wilderness area have yet to be awarded or quantified in court. In response to the Sierra Club case that attempted to force the federal government to file for reserved rights for wilderness areas in Colorado (Marks 1987), the U.S. Court of Appeals (911 F.2d 1405–1422 [10th Cir.]) concluded in 1990 that the Forest Service was not obligated to assert federal reserved rights in the absence of a threat to the wilderness characteristics of the Colorado wilderness areas, and that to date the wilderness characteristics had been sufficiently preserved. Although not denying the possibility of federal reserved water rights for wilderness areas, the Court of Appeals vacated a 1985 U.S. District Court judgment that federal reserved water rights do exist in designated wilderness areas, asserting that the issue was not ripe for review given the lack of a threat to the wilderness water resources in question.

Transfer of Existing Water Rights

Transfers of water rights may occur as gifts or purchases. As water has become more scarce in the western United States, purchases of water rights have become more common and water markets have begun to play a more important role in water allocation (Saliba et al. 1987a, 1987b). Of course, opportunities to market water vary depending on local laws and institutional constraints. In some locations and for some categories of water, markets are well established. Perhaps the best known example is the market for shares of water from the Colorado Big Thompson project in northeastern Colorado (Howe 1986; Saliba et al. 1987a). In other locations occasional transactions occur without the aid of a well-established market (Colby 1990). And, in addition to permanent transfers of water rights, water options, usually for municipal use of agriculture water during dry years, are being considered (Holburt et al. 1988; Quinn 1989).

Although most transfers of water rights or options are for consumptive use, transfers for instream flow purposes are becoming more common. Table 1 lists 15 recent purchases of water for instream flow, gleaned from the Water Intelligence Monthly (Stratecon, Inc., Claremont, California) and its predecessor, the Water Market Update (Shupe and Associates, Inc., Santa Fe, New Mexico). The table includes transfers of water rights in perpetuity and leases for shorter periods (usually only the current year). Prices per acre-foot are listed, for those sales for which data were available, on an annual basis (prices for multiyear periods were converted to an annual basis using a discount rate of 4%). The prices are generally below $10 per acre-foot per year. Most purchases were from irrigators, and were used to augment unusually low flows.

Purchase of existing consumptive use rights for transfer to instream uses along specified stream stretches makes water available for use downstream of the designated stretch. Selling water to downstream consumptive users can help offset the cost of the original purchase. Although outright sale of the water right to downstream users entails risks of subsequent transfer of the right (perhaps upstream of the stretch), rental of the right (i.e., sale of the water on an annual basis) would seem to be an attractive option (Livingston and Miller 1986). Currently, only a few states (e.g., Colorado, Oregon, Utah, and Wyoming) specifically provide for such transfers within their instream flow program (MacDonnell et al. 1989).

VALUE OF INSTREAM FLOW FOR WILDERNESS

In economic terms, what is the worth of water in wilderness areas? The transactions listed in Table 1 do not indicate a high value for instream flow, but actual transactions for instream flow probably do not indicate the full economic value of instream flow, principally because the nature of instream flow as a public good makes it difficult for interested parties to participate in the transaction (and easy for others to obtain a free ride). Perhaps studies of the economic value of instream flow can offer additional evidence. Economic value studies fall into two groups, those that focus on recreation value, and those that focus on total economic value, including preservation or existence value.

Recreation Value

Table 2 lists nine studies indicating the value of instream flow for recreation. Recreation activities studied include fishing, boating, and general shoreline activities (e.g., camping, picnicking). Except for Hansen and Hallam's (1991) use of cross-sectional analysis across the 48 conterminous states, the studies focused on specific rivers and used either the contingent valuation method (CVM) or the travel cost method (TCM). Most studies showed the value of flow reaching a peak and then decreasing as the flow level increased (Figure 2). On an acre-foot basis, the CVM and TCM studies found that the marginal value of flow at times of low flow varied from less than $1 to $25. That is, recreationists were apparently willing to pay from $1 to $25 for an additional acre-foot of water to augment relatively low flows during periods of recreation use. Higher values within this range tended to be found on smaller rivers (where an acre-foot of water would have a greater relative impact) and more heavily used rivers. Hansen and Hallam's (1991) cross-sectional analysis indicated that marginal values of flow for fishing were below $10 per acre-foot in most regions of the country, but considerably above that in some areas, especially the drier Southwest.

TABLE 1

Recent purchases of water for instream flow, wetlands, and lake levels[a]

Year	Purchaser	Quantity (acre-foot/year)	Price ($/acre-foot/year)[b]	Type of transaction	Original use	Proposed use
1987	Lander County, Nevada	3,000	9	Right	Irrigation	Maintain lake level for fishing and boating
1987	Montana Department of Fish, Wildlife, and Parks	10,000	2	One-time	Irrigation (from Painted Rocks Reservation)	Fish survival on Bitterroot River
1989	Nature Conservancy	2,000		One-time	Irrigation option	Fish on N Poudre River in northern Colorado
1989	Solano, Idaho; Davis, California; Yolo Co., California; etc.	1,000		One-time	Irrigation	Riparian habitat on Putah Creek near Sacramento
1989	California Department of Fish and Game (DF&G)	30,000	5	One-time	Miscellaneous	Waterfowl and fish on San Joaquin River
1989	Upper Snake water bank, Idaho, with the Nature Conservancy			One-time	Irrigation	Trumpeter swan habitat on Henry's Fork River
1989	New Mexico Natural Resources Department			25 years		Time releases from El Vado to Abiquiu on Rio Chama for rafting
1989	California DF&G	1,500	10	25 years	Effluent	Duck ponds and riparian vegetation for San Jacinto Wildlife area near Palm Springs
1989	U.S. Fish and Wildlife Service (F&WS), western Nevada			Rights	Irrigation (Carson River)	Stillwater wetlands, mainly for waterfowl
1989	Nevada Waterfowl Assoc.	32	11	Rights	Irrigation (Carson River)	Stillwater National Wildlife Refuge, Nevada
1989	Nature Conservancy	400	14	Rights	Irrigation	Stillwater National Wildlife Refuge, Nevada
1990	Nature Conservancy	964		Rights	Irrigation (Truckee River)	Stillwater National Wildlife Refuge, Nevada
1990	Colorado Water Conservation Board	10,000		40 years	Unused storage	Releases from USBR's Ruedi Reservation for Colorado River
1990	U.S. F&WS, California DF&G	67,442	7	One-time	Unused storage	Wildlife refuge; duck ponds

TABLE 1
Continued

Year	Purchaser	Quantity (acre-foot/year)	Price ($/acre-foot/year)[b]	Type of transaction	Original use	Proposed use
1991	New Mexico State Game Commission			25 years	Irrigation	Sufficient water for minimum pool in Morphy Lake (northern New Mexico) for recreation

[a] Sources: 1987–1989, Water Market Update; 1990–present, Water Intelligence Monthly.
[b] Prices for multiyear transactions (e.g., of water rights) were converted to annual basis using a 4% interest rate. Some prices were not available.

The value of instream flow in a particular river may be higher than those values listed for the individual recreation activities in Table 2, for three reasons. First, the values of different activities are additive where participants in more than one activity can concurrently utilize increased flows without experiencing significant decreases in recreation quality because of crowding. Second, the values apply to the stretch of river studied. The willingness to pay of recreationists downstream of the study stretch would add to the economic values. Third, leaving water in the stream makes it available for nonrecreational uses downstream, such as electric energy production.

The studies by Daubert and Young (1981), Hansen and Hallam (1991), and Duffield et al. (1991a) compared the value of instream flow with the values of withdrawal for irrigation. They found that, during low flow periods, the value of instream flow was often greater than the marginal value of withdrawal for irrigation.

Preservation Value

Because wilderness areas are valued for more than just the recreation opportunities they provide, estimates of river users' willingness to pay for recreation may fail to capture the full economic value of instream flow in wilderness areas. River recreationists may be willing to pay some additional amount, above their willingness to pay for recreation opportunities, to preserve pristine streamflow conditions. Furthermore, people who never visit a wilderness river may value maintenance of such conditions.

Table 3 lists four water flow studies that focused on what has been called "total economic value" (Peterson and Sorg 1987); that is, on not only the value of instream flow for onsite recreation but also on people's willingness to pay for preserving instream flows for future generations (termed "bequest" value) or just for the knowledge that such flows are preserved (termed "existence" value). All four studies used the CVM. Three of the studies focused on rivers and the other study focused on a lake.

Total values obtained in the studies varied from $15 to $115 per household per year. Many reasons could be posited for the differences among the five estimates listed in Table 3. Of key importance is the nature of the "good" that is being hypothetically purchased in each of the studies (the specific improvement in flow that is described in the contingent valuation question). As seen in the study of Mono Lake (Loomis 1987), the first increment of improvement in flow was worth considerably more than the second. As documented in Table 3, each good is quite different, varying from guaranteeing protection from any development to augmenting flows via purchase of water.

Contingent valuation studies of existence value may be subject to unexpected biases and influences (Peterson and Sorg 1987). It is not the purpose of this paper to critique each study. However, assuming the

TABLE 2

Economic studies of the recreation value of instream flow

Author (Date)	River (state)	Method[a]	Activity	Relationship[b] to flow	Aggregate marginal value of flow	
					$/acre-foot	Flow level
Daubert and Young (1981)	Cache La Poudre (Colorado)	CVM (entry fee)	Fishing	Concave	12	Low flow (100 cfs)
			Shoreline use	Concave	8	Low flow (100 cfs)
			White-water boating	Increasing linear	5	Low flow (100 cfs)
Walsh et al. (1980)	Nine rivers (Colorado)	CVM (trip cost)	Fishing	Concave	13	35% of maximum 1978 flow
			Kayaking	Increasing sigmoid	4	35% of maximum 1978 flow
			Rafting	Increasing sigmoid	2	35% of maximum 1978 flow
Narayanan (1986)	Blacksmith Fork (Utah)	TCM	Camp, hike, fish	Increasing sigmoid	1	Low flow (80 cfs)
Ward (1987)	Chama (New Mexico)	TCM	Fishing and boating	Concave	25	Low boating flow (1,000 cfs)
Bishop et al. (1987)	Colorado (Arizona)	CVM (trip cost)	Rafting	Concave	1	Low flow (10,000 cfs)
			Fishing	Concave	<1	Low flow (10,000 cfs)
Johnson and Adams (1988)	John Day (Oregon)	CVM (activity fee)	Fishing	Increasing or decreasing[c]	2	Mean summer flow (204 cfs)
Harpman (1990)	Taylor (Colorado)	CVM (fish population maintenance cost)	Fishing	Increasing to a maximum	2	Critical low winter flow (40 cfs)
Hansen and Hallam (1991)	Many (all 48 states)	Cross-section	Fishing	NA	Wide range	Actual

TABLE 2
Continued

Author (Date)	River (state)	Method[a]	Activity	Relationship[b] to flow	Aggregate marginal value of flow	
					$/acre-foot	Flow level
Duffield et al. (1991a)	Big Hole (Montana)	CVM (trip cost)	Fishing	Concave	25	Low flow (100 cfs)
	Bitterroot (Montana)	CVM (trip cost)	Fish and shoreline	Concave	10	Low flow (100 cfs)

[a] CVM = contingent valuation method, TCM = travel cost method.
[b] Relationship of total value to flow. Concave to the horizontal (flow) axis, indicating an increasing and then decreasing function of the dependent variable to flow volume. NA = not applicable.
[c] Johnson and Adams coupled a fish production model with results of a CVM. The resulting relationship was increasing or decreasing depending on season.

TABLE 3
Studies of the total economic value of instream flow

Author	River	Total willingness to pay ($/household/year)	Percent of total for: Use	Percent of total for: Bequest/existence	Good being purchased
Walsh et al. (1985)[a]	11 rivers in Colorado recommended for W&S designation	95	33	64	"guarantee that these rivers are protected . . . from diversion and dams. . . . Assume that if you do not pay, the process of water development will begin next year."
Loomis (1987)	Mono Lake	115	21	79	Utility bill increase for first level of improvement in lake level, salinity, bird survival and diversity, visibility
		39			Utility bill increase for second level of improvement
Clonts and Malone (1990)	15 free-flowing rivers in Alabama	57	31	69	Preserve the rivers as free flowing
Duffield et al. (1991b)	5 Montana rivers	15	20	80	Membership in trust fund "to buy water needed to increase summer flows. . . . The rivers reached record low flows in recent years . . . higher flows would be better for trout populations . . . many species of birds, wildlife, and plants would benefit."

[a] See also Sanders et al. (1990).

studies' results are reasonable, three observations are particularly relevant. First, the studies consistently show that most of the total value is associated with bequest and existence motives, suggesting that the values recreationists place on instream flows underestimate the full social value of maintaining instream flow. Second, the values obtained in such existence value studies are not easily expressed in terms of specific quantities of water, because the goods being purchased have typically not been carefully defined. Of the four studies listed in Table 3, only the Mono Lake study offers the possibility of quantification in terms of water volume. Third, the goods being hypothetically purchased are not sufficiently well specified to allow conclusions about the marginal value of flow preservation as the level of preservation approaches pristine conditions.

SUMMARY AND CONCLUSIONS

Aside from denials by water and land management agencies of applications to divert flow, two basic mechanisms exist for preserving instream flow for wilderness areas: creation and transfer of water rights. Establishment of new rights via legal action will not necessarily be successful for downstream wilderness areas, mainly because flow in many basins is already fully appropriated, especially in drier areas where the water issue is most pressing, and because of the strong opposition that reserved rights encounter in some locations.

Market transactions of water are becoming more common, and some have been made for instream flow augmentation. Both transaction evidence and economic value studies indicate that there is substantial value to instream flow that often exceeds the marginal value of alternative uses such as irrigation. The prices actually paid for instream flow in recent transactions tend to be lower than the values indicated in most economic value studies, but this is reasonable because the mechanisms for purchase of water for instream flow probably fail to reflect the willingness to pay of most interested parties, who remain either intentional or unintentional free riders of the transactions. As the full value of instream flow becomes better understood, and as more experience is gained in market transfer of water rights, perhaps the potential for purchase of senior water rights to augment instream flow will be recognized.

Values established in instream flow transactions to date, as well as those estimated for recreation uses of instream flow, reflect the value of flow increments in times of relatively low flow. It is reasonable to expect that the marginal value of flow for all but preservation goals approaches zero at some level as flow increases. Studies so far offer little guidance about the marginal value of flow in wilderness areas, where preservation of more or less natural conditions is also a recognized goal. Assuming flows are timed sufficiently well, diminishing marginal utility probably applies to wilderness water as well, but we need to better understand the marginal value of naturalness.

Some of the opposition to reserved rights for wilderness areas results from uncertainty regarding the proportion of virgin flow necessary to fulfill the purpose of wilderness designation. Recent studies of instream flow needs have indicated that recreation and conservation purposes often require considerably less than virgin flows. Resolution of this issue for wilderness will tend to defuse the wilderness water controversy and enhance opportunities to protect the most valuable wilderness water flows.

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