LeRoy Hansen

Alternative Allocations of Water in Rural Areas

Especially in the West, so much of a stream's flow is sometimes diverted for irrigation that the stream cannot support its normal fish and wildlife population. Recreational uses of the stream can be diminished or lost too. Without some kind of market mechanism, water allocation among competing uses may not meet society's needs. For example, if water's recreational value exceeded its irrigation value, water could be purchased from farmers for recreation, thereby increasing its overall value to society. This article takes a step toward developing a measure of the recreational value of streamflow.

The allocation of water among competing uses may determine whether some activities, like recreational fishing, thrive or die out in some rural areas. Thus, the quality of rural life, especially in the arid Western States, is affected by how water is allocated among competing demands of recreation, agriculture, municipalities, and others.

Agricultural water use in irrigation has been (and, in some areas, continues to be) subsidized through public financing of pumping costs and irrigation infrastructure maintenance. As a result, agriculture has become the single largest consumer of water in the United States.

Many streams have seen a significant depletion of their flow. The Colorado River, for example, serves as a source of water for agriculture and municipalities. Its water offers fishing, whitewater rafting, and other recreational opportunities. However, its water is used so extensively, primarily by agriculture, that the river no longer reaches the sea. In the lower portion of the stream, therefore, streamside vegetation is lost, as are wildlife and recreational benefits.

Irrigation is the primary consumer of the Colorado's water. Yet people in the Western States might prefer to use the river less for irrigation and more for fishing and other recreational uses, given a choice.

This article describes research that estimates water's value as a fishery resource. Information on water's recreational values can help policymakers identify where some reduction in agriculture's share of water is in the public interest. Because streamflow is a major influence on a stream's fish population, and because the value of recreational fishing is high in some areas, it may sometimes be justifiable to reallocate water away from agriculture and back into streams. By allocating water to its higher valued use, policymakers could achieve a balance in the demands for water similar to that which an effective "water market" would achieve.

The Recognition of Recreational Water Values

Recreational fishing requires enough water in streams to maintain fishing quality. The Colorado River is but one example in the United States where the depletion of streamflow is significant. The depleted flows of the Truckee and Carson Rivers of Nevada for irrigation have resulted in water degradation from irrigation return flows and a 90-percent reduction in the area of the associated wetlands since before irrigation became significant. Seven million fish were estimated to have died there in 1987 and waterfowl populations are estimated at 40 percent of normal levels.

Efforts have been made in some areas to implement water policies with a greater environmental focus, but not always with success. On May 21, 1990, the U.S. Supreme Court ruled uanimously against States seeking to gain more authority on flow releases by Federal powerplants for protection of fish and wildlife. California was supported by the other 49 States in *California v. Federal Energy Regulatory Commission (FERC)* in a failed effort to set minimum flow rates that exceed those set by FERC.

On the other side, in March 1989, the administrator of the Environmental Protection Agency overrode a regional EPA official's approval of a dam on the South Platte River. The already depleted level of flow in the South Platte had reduced the river's capability of supporting the wildlife that depend on the river and its fish populations. Further reductions in flow have been temporarily halted.

Balancing Competing Demands for Water

Water, like land, must be allocated among competing uses. Access to irrigation water is critical to some farmers, particularly in areas of low rainfall. But water serves other valuable uses, such as drinking or recreation. This raises the question of what might be a reasonable allocation of limited stream and water resources among competing uses. Few would argue for the extreme position that all water should be used for a single purpose. We do not want to draw so much irrigation water from streams that they run dry. Nor would many people claim that no water should be drawn off streams for irrigation, since irrigation is critical for crop production in some areas.

In 1776, Adam Smith suggested that people pursuing their own gain in a free market economy also produce an optimum for society, as if guided by an invisible hand. Economists have

Water Rights in the Western States

Low rainfall makes the rights to water in the West very important. Water laws in this region are based on the doctrine of prior appropriation. This doctrine allows water diversion as long as the water has no pre-existing claim and the diverter will put the water to beneficial use. Individual water rights are ranked according to who first obtained the rights. Thus, in a dry year, those with lower ranked rights may receive no water. Such a doctrine was adopted to encourage settlement in the West. It also encouraged water use for agriculture.

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Current water allocation methods often do not take into account the value of recreational uses of water. That recreational value, which includes boating, fishing, or whitewater rafting (here on the Gallatin River in Montana), can sometimes be significant.

elaborated this theorem in the years since, but the idea that "competitive equilibrium" is socially optimal remains. Applied to the water problem, this theorem says that if water is allocated according to what people will pay for it, the last quart applied in irrigation, the last quart in a fishing stream, and the last drink of water will all yield the same satisfaction to society.

This principle has been applied by some municipalities. In their efforts to meet their citizens' demand for more water, municipalities have sometimes purchased water rights from farmers. Unlike municipalities, however, use of water for fishing is not metered so the market cannot be estimated for this use of water. A market result will not be optimum unless everybody gets to bid for the water on an equal basis, and, in this case, those who enjoy fishing are not given a chance to bid. Thus, without public intervention, an efficient allocation of water to recreational uses will not necessarily be made.

Potential Economic Gains

The lack of a market for recreational uses of water means that farmers lose an opportunity to sell in this market. If the price of water for recreational uses were high enough, farmers could sell a portion of their annual water allocation. By reallocating water in this manner, those who fish would be better off with the improved quality of fishing, and farmers would be better off having taken advantage of an opportunity to sell a portion of their water rights.

A healthy stream with normal populations of aquatic plants and fish offers rural communities fishing, boating, canoeing, swimming, whitewater rafting, hunting, and other recreational choices. These add much to the quality of life in rural areas. Recreation also offers economic opportunities. Businesses related to sports and leisure, such as bait shops, boat rentals, eating establishments, and hotels, can thrive near bodies of water that support recreation. Recreation and tourism industries can generate economic growth in rural areas.

But when is the public best served by an increase in the allocation of water to recreational uses? While many recreational activities may be enhanced by increased water in streams, this research on recreation water values focuses on fishing because it is the largest of the recreational demands for water.

Because no market exists, it is difficult to assign values to water resources when used in certain ways. However, it is possible to estimate the values of these resources based on observations of individuals' behavior. I have estimated the marginal recreational value of water in streams and, to indicate where water reallocations may be most beneficial, I compared these values

"Marginal" Value--

"Marginal" value means, roughly, the value of an additional unit. Consider a farmer adding irrigation water to a wheat field. The first acre-foot of water will produce a large increase in wheat production. The 100th acre-foot will add much less: that is, the "marginal product" diminishes. If water costs $10 an acre-foot (including the costs of applying it), it will pay the farmer to continue to add irrigation water until the last acre-foot of water increases production just enough to raise the farmer's revenues by $10. At this point, marginal value of water is $10 an acre-foot. The net marginal value of water (additional revenue minus additional costs) will then equal zero.

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As streamflow declines, so too does the quality of fishing. In many areas of the country, especially in the West, the marginal value of water for fishing may exceed that for use in farming.

with water's marginal value in irrigation (see box, "Marginal Value").

Value of Water for Stream Fishing

I used a two-step procedure to estimate the marginal value of water as a resource for stream fishing. First, the response of downstream individuals for a change in streamflow (as they respond to the subsequent improvement in the quality of fishing) is quantified in terms of days fished. Second, we need to put a value on that improvement.

Downstream effects can be significant because a reduction in the amount of water diverted at some point in a stream will increase the level of streamflow in all downstream reaches and the downstream reaches may involve many fishing sites. Work by biologists provides a reliable method for relating streamflow diversions to fishing quality. By applying this method to data on the extent of streamflow diversions, I generated estimates of fishing quality across the United States. I used data from the National Resources Inventory (NRI), a survey of land and water resources by the Soil Conservation Service of the U.S. Department of Agriculture, to determine the availability of areas to fish. By combining the fishing quality information from the U.S. Water Resources Council with the NRI data, I obtained an indicator of the total availability of fishing resources to individuals across the country.

Insight into the demand for water can be gained by observing people's behavior across differing levels of fishing quality. And people across the country have different levels of availability of fishing resources. The change in the number of days an individual fishes for a given change in the availability of fishing resources was estimated using observations from a cross-section of the U.S. population. The applied behavioral model included socioeconomic variables along with the measure of total fishing resource availability.

The observations came from the national survey of Fishing, Hunting, and Wildlife Associated Recreation conducted by the Bureau of the Census. The survey included an initial sample of some 340,032 individuals to determine whether an individual fished in 1980. A followup survey of 35,615 individuals who fished provides added details on fishing behavior from the U.S. Water Resources Council.

The results of the analysis show a correlation between the amount people fish and the quality of fishing as indicated by streamflow and other factors. This result highlights the point that resources used in ways that are not valued by the market may have public value nonetheless. If policymakers considered these nonmarket values of water use, they probably would allocate resources differently than if they considered only market-assigned val-

Fishing Factors

The number of days an individual fishes depends on the person's socioeconomic characteristics as well as the surrounding environment. Listed below is the estimated change in the number of days fished for changes in some individual characteristics.

Days fished changes by:	For:	Relative to:
4.52	Males	Females
1.04	Farm raised	Not raised on farm
3.05	Retirees	People not retired
2.67	Students	People out of school
1.65	Rural people	Urban people
1.25	25-year-olds	20-year-olds
.01	45-year-olds	40-year-olds
-1.17	60-year-olds	55-year-olds
.15	Each year of education	
.16	$30,000	$20,000 annual income
.15	$60,000	$50,000 annual income
.13	$120,000	$110,000 annual income

Table 1—Water values in recreational fishing and irrigation

River basin[1]	All down-stream people	Irrigation value	Within basin value
	Dollars/acre-foot		
205	2.91	112.53	2.91
301	1.49	32.27	1.49
302	2.05	0	2.05
304	2.16	0	2.16
305	4.10	10.84	4.10
306	1.52	0	1.52
307	.59	13.95	.59
602	.69	10.82	.49
702	3.24	32.17	.84
703	2.40	0	1.34
704	1.06	0	.64
705	.42	0	.16
801	.26	28.21	.08
802	.18	0	.10
803	.08	7.01	.08
901	1.44	0	1.44
1001	3.58	0	.17
1002	4.29	0	.57
1003	3.73	0	.15
1004	5.62	0	1.21
1005	3.41	0	1.03
1006	2.38	0	.44
1007	47.88	2.21	41.56
1008	6.32	24.15	4.38
1009	1.94	0	.77
1010	8.89	8.63	7.72
1011	1.17	0	.75
1101	1.08	4.58	.82
1102	106.48	0	101.45
1103	5.03	27.11	3.42
1104	1.61	62.27	1.35
1105	6.72	0	5.11
1106	15.34	0	14.22
1107	1.12	0	.94
1201	1.59	12.08	1.59
1202	3.75	0	3.57
1203	4.81	17.30	4.81
1204	8.64	0	8.64
1205	3.14	0	3.14
1301	80.85	0	26.19
1302	54.66	0	34.17
1303	20.49	0	16.10
1304	96.49	13.57	76.00
1305	4.39	0	4.39
1401	39.94	0	3.31
1402	38.36	0	1.53
1403	36.83	0	1.44
1502	35.39	0	35.39
1503	1,502.29	0	1,466.90
1601	7.12	0	7.12
1602	3.38	0	3.38
1603	261.89	0	261.89
1604	9.50	0	9.50
1701	.56	0	.21
1702	.21	0	.11
1703	1.57	0	.16
1704	.35	0	.36
1705	.11	0	1.11
1706	.16	0	.16
1707	.36	0	.36
1801	1.11	0	1.11
1802	2.63	429.89	2.63
1803	22.67	0	22.67
1804	9.81	0	9.81
1805	6.55	0	6.55
1806	104.56	0	104.56
1807	17.47	0	17.47

[1]River basins and the direction of streamflow are shown in figure 1.

ues in dealing with common resources such as water.

Results of the estimated model provide some interesting insight into the relationship between individuals' characteristics and their fishing behavior. For example, men average 4.5 days more fishing per year than women (see box "Fishing Factors"). Also, 25-year-olds fish (on average) 1.25 more days a year than 20-year-olds, 45- and 40-year-olds fish about the same number of days, and the number of days fished drops by over 1 day for 60-year-olds relative to 55-year-olds. Notice that marginal changes in days fished is not the same at all ages. The same is the case for the effect of fishing resource availability. In this case, the greater the availability of fishing resources, the less the individual is affected by changes in flow.

With the estimated response of individuals, the effects of diverting or consuming an additional quantity of streamflow (or of increasing streamflow) can be calculated for all individuals downstream. By summing the responses of those downstream, the total change in the number of days fished for a change in streamflow is estimated.

To determine the value of water as a fishery resource, we must approximate the value of a day of recreational fishing. Nine studies have approached this question. Values ranged from just under $10 to just over $20. I selected a conservative figure of $10 per day to estimate the marginal value of water used for fishing.

Value of Water for Agriculture

I used the National Agricultural Resources Interregional Model (NARIM) to estimate the net marginal value of water to irrigators. The details of the model are beyond the scope of the discussion here, but it was developed at Iowa State University for problems associated with agricultural resource use.

The NARIM model recognizes that farmers use irrigation water because it adds to the profitability of their farm. The model includes detail on the cost of water to farmers and on quantity restrictions by river drainage basin. Costs include pumping costs, application costs, and any fees that the farmer must pay per unit of water.

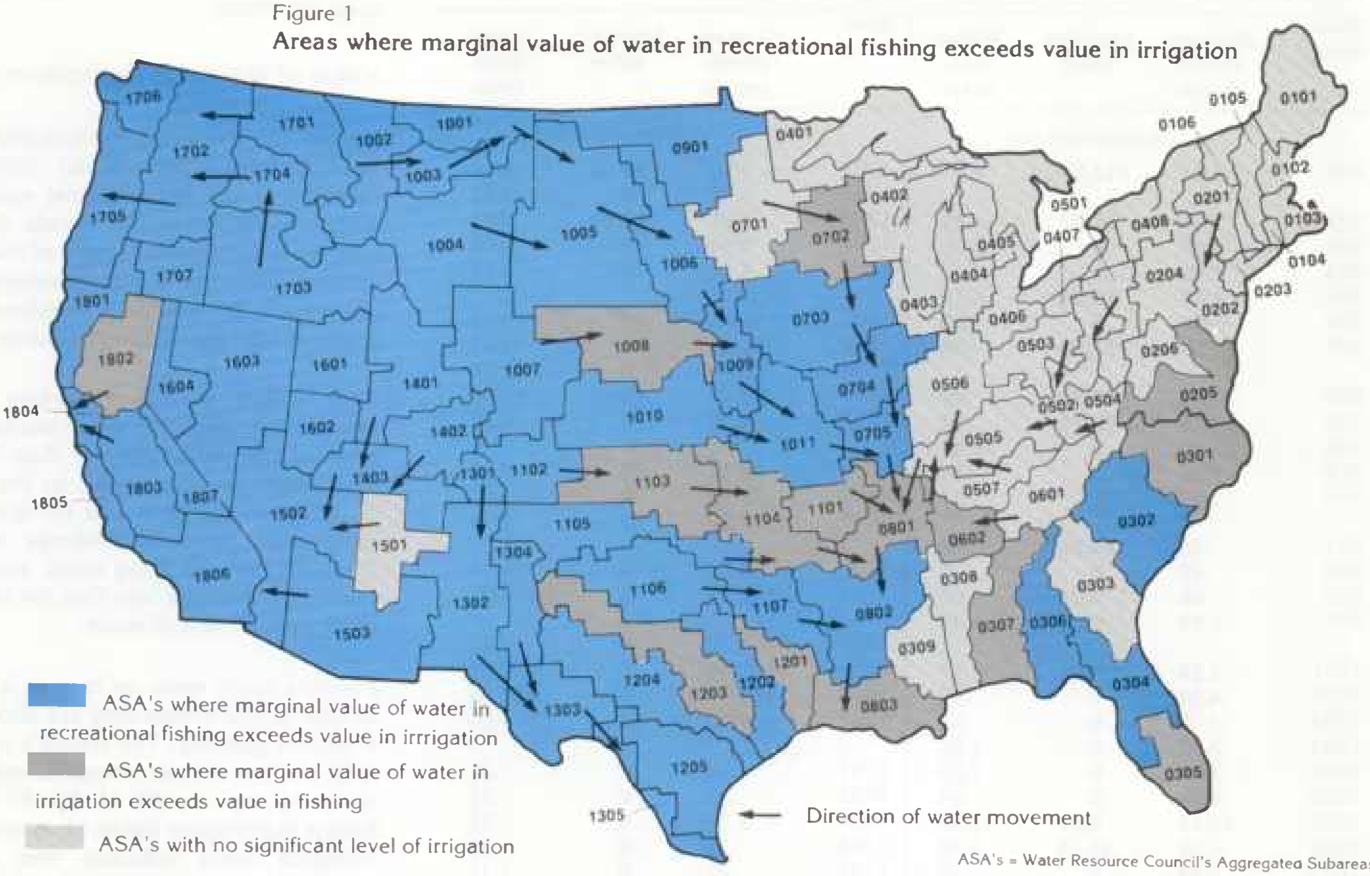
Farmers apply water as long as it adds to their profits unless they are allocated a limited quantity. The model's results indicate that the net marginal value of water is zero in 49 of the 67 river basins that irrigate (table 1). A zero net marginal value indicates that water availability is not significantly restricted in those regions: farmers can get any amount of water they want (given the prices they face) but are unwilling to pay for more water because the additional cost is greater than the value of the output it would produce. The key question is whether the marginal value of water for stream fishing is higher than for irrigation.

Comparing the Two Values

The estimates of marginal water values are listed in table 1. Values are estimated by river drainage basin. For each basin, the marginal recreational fishing value is estimated for those who live within the basin and for all those affected (both within the basin and those downstream). Also listed is the marginal value of water to agriculture.

Table 1 is limited to 67 of the 99 river basins in the continental United States where the level of irrigation is significant. In 52 of these 67 river basins, the value of a marginal unit of water is greater in recreational fishing than in agriculture. This means that in these 52 regions, the last acre-foot of water to be drawn from the stream for irriga-

Figure 1
Areas where marginal value of water in recreational fishing exceeds value in irrigation



tion would have a higher net value if left in the stream to support fishing.

The locations of the river basins where marginal recreational values are greater than water's marginal value in agriculture are shown in figure 1. In most of the Western States, society would appear to benefit from some water reallocation. Water has the greatest estimated marginal fishing values in Utah, Colorado, Arizona, New Mexico, and western Texas. These States tend to allocate a large portion of their surface water to irrigation.

The value of streamflow as a fishing resource reflects both the scarcity of fishing resources and the number of people affected. While streamflow diversions in the more water-abundant Eastern States are not, in general, as significant as in the Western States, the greater density of the affected population tends to add to water's recreational fishing value.

The results of this study indicate that streamflow is important as a recreational fishing resource. The estimated water values provide an indication of where streamflow reallocation would be most beneficial. These marginal recreation values also indicate a maximum price that might be justified to offer farmers for sale of their water rights. Farmers could gain by selling the less productive water to increase streamflow levels. Recreational values of water are small, below $10 per acre-foot in most areas, so any adjustments will likely have little effect on total agricultural output.

Most water allocation decisions are made by State governments. The significance of downstream fishing values indicates that significant benefits of streamflow may be provided to people outside of the boundaries of the State where the water may be diverted. Thus, a more appropriate framework for water allocation would be one that involves all downstream States.

By improving the allocation of streamflow, rural communities can benefit in three ways. First, the improvement in the quality of fishing improves the quality of life for those who like to fish. Second, a water market provides farmers an opportunity to sell water rights if such a sale appears profitable. Third, improved recreational fishing can increase economic opportunities in rural areas in the form of bait and tackle shops, restaurants, lodging, and fishing guides. Because recreational demand for water is expected to grow, the benefits of recreational water use are also likely to grow.

RDP

For Additional Reading . . .

LeRoy Hansen and J. Arne Hallam, "National Estimates of the Recreational Value of Streamflow," *Water Resources Research* (forthcoming).

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