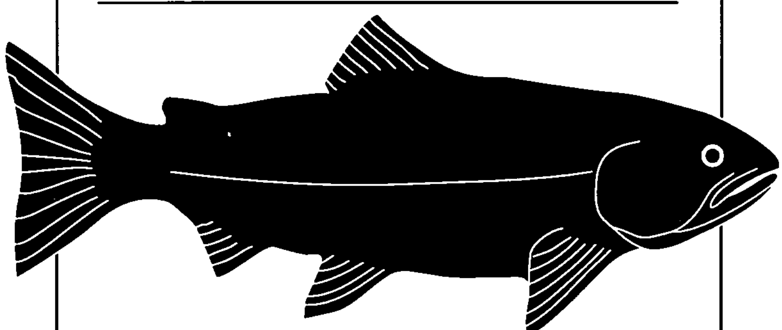
WHAT ROLE CAN IDAHO WATER PLAY IN SALMON RECOVERY EFFORTS?



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The University Task Force on Salmon and the Columbia River System

The Task Force is a group of faculty from the University of Idaho, Oregon State University, Washington State University, and the University of Washington with interest and expertise relating to the Columbia River system. They were appointed by the Agricultural Experiment Stations and Extension Service directors of Idaho, Oregon, and Washington and given the following charges:

- Identify research and educational issues that the universities can address within the framework of their missions, capabilities, and resource bases;

- Identify resources and create working networks in each state to address identified issues relating to the Columbia River system salmon and steelhead runs;

- Develop a working plan to organize research and public education programs:

  Document the current knowledge base;
  Prepare educational materials;
  Plan and conduct workshops with interested agencies, organizations, and interest groups; and
  Conduct research and education programs.

The Land Grant and Sea Grant universities of Oregon, Idaho, and Washington are repositories for a substantial amount of information relating to the resources of the Columbia River system. They are also home for many highly trained scientists with relevant expertise. These scientists and the knowledge available to them could have considerable bearing on improving solutions to the problems arising from reduced populations of native salmon.

Although the issues will, in the end, be decided by the public through a variety of political processes, the quality of these decisions will depend on the quality of information on which the decisions are based.

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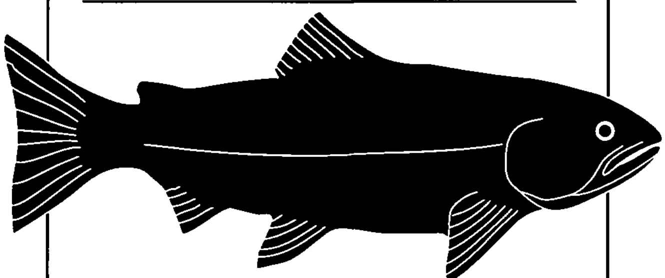

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Contents

What Role Can Southern Idaho Water Play in Salmon Recovery Efforts?

This publication examines the options for obtaining water from southern Idaho as part of anadromous salmon recovery efforts mandated by the Endangered Species Act (ESA). The Snake River sockeye salmon *(Oncorhynchus nerka)* was listed as endangered in 1991. The Snake River spring–summer and fall chinook salmon *(Oncorhynchus tshawytscha)* were listed as threatened in 1992. Water from southern Idaho would be part of a larger flow-augmentation plan designed to flush the young salmon (smolts) to the sea. Flow augmentation is one of many proposals being considered by the National Marine Fisheries Service (NMFS), which is charged with carrying out the mandates of the ESA for anadromous fish. It is likely that some combination of these proposals will be included in the recovery plan that NMFS is due to release late in 1993.

An important goal of this publication is to inform the public of some of the possible impacts of salmon recovery on southern Idaho irrigation, an important constituency often left out of salmon recovery discussions. The main conclusions are:

- The Snake River basin is almost fully appropriated, especially during dry years.
- Efficiency improvements will produce little, if any, new water for fish. It may be possible to shape* water flows for fish in the short run through interaction with the Snake River plain aquifer, but in the long run new flow-augmentation water must come from a reduction of consumptive use. Water taken for fish means less water for farmers and other instream uses, and the key issue is how best to obtain that water.
- A dry-year option market might provide up to 1.2 million acre feet (maf) of additional water for fish needs during dry years (provided it is not needed every year). Farmers could agree to provide up to 50 percent of their normal consumptive use for which they would be paid from the hydropower value of the water.

* The word "shape" here means to alter the timing of river flows by using storage reservoirs and aquifer interaction. Shaping can shift river flows between the months of a year. Water that normally would be included in spring runoff, for example, can be held in storage for summer irrigation use or in winter for peak power use. Shaping also can shift water use between years. Water that was pumped from the Snake River plain aquifer during the recent drought, for example, may come at the expense of reduced aquifer discharge into the Snake River in future years.

- Expansion of the Idaho water banks has been suggested as a way of obtaining additional water for fish. Care needs to be taken to ensure that any water taken from the water bank comes from reduced consumptive use. If not, then third-party water users are likely to be hurt and long-run return flows from the Snake River Plain aquifer reduced as a result.
- If water is needed for streamflow augmentation every year, then a retirement plan for marginal farmland might be a good strategy. This water would have some hydropower value which could help fund such a program.
- Serious institutional, legal, political, and hydrologic issues would have to be addressed before any of these market alternatives could be considered.

An Overview of the Problem

Various actions have been proposed to aid recovery of endangered and threatened salmon stocks in the Columbia and Snake River drainage.* Many of these measures focus on the need to move salmon smolts through the lower Snake River more quickly. Drawdown proposals call for lowering the levels of one or more reservoirs on the lower Snake River to achieve greater river velocity without requiring additional water. Augmentation approaches call for using additional water to achieve greater velocity without modifying reservoir levels.**

The purpose of this paper is not to advocate either drawdown or augmentation. Both proposed actions have received considerable attention from researchers, the media, and those involved in the political process. The discussion is often framed as drawdown versus augmentation because reservoir drawdown might make flow augmentation unnecessary. While it may be simpler to think of them as strict alternatives, one should keep in mind that the recovery plan put together by the National Marine Fisheries Service might select drawdown, augmentation, neither, or elements of both. It has been well publicized that drawdown would affect barge transportation

* For a more comprehensive discussion of possible recovery actions, see University Task Force on Salmon and the Columbia River System, "Alternative Actions for Restoring and Maintaining Salmonid Populations on the Columbia River System." Pacific Northwest Extension Publication PNW 407, March 1992.

** The Northwest Power Planning Council has called for a water velocity equivalent of 85,000 cubic feet per second (cfs) at current reservoir operating levels from April 15 to June 15, the critical months of fish migration. The Columbia River Basin Fish and Wildlife Authority, however, has called for a velocity equivalent of 140,000 cfs, which provides for a 143-hour particle travel time at current reservoir operating levels. Unfortunately, there is not enough water in the system to meet this target in all low-flow years. If the four lower Snake River dams are drawn to spillway crest, however, the 143-hour target could be achieved in any low-flow year within recorded levels.

on the lower river, hydropower generation at the affected dams, and irrigators who pump from the affected pools.[1] The full range of effects from augmentation measures are less well known. Some plans talk of the need to obtain water from southern Idaho to augment river flow, but the costs and implications are rarely addressed. The purpose of this publication is to examine the feasibility and costs of several options for obtaining water from southern Idaho, so this information can become a part of the ongoing discussion of drawdown and augmentation.

More than a century ago, the Columbia River system produced as many as 16 million returning adult anadromous fish, that is, fish such as salmon and steelhead trout that are born in fresh water, migrate to and mature in the ocean, then return to fresh water as adults to spawn.[2] In the past 100 years, more than 136 dams have been built, transforming this river system into a series of lakes and reservoirs.[3] While these dams have yielded a bounty of irrigated agriculture, hydropower, barge transportation, and flood control, they have also contributed to the decimation of fish runs, reducing stocks to fewer than 2.5 million fish returning to the Columbia River system.* Most of these fish are produced from hatcheries. Wild runs have declined to only 2 percent of their predevelopment numbers. By one estimate, 250 distinct stocks of salmon and steelhead in the region have gone extinct.[4] Figure 1 and (on page 4) Figure 2 show the sharp decline in salmon numbers on the Snake River which led to listing the sockeye as an endangered stock under the ESA in the fall of 1991, and the spring-summer and fall chinook as threatened stocks in the spring of 1992.

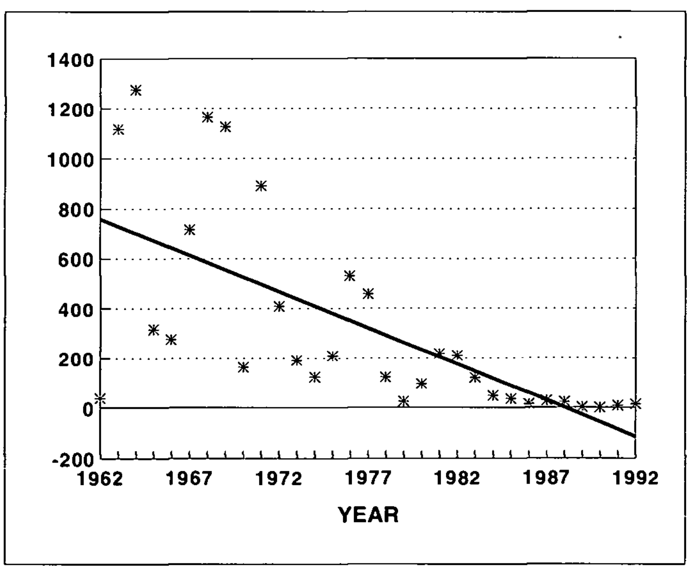


Figure 1.—Sockeye salmon returning to Idaho, 1962–1992. *U.S. Army Corps of Engineers.*

* Dams are not the only cause of declining wild stocks. Other important factors include overfishing, mining, logging, grazing, irrigation, and water pollution.

These listings are one more chapter in a long battle to revive salmon runs. Previous actions to save anadromous fish include the barging of young smolts downstream through the mainstem dams, flow augmentation, habitat restoration, reducing predation, installing screens on dams and irrigation diversions, and hatchery production. These efforts, particularly barging of smolts, appear to have helped steelhead (Figure 3), but the effect on chinook and sockeye runs is less clear, considering their continued downward trend.[5] Since 1980, over $1.5 billion in expenditures and lost revenue has gone to revive the Columbia Basin anadromous fisheries. The bulk of these costs have been incurred by Bonneville Power Administration (BPA), which plans to commit an additional $2 billion to $3 billion in the 1990s.[6] These costs are ultimately borne by Pacific Northwest electricity users.[7]

Figure 2.—Chinook salmon returning to Idaho, spring-summer-fall stocks, 1962–1992.
U.S. Army Corps of Engineers.

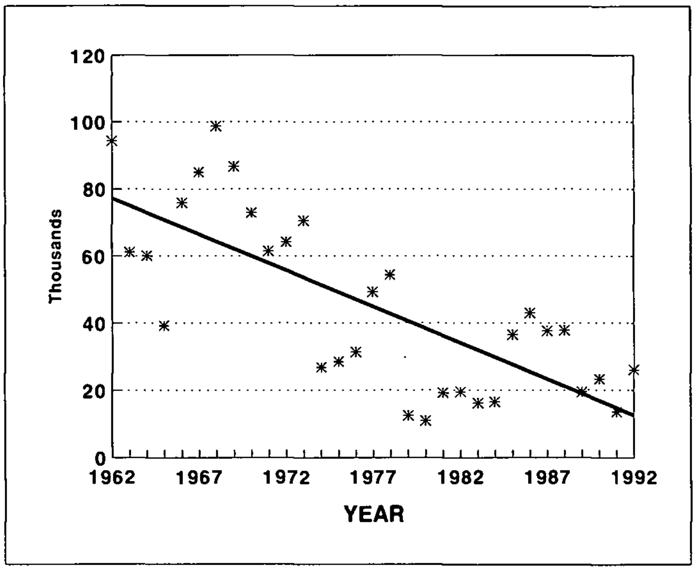
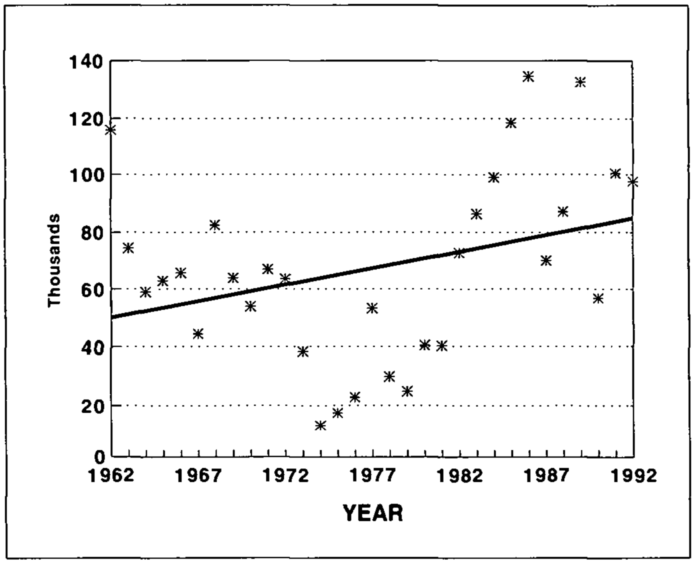


Figure 3.—Steelhead salmon returning to Idaho, 1962–1992.
U.S. Army Corps of Engineers.



Additional actions apparently will be needed to save the salmon, with reservoir drawdown and flow augmentation schemes being prominent among the proposals. Drawdown proponents argue that this strategy can help salmon passage without requiring additional water. Drawdown opponents argue that drawdown consequences such as lost hydropower and disturbed barge transportation impose unacceptable costs[8] on the region. Other actions such as changes in fish harvest, spawning habitat, or smolt transportation are sometimes seen as alternatives to both drawdown and augmentation. Although arguments about most of these possible recovery actions have been amply aired elsewhere, the implied alternative of using water from southern Idaho to augment flows rarely has been addressed in detail.

Smolt migration occurs during the spring months from April 15 to June 15, historically the peak flow months for the Snake and Columbia rivers. Figures 4 and 5 show how peak flow has been reshaped over the last 60 years by

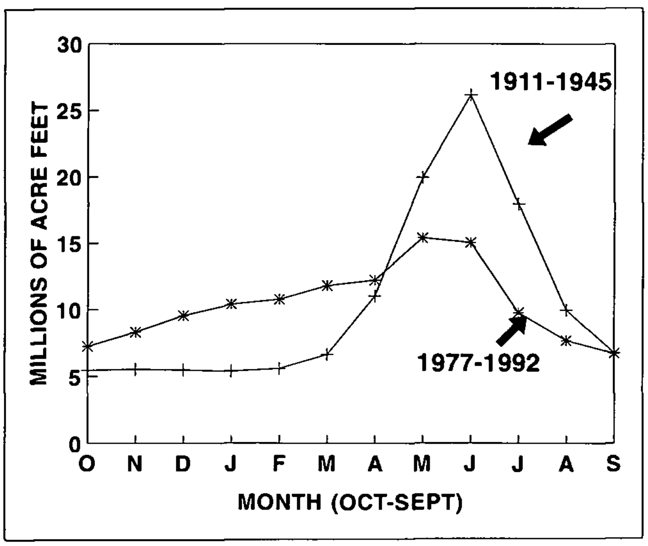


Figure 4.—Historical Columbia River flows at The Dalles, Oregon. Monthly averages 1911–1945 and 1977–1992. *U.S. Geological Survey.*

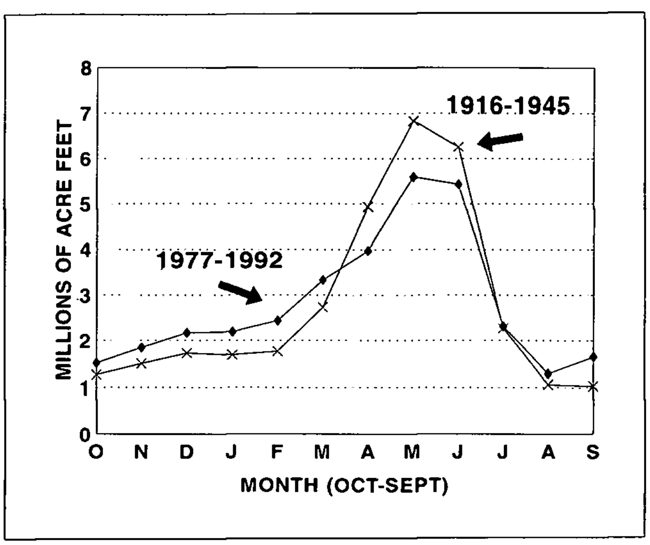


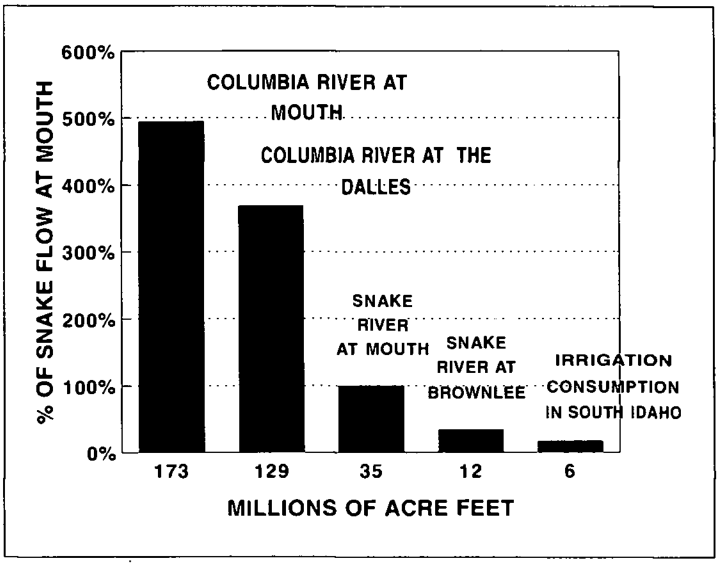
Figure 5.—Historical Snake River flows at Lewiston, Idaho and Clarkston, Washington. Monthly averages 1916–1945 and 1977–1992 (missing data 1923–1928). *U.S. Geological Survey.*

hydropower dams and storage reservoirs. A substantial part of flow in both the lower Snake and lower Columbia rivers has been shifted from the natural spring runoff period to either the winter peak period for power demand or to the summer months for irrigation. Because of slow-moving slackwater pools behind each dam and reduced flow in the critical spring months, the time it takes a smolt to travel from stream bed to the sea has increased.*

How much water can the Snake River basin provide?

Most flow augmentation plans call for some additional water from southern Idaho. The Northwest Power Planning Council (NPPC), for example, proposes that 427,000 acre feet (af) of augmentation water be obtained in each of the next few years. In the longer run the NPPC proposes an additional 1 million acre feet (maf) through "...using water efficiencies, market mechanisms, water transactions, and the like."[9] The only other augmentation sources — water from Dworshak and Brownlee reservoirs — are limited by the capacity of these pools and their functions to provide power and flood control. However, there are also limits to how much water can be obtained from southern Idaho. Figure 6 shows that the Snake River supplies just 20 percent of average annual Columbia River flow although the Snake River

Figure 6.—Columbia River flows as a percentage of Snake River discharge. Average annual flows from July 1928 to June 1968.
U.S. Army Corps of Engineers.



* There is some controversy on this issue. Water particle travel time from the headwaters of the Snake River to the estuary at the mouth of the Columbia River has increased from roughly 7 days before the dams to about 40 days today. The increase over predam water particle travel time ranges from a factor of 6 in high-water years to 15 in low-water years.[2] The U.S. Army Corps of Engineers estimated that smolts' travel time from streambed to estuary ranged from 15 to 60 days predam and from 30 to 90 days postdam.[10] The difference between the estimates of these two changes illustrates the current controversy over the relation between smolt migration and river flow.

drainage covers 45 percent of the Columbia River basin. Only 34 percent, or 12 maf, of the Snake River's 35 maf originates above Hells Canyon. Agriculture in southern Idaho consumes roughly 6 maf annually,[11] which is only 3.5 percent of the Columbia River's average annual flow and only 17 percent of average annual Snake River flow. Total active storage capacity is about 11.3 maf (see Figure 7), and storage plays an important role in managing Idaho water. The Columbia Basin Fish and Wildlife Authority proposed a target flow of 140,000 cfs or 8 maf/month as the flow needed between April 15 and June 15 at lower Snake River dams to flush smolts downstream to the sea.

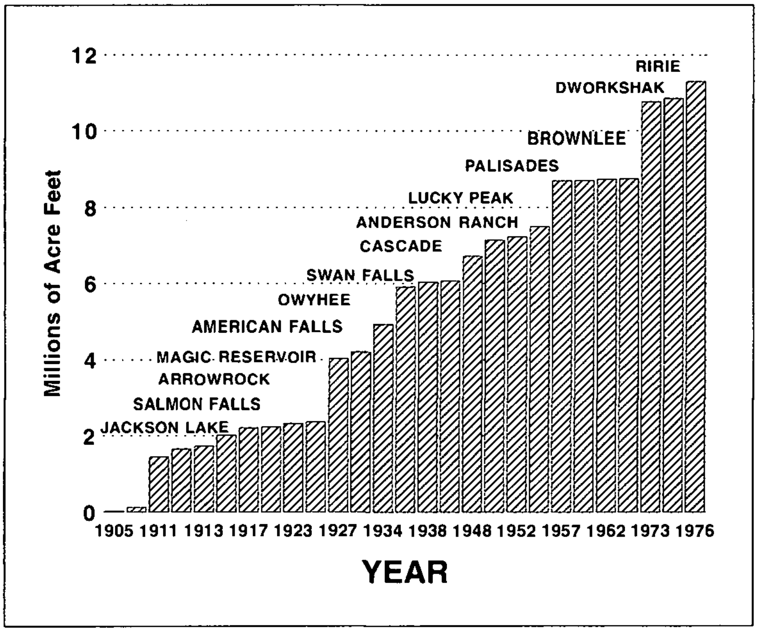


Figure 7.—Idaho reservoir storage history. *Idaho Department of Water Resources; Hydrosphere.*

This target flow clearly illustrates the limits of southern Idaho water resources because the target cannot be met solely by using additional water from the upper Snake River basin. In the low-flow year of 1977, it would have taken more than twice the total water consumed by all irrigated agriculture in southern Idaho to meet that target; alternatively, it would have taken all of the storage in Idaho.[12] Even the Northwest Power Planning Council target of 85,000 cfs, or 4.8 maf/month, is beyond reach in many years. Actions of this magnitude might have severe consequences on the irrigation-based economy of southern Idaho.

What can we learn from the recent drought?

The recent drought, lasting nearly 6 years, is the most severe ever recorded in the Snake River basin. The drought shows signs of abating given the snowfall and rain during the 1993 water year, although its ending is not yet definitive. As indicated in Table 1, between October 1991 and September 1992, the Snake River reached its lowest flow in 70 years at both Murphy gauge near Boise and at Lewiston.* Table 1 lists the 10 lowest flow years at six points on the Snake and Columbia rivers: Heise in the far upper Snake; Murphy, near Boise; Weiser; Clarkston/Lower Granite near the Idaho–Washington state line; Priest Rapids on the upper Columbia above its confluence with the Snake; and The Dalles on the lower Columbia. A rank of 1 designates the lowest flow year of record and 10 is the tenth lowest. At

Table 1.—The 10 lowest flow years on the Columbia and Snake rivers, 1929–1992.

	Snake River				Columbia River	
Rank	Heise	Murphy	Weiser	Clarkson	Dalles	Priest Rapids
1	1934	1992*	1992*	1992*	1944	1944
2	1931	1991*	1988*	1977	1977	1941
3	1940	1935	1991*	1931	1931	1937
4	1941	1988*	1934	1988*	1937	1931
5	1961	1961	1931	1937	1941	1929
6	1991*	1990	1990*	1987*	1930	1977
7	1988*	1934	1977	1930	1929	1973
8	1989*	1989*	1935	1935	1988*	1930
9	1937	1941	1961	1944	1973	1940
10	1992*	1940	1937	1990*	1987*	1988*

1 = lowest flow, 10 = tenth lowest flow
* recent drought

U.S. Bureau of Reclamation, U.S. Army Corps of Engineers, and the Idaho Department of Water Resources. Data for water years 1992 and 1993 to date are preliminary and subject to change.

* The Boise Project Board, for example, cut off irrigation supplies in early August 1992, affecting 19,000 farmers (167,000 acres) in Ada and Canyon counties in the western part of the Snake River plain. In the eastern plain, upper Snake River watermaster Ron Carlson estimated, virtually every reservoir in southern Idaho would have been drained in the summer of 1992 if it hadn't been for an early frost in August which killed a substantial amount of crops. Thus, according to Carlson, an "unexpected" flow of approximately 350,000 af was carried forward to 1993.

least 4 of the 10 lowest flows were recorded during the recent drought at all four points on the Snake River. The drought appears, however, to have had a slightly less impact on the Columbia River. Table 2 is a comparison of the 10 lowest flow years at each location to the 10 lowest flow years at each of the other five locations. For example, 80 percent of the lowest flow years at Murphy were also among the lowest flow years at Heise. Because the Columbia River basin is large, it is not surprising to find a relatively low correlation among the drought years at the more distant points within the basin. This fact is important because it complicates efforts to provide additional water for fish needs and other uses from one part of the Columbia River basin to another. Drought is rarely severe enough and widespread enough to affect all areas of the basin. However, the recent drought appears to be just such a case.

Note the timely relevance of the drought to the salmon issue. It is the low-flow years that are the most important to water management. Electric utilities in the region place a high value on firm power that can be guaranteed in all years, even during the worst drought. Nonfirm power, produced in other years with flows exceeding the historical minimums, is less valuable. Agriculture also relies on an assured water supply to sustain production levels and economic viability. Fish especially need water during drought years. Each of the competing water uses — agriculture, power, and fish — needs water most when it is scarce.

Table 2.—Coincidence (%) of low flows at points along the Columbia and Snake rivers during the 10 lowest flow years, 1929–1992.

	Snake River				Columbia River	
	Heise	Murphy	Weiser	Clarkson	Dalles	Priest Rapids
Heise	100	80	70	40	40	40
Murphy	80	100	70	40	20	30
Weiser	70	70	100	70	40	40
Clarkson	40	40	70	100	70	60
Dalles	40	20	40	70	100	80
Priest Rapids	40	30	40	60	80	100

Competing endangered species

The situation has become more complicated as more Idaho species are considered threatened or endangered. Measures to save one protected species may harm others. Some bald eagles (endangered in Idaho) feed on fish produced when Cascade Reservoir is kept at least partly full. Alternatively, this water could be used to augment salmon flows, with potential consequences for eagles nesting near the reservoir.*

The recent U.S. Fish and Wildlife Service's decision to list five species of Snake River mollusk as endangered and one as threatened places other constraints on salmon recovery efforts.** If attempts to get salmon augmentation water from the upper Snake in the spring come at the expense of flows during the rest of the year, this may harm resident mollusk populations. If other species such as bull trout or sturgeon are given ESA protection, this could pose similar complications.

A similar situation exists between listed salmon stocks, which have differing requirements for timing and location of flows. This raises the very real possibility that actions taken to augment flows for one salmon stock might harm another salmon stock. Additional water provided for spring migrants, for example, might mean less water for returning adults later in the summer.

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* Competition between listed species, protected species, and potential candidates for listing is becoming a serious problem basinwide. Sea lions and seals, for example, feed on anadromous salmon along the Pacific Coast.[13] Idaho alone has 15 animal species protected by the ESA and 25 new species waiting in line. Listing five species of Snake River snails may prevent water from the upper Snake River from being used for flow augmentation (flushing) for salmon.[14] Conversely, listing one species may benefit another troubled species. It is possible, for example, that the listing of the bull trout in Washington state at Rimrock Lake could help protect the Rimrock kokanee by ensuring minimal pools in Rimrock Lake.[15]

** The Alliance for the Wild Rockies filed a petition to protect the bull trout.[16] In addition, in late 1992, the Idaho Spring snail, the Snake River physa snail, and the Banbury Springs limpet were listed as endangered and the Bliss Rapids snail as threatened.[14] Various conservation groups have proposed ESA protection for the Kootenai River white sturgeon and the Bonneville cutthroat trout.[17] There is also the danger that future listings of species such as the Snake River sturgeon could cause water quality problems in the middle Snake River .[18]

Options for Obtaining Water from Southern Idaho

Irrigation efficiency improvements, option water markets, expanded water banks, and irrigated acreage retirement all have been mentioned as ways to secure additional southern Idaho water for salmon recovery.

Improved irrigation efficiency

Diversions of water to southern Idaho irrigation districts range from 3.8 to 14.1 af/acre and average 6.4 af. Consumptive use by crops, on the other hand, ranges between 1.5 and 2.0 af.[19] This leaves as much as 4.0 af, or more, that might appear to be "wasted." However, proposals to increase irrigation efficiency (often misidentified as conservation*) and to appropriate the "saved" water for salmon are overly simplistic and generally erroneous. Most of this "wasted" water either percolates from canals and irrigated fields to recharge the Snake River aquifer or drains back into the river as surface return flow. In the latter case, it may create artificial wetlands, habitat for a variety of wildlife, which would be adversely affected by efficiency improvements. The water finds its way back to the river downstream either as return flow or springflow from the aquifer, where it can be reused. It has been estimated that there are 16 maf of diversions in the upper Snake basin but only 5 maf of river flow to support those diversions.[20] Each acre foot of water is diverted three times in its course down the river. Water "wasted" by an individual farmer or water district becomes the water source for neighbors downriver.

Effect of efficiency improvements on third parties

Each of three sources of water — flow, storage, and groundwater — is subject to some version of the prior appropriation doctrine. The historical basis of the prior appropriation doctrine was: "first in time, first in right"; or more informally: "first come, first served." While the priority systems for flow and storage rights historically have been separate from ground water priority rights, there are close hydrologic links among all three. However, these links are both legally and institutionally murky and ultimately may be clarified in the courts. Water rights are created by the act of putting water to beneficial use and are appurtenant to the land. Junior water rights holders receive what water remains after the senior users have filled their needs. When junior users rely on return flows from more senior users, there can be

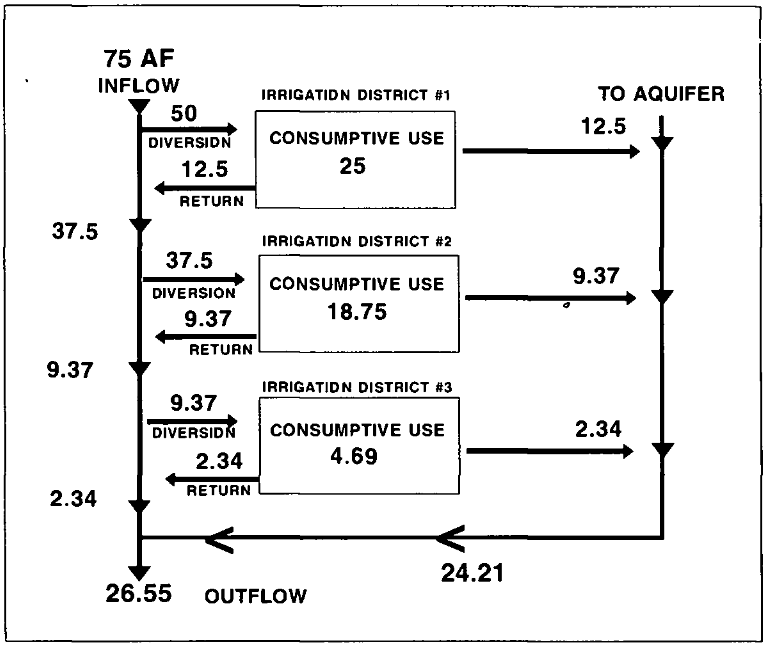
* Note the difference between irrigation efficiency and conservation. An increase in irrigation efficiency is an increase in the efficiency of delivering water to the crop. True conservation, in contrast, is developing a crop that consumes less water. This confusion is reflected in the literature, and most references to conservation actually refer to increased irrigation efficiency

severe third-party effects from efficiency improvements. If a senior user installs a sprinkler system and increases irrigation efficiency, his diversions will be reduced. While this may keep more water instream, helping resident fish, much of this water may be diverted by thirsty downstream junior users. The efficiency improvements will come at the expense of reduced aquifer recharge and return flows, which may harm other downstream users and may make less water available to augment flows for salmon.

A simple model of efficiency improvements. A simple river basin model can help illustrate the effects of increased irrigation efficiency. Consider two scenarios: the 50 percent efficiency scenario shown in Figure 8, which is the base case, and the 75 percent efficiency scenario in Figure 9.

Figure 8 illustrates a water basin with three irrigation districts and an initial streamflow of 75 af. Each district has a diversion right of 50 af and an irrigation efficiency of 50 percent. District 1 is assumed to have the highest priority water right and District 3 the lowest. Irrigation District 1 diverts 50 af but, with 50 percent efficiency, it consumes 25 af. Return flow is assumed to be split equally between runoff and deep percolation; so of the 25 af not consumed, 12.5 af percolates to the aquifer, and 12.5 af is surface return

Figure 8.—Streamflows at 50 percent irrigation efficiency.



flow. It is further assumed, for simplicity, that the unconsumed diversion is split equally between the aquifer and return flow for all districts in both models. Including the return flow, District 2 is left with only 37.5 af to divert of which 18.75 af (50 percent) is consumed, 9.37 af is surface return flow, and 9.37 af percolates (i.e., returns) to the aquifer. This same result follows for District 3. Streamflow exiting the basin is 2.34 af. In the long run, at 50 percent efficiency the total outflow available for downstream uses is 26.55 af, consisting of the return streamflow plus the 24.21 af that percolated into the aquifer and will eventually return to the river as springflow.

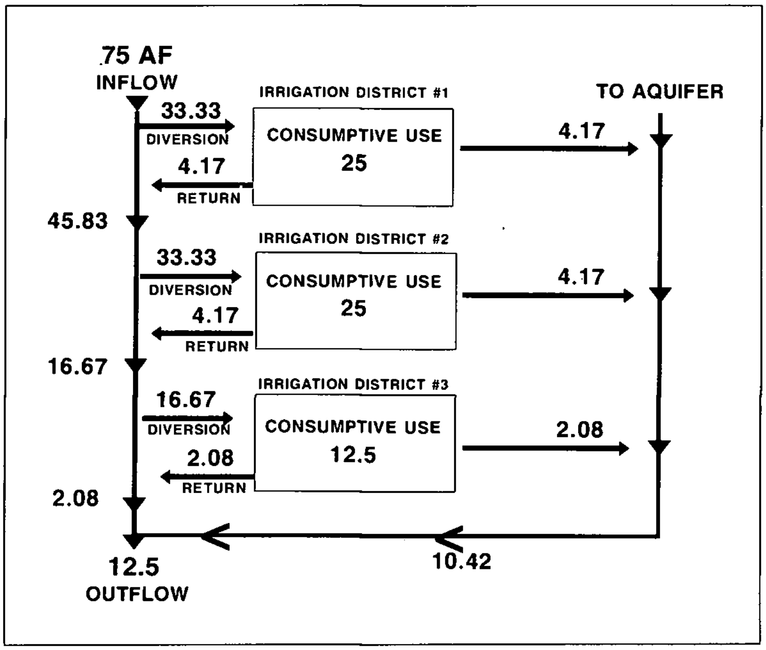


Figure 9.—Streamflows at 75 percent irrigation efficiency.

In Figure 9, each irrigation district has increased its efficiency from 50 percent to 75 percent. District 1 now diverts only 33.33 af in order to meet its consumptive use requirement of 25 af. Surface return flow and aquifer return flow are now both 4.17 af. There is now enough water left in the stream that District 2 can fill all its needs. It diverts 33.33 af of which 75 percent is consumed and the balance is allocated as for District 1. District 3 is still short of water, although better off than under the 50 percent efficiency scenario. Outflow from the basin consists of 2.08 af of exiting streamflow and 10.42 af of aquifer return flow, for a total of 12.5 af of water available for fish in the long run.

The paradox can be seen in Figure 10: Increasing irrigation efficiency from 50 to 75 percent actually reduced exiting streamflow from 2.34 af to 2.08 af below the last diversion. At the same time, aquifer recharge and springflow fell from 24.21 af to 10.42 af. Total long-run streamflow available for downstream fish use fell from 26.55 af in the 50 percent scenario to 12.5 af in the 75 percent efficiency scenario. Consumptive use, on the other hand, increased from 48.44 af to 62.50 af. The efficiency improvements clearly were good for irrigators with junior water rights but actually reduced the water available for downstream uses such as endangered salmon.

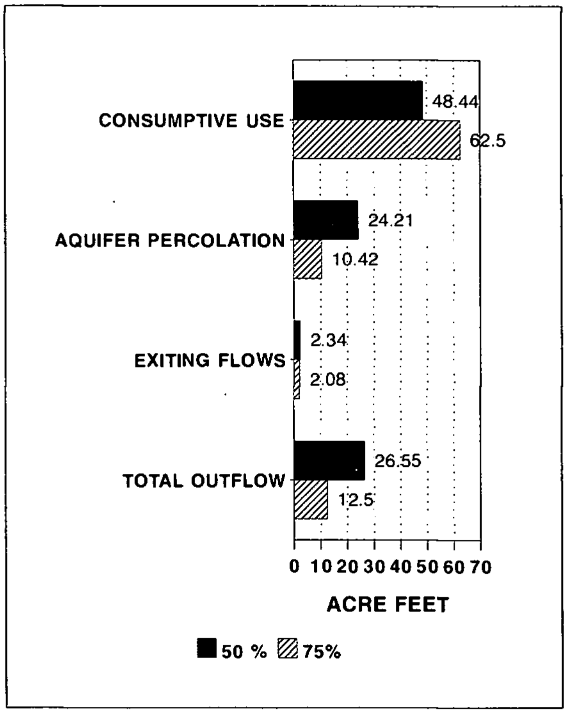


Figure 10.—Comparative effects of 50 percent and 75 percent irrigation efficiencies.

These scenarios are based on an overappropriated situation such as a drought period when there is insufficient water for all users to fill all their water rights. What would happen if the water supply were adequate to supply all rights — if it were, say, 125 af inflow in Figures 8 and 9? Now all three users would divert 50 af in the 50 percent efficiency scenario, and 33.3 af when efficiency improves to 75 percent. In cases where the basin is not overappropriated, efficiency improvement would not affect diversions by junior right holders. Efficiency improvement would, however, change where the "excess" water is located. More water would stay in the stream, and aquifer recharge and long-run springflow would be reduced by an exactly offsetting amount. There would be no net long-run effect on basin outflow available downstream for fish. Even in this case it is possible for crop consumptive use to increase. Increasing irrigation efficiency by upgrading irrigation methods from a gravity system to a sprinkler system, for example, can result in better irrigation timing and uniformity, better crop growth, and higher yields but leave less water for instream uses.

The bottom line is simple: If there is an increase in water use efficiency while there are unsatisfied water use claims downstream, the extra instream flows will be diverted and consumed unless there are major, expensive, and politically difficult changes in the way water rights are allocated and in the way stream diversions are measured and controlled. If the basin is not overappropriated, the efficiency improvements will, at a minimum, shift the location of water between stream and aquifer. In no case does irrigation efficiency improvement lead to any new water for fish.

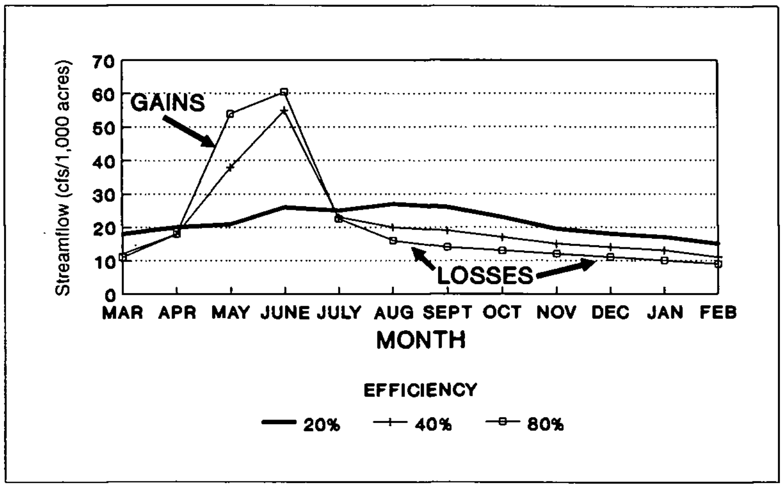
Which best describes the case in southern Idaho: overappropriation or underappropriation? While the average annual flow of the river at Milner gauge near the lower end of the upper Snake River basin, is about 2 maf,[21] such averages are misleading. Milner Dam almost totally eliminated water flows in the river at that point between May 1987 and March 1993. Very little water was released downriver from Milner except for gate leakage and stored water released to downstream users through the water bank. During this period almost all water originating above Milner went to fill flow rights and storage refill rights of irrigators. Hence, in dry periods when salmon might badly need more flow, the upper Snake River may be fully or overappropriated.

The reduced aquifer recharge will occur, with a time lag, as reduced springflow where the aquifer spills back into the river. The effect of irrigation on springflow will begin to show up within a year and will extend over as many as 50 years because efficiency improvements generally are permanent changes in irrigation hardware or management, and they lead to permanent consequences for aquifer recharge and basin outflow. In the next section, a more detailed model is used to look more carefully at these questions of timing.

More detailed models of efficiency improvements. Frazier, Whittlesey, and Hamilton expanded upon the simple model presented above in their computer model of irrigation efficiency improvement.[22] One of the more important features of the model was the estimation of monthly flows within each water year over a multiyear simulation cycle, including a simulation of the time lags of surface- and aquifer-return flows. The conclusions from their model confirm the results from the simple model: No new water is created by improved irrigation efficiency. However, it may be possible to reshape flows for fish, especially in the short run. Efficiency improvements may leave more water instream in the spring months. However, the long-run cost of these improvements is less water during the remaining months due to aquifer depletions and/or increases in consumptive use. This can be seen clearly in Figure 11, which represents a scenario with rill irrigation, overappropriated water rights, and mostly aquifer returns. The initial scenario has a 20 percent irrigation efficiency, which is compared to subsequent efficiency levels of 40 percent and 80 percent. Increased efficiency results in greater flows from March through June, at the cost of reduced flows from August through February. The shift would have been even more pronounced in the case of underappropriation.

This model also makes it possible to sort out the short-run and long-run effects of efficiency improvements. Improved efficiency can increase downstream flows for a period of from several years up to perhaps a decade before the reduced aquifer recharge is finally reflected in declining springflow. This could be viewed as either an opportunity or a danger. It means that efficiency improvements could be used to get more water now for salmon when the fish really need help, proceeding on faith that other strategies will be available to deal with future lower flows. Alternatively, the danger is that efficiency improvements made today to help fish may in fact hurt long-run fish survival.

Figure 11.—Impacts, by month, of irrigation at various efficiency rates.



Effect of past efficiency improvements on the aquifer

The Snake River aquifer is estimated to contain 300 maf of water in its upper 500 feet (its thickness, however, can reach 5,000 feet). The largest points of discharge are near Thousand Springs (approximately 4.5 maf in 1980) and American Falls Reservoir (approximately 2 maf). Recharge of the aquifer comes from the Snake River and its tributaries, from precipitation, and from deep percolation from irrigation canals and irrigated fields.[23] According to one estimate, groundwater storage increased 24 maf from 1890 to 1952. Aquifer discharge increased from 1900 to 1950 as irrigation expanded in the Snake River basin. Springflow from the aquifer began to decline soon after World War II. Initially this was due to expansion of irrigation based on deep-well pumping from the aquifer and the substitution of pumped groundwater for surface diversions. Irrigation deep-well permits in the eastern Snake River plain rose from about 1,000 in 1959 to more than 5,000 by 1993.[24] Most recently, the downtrend in aquifer discharge appears to be fueled by irrigation efficiency improvements throughout the basin, especially the replacement of flood irrigation methods with sprinkler systems.

The water supply situation in southern Idaho may now be in disequilibrium. As farmers have switched to groundwater for irrigation or to increased irrigation efficiency, more water has been left instream. This "additional" water has been appropriated by others to irrigate new land. If, as some fear, the basin is now fully appropriated, then a transfer of water from the future to the present may have occurred. Water released by efficiency improvements and used to irrigate new land may result in reduced future springflows, which in turn might cause future harm to senior water rights holders and to downstream fish flow needs.

The decline of discharge at Thousand Springs illustrates this point. From 1900 to 1950, aquifer discharge from Thousand Springs between Milner and King Hill rose from 3.0 maf to 4.9 maf, then declined to 4.0 maf by 1991. Figure 12 dramatically illustrates the 20,000 af/year downward trend in discharge at Thousand Springs from 1951 to 1991. The decline of the aquifer

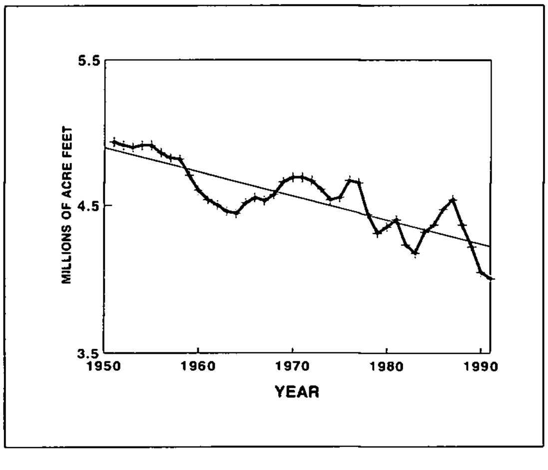


Figure 12.—Trend of aquifer discharge at Thousand Springs, Hagerman, Idaho.
U.S. Geological Survey.

has serious implications for fish. It reduces the annual total river flows which, in turn, is likely to harm resident fish, aquatic wildlife, and salmon. No matter what actions are taken to get more water for fish, any proposal for salmon recovery must recognize that the flows presently originating from springflows will continue to trend downward for many years as a consequence of past changes in southern Idaho water use.

Markets for Water

Efficiency improvements alone will not provide more water for salmon. Because the upper Snake River basin is fully appropriated, at least in dry years, any additional water to augment flows for salmon recovery probably will have to come directly from reductions in irrigation consumptive use. Markets have been proposed to transfer water during periods of drought from low-value agriculture uses to higher value agriculture, power production, and anadromous fish uses. However, one should proceed cautiously because markets may be efficient for resource allocation but are not necessarily equitable.

Efficiency versus equity in water markets

Markets serve as the centerpiece of the free enterprise system, channeling goods, services, and production inputs into their most productive uses. In this sense, markets are widely thought of as efficient. Water markets, while not yet widespread, do exist in various kinds and are generally seen as promoting efficient water use. Some questions remain, however, about the equity of such market solutions.

Water markets usually take as given the initial distribution of water rights. These rights are based on a long history of diversion and beneficial use. Water rights are not real property. Instead, the water is owned by the state, and a water right is the right to use the water. One reason why water banks are created is to allow farmers to sell surplus water in one year without jeopardizing their permanent right to the water. Otherwise, their willingness to sell the water could be construed as admission that they don't need it.

The equity issue boils down to whether the present distribution of water rights provides a fair basis for buying and selling water. If farmers hold rights to water in excess of their needs, then is it fair for them to profit from the sale of this water? Does it matter if the water system was developed using public money or that the state owns the water and the farmers own only a right to use the water? Mason Gaffney cites the extreme case of the Palo Verde Valley in southern California: "... that means some water takers would continue forever paying only $3.50/af for what it costs the taxpayers $60/af to deliver, and they may sell for $400/af and up as demand rises."[25] While the Idaho values may be less divergent, the same issue is relevant.

Some observers argue that the efficiency gains from water markets would be worthwhile irrespective of the initial distribution of water rights.[26] Practically, it would probably be easier to get Idaho irrigators to cooperate in a program of flow augmentation for salmon recovery if the present water right distribution is taken as given. Any recovery action that relies on significant changes to Idaho water right structures is likely to meet with vigorous opposition. Markets might sidestep this reaction by allowing farmers to be willing sellers.

This equity versus efficiency argument is not going to be settled here. However, the issue is likely to surface if water markets should become a significant component of salmon recovery efforts.

Dry-year option markets

One type of market proposed for salmon recovery, the contingent water market, builds on the idea that river flows are quite variable, and fish and hydropower are most in need of extra water in dry years. Such a market would involve selling farmers' or irrigation districts' option leases for water at a free market price to some entity, such as BPA, interested in salmon flows. The lease terms would let the farmers use the water in most years but would make water available for instream uses such as salmon and hydropower in drought years.

An option market based on power needs. Whittlesey, Hamilton, and Halverson have studied an option water market driven by electrical power needs rather than by fish needs.[27] They describe a market including up to 900,000 participating acres to provide 625,000 af of water for power production in drought years. The water from an option market would be especially valuable for two reasons. First, because the water would be delivered in drought years, the power generated would be firm power. Second, this would increase the firm power base available in all years, raising the value of an equivalent amount of nonfirm power to the higher value of firm power.

Participating farmers would agree to provide up to 50 percent of their normal consumptive use* to the market in interruption years, depending on the severity of the drought. Presumably the market rules would specify the flow conditions under which interruption would occur. Whittlesey et al. assumed market rules such that, on average, participants would be interrupted only 8 of every 51 years. Depending on where the participating farmers are located, the water they release would generate power at most of the 13 dams on the upper Snake River that supply electricity to Idaho Power Company and at all 8 of the downriver federal dams. The higher in the system the water is located, the greater its power value.

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* Keep in mind we are discussing a reduction in consumptive use (i.e., water used by crops), not a reduction in diversions. It might be necessary to reduce diversions by several acre feet in order to yield one acre foot of reduced consumptive use.

An acre foot of foregone water consumption in southeast Idaho could alternatively generate as much as 1,264 kilowatt hours (kwh) at Idaho Power Company dams, or 1,882 kwh if the federal dams are included. Over a 25-year period, the present value of the power produced from the market would range from $400 to $500/participating acre.* The present value of farm losses over the same period would average $45/participating acre. Since the value of the power exceeds the agriculture losses by a factor of 10, this suggests that an option market based on power needs might be feasible.

An option market based on salmon needs. If an option market tailored to meet the needs of power production looks promising, how about an option market tailored to meet the flow needs of salmon? In 1992, Hamilton and Whittlesey adapted their model to address this issue. They determined that an option market probably could be expanded beyond the 900,000 acres in the previous study to include up to 1.9 million acres and provide 1.2 maf for salmon in dry years.

One potential difficulty is that timing of power needs and fish needs often don't coincide. For example, water for power is most valuable for the BPA system in the winter due to peak winter heating loads, but Idaho Power Company needs to meet demand peaks both in the winter for heating and in the summer for irrigation pumping. Anadromous fish, on the other hand, need the water the most during the spring runoff (April 15 to June 15) when it is least valuable for power. As noted earlier, a drought in one part of the Columbia River basin does not necessarily imply drought in other areas. Similarly, inadequate flows for salmon in the lower Snake River do not necessarily coincide with a water shortage for power needs.

Nonetheless, water provided for anadromous salmon from a contingent water market would have substantial power value if, in fact, it is run through the turbines rather than spilled. Hamilton and Whittlesey estimate the present value of that water ranges from $63 to $99/participating acre, depending on the scenario and on the assumed interest rate. The present value of farmer costs from participating in the option market range from $27 to $48/participating acre, again depending on farm type and interest rate. The power value of the water still exceeds the cost to agriculture by a ratio of two to one.

Still, many questions need to be answered before an option water market could be implemented. For example, what conditions would be used to trigger water delivery? What system modifications and water measurements would it take to monitor market compliance and to move market water downstream without harming other users? What entities would buy and sell?

* It is assumed that for each 1.5 af of consumptive use foregone via an option market, 0.5 af of reduction in aquifer recharge occurs. Thus, the steady-state value of potential power production has been reduced by a third to account for the long-run impact of a water market.

What would be the needed system modification and market transaction costs? Still, if salmon recovery efforts should zero in on southern Idaho water as a key element in recovery efforts, the option market certainly should be considered further.

Expanding the water bank to enhance streamflow

Three water banks now operate in Idaho: District 1 in the upper Snake River basin; District 63 in the Boise area; and the Payette founded in 1989. District 1 is the largest, oldest, and most active. The District 1 bank, which includes much of southeast Idaho, was established by the Idaho legislature in response to the 1977 drought to allow farmers who had unused storage water to sell it to farmers who needed water. Water transfers had been occurring informally for many years before; the legislature simply codified the process. Historic use of the District 1 bank is illustrated in Figure 13. The 13-year average amount of water available from the bank was 370,702 af. Agriculture bought 36,901 af or 10 percent; Idaho Power bought 150,923 af or 41 percent; and 182,878 af or 49 percent remained unsold.[28] The highest volume year was 1986 with 1.03 maf available for sale and the lowest was 1992 when essentially no water was available because of the drought. In drought years — 1988, 1990, and 1992 — sales to agriculture far exceeded power sales.

In periods of drought, unsold water bank water can be carried forward into future years, but once it is sold and used it is gone from the system. One should be careful not to interpret the annual unsold water in the water bank as an indication of additional water available every year, because this would be double counting.

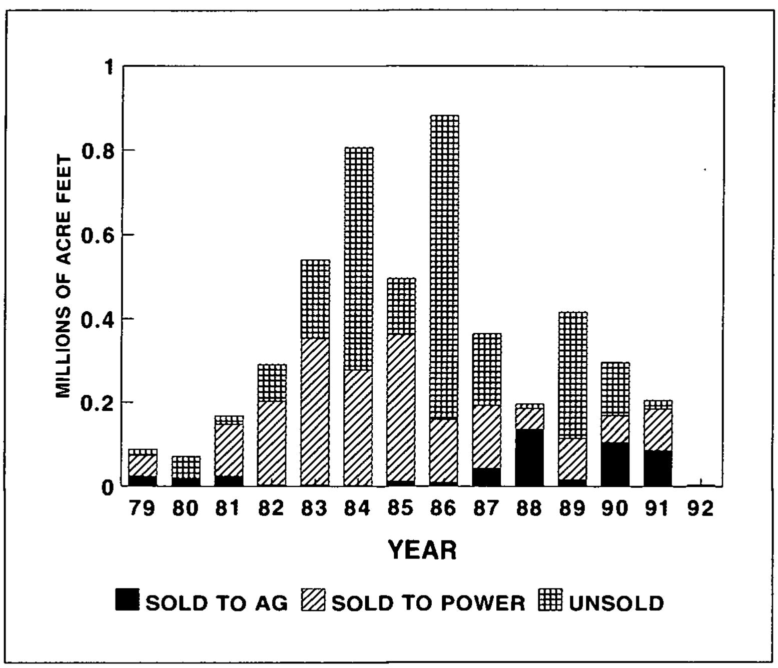

Figure 13.—District 1 Water Bank sales in southeast Idaho, 1979–1992. *ERO Resources, Denver; Watermaster, District 1.*

At present, several important procedural restrictions limit the usefulness of the District 1 water bank as a way to augment flows for either fish or power. First, farmers in the district have highest priority to purchase water bank storage before it can be released for other uses. Second, payment for water currently is restricted on a two-tier rate structure of $3.50 /af above Milner Dam and $9/af below Milner Dam (changed recently from a single rate of $2.75/af) which tends to inhibit out-of-region water use. Third, legislative approval is needed for any uses outside Idaho, such as for fish or power needs. Fourth, if a storage right holder sells water to a user outside the district, his refill priority for the following year falls to last. Once the water storage space is filled, however, his refill priority returns to its original status. While these restrictions do limit the usefulness of the water bank for salmon recovery, they also serve the legitimate purpose of minimizing third-party damages from the water bank.*

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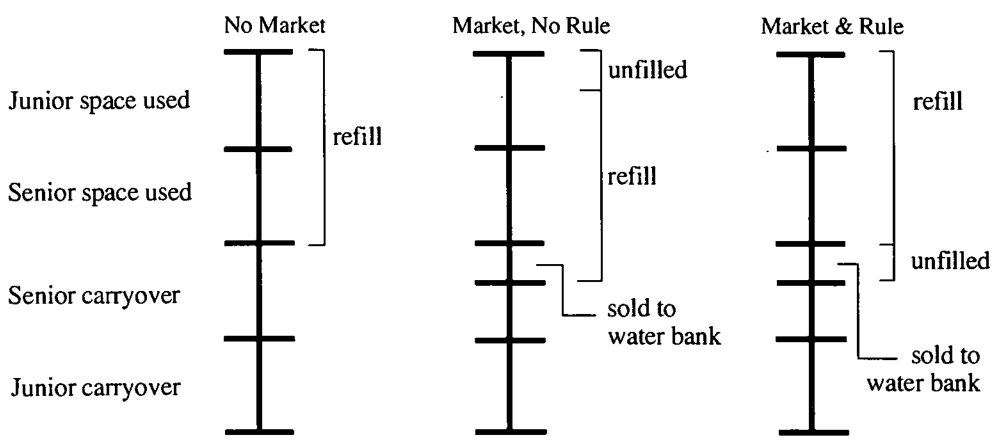
* The refill rules protect the refill rights of nonparticipants from damage caused by other right holders who participate in the market. If a dry year follows a year when some space holders sold water through a water bank, there is a risk that reservoirs might not completely fill. Without the rule, those who sold water would have received income from the sale, while those who didn't participate in the market would get less water than if no market had existed. The following diagram illustrates the problem.



Suppose a reservoir has 100,000 af of storage space, half held by each of two irrigation districts with different priority dates. Also suppose that half of each district's water is needed for irrigation and that subsequent flows are exactly enough to refill the reservoir for the following irrigation season.

Now suppose the district with the senior right decides to put 10,000 af of its carry-over water into the water bank; this water is sold and delivered downstream. Now there is not enough water to completely refill the reservoir — 10,000 af of storage space will be left empty. The question is, whose space is empty? If the refill rules are not changed, the senior district not only benefits from the sale of the water, it also ends up with full reservoir space the next year while the junior user ends up with 10,000 af of empty reservoir space. Only if the refill rules are changed do the benefits from selling water and the risk of nonrefill fall on the same district.

The present water bank simply is unable by itself to supply the enormous water requirements for fish. Figure 13 clearly shows that the water bank alone has little chance of providing the volume of water requested by the Northwest Power Planning Council from southern Idaho. Their short-run target of 427,000 af is beyond reach in many years, and the 1.427 maf long-run target is beyond reach of the water bank in virtually all years. Most important, in multiyear drought periods, the water bank may not be able to provide any water for fish.

Could the water bank be changed and expanded to reliably provide flow augmentation for salmon? If water bank prices were allowed to reach free market levels, higher prices might encourage farmers to commit more water to the bank. If prices were high enough, farmers would be willing to increase their irrigation efficiency and even to cut back on the lowest value uses of water in order to sell more water through the bank. In recent drought years, the California water bank has successfully moved water from low-value agricultural uses to higher value agricultural and urban uses.

To the extent that expanding the water bank for fisheries enhancement also increases hydropower generation, this could fund some or all of the water purchases.

One might even envision an option market for storage water. Farmers could use the stored water in most years but would agree to deliver the water for fish in dry years. In many ways, it would be much easier to implement an option market for storage water than the option market for flow water discussed earlier. It should be much easier to measure, control market compliance, and deliver stored water than flow water.

The downside is that expanding the size of the water bank by increasing irrigation efficiency or by eliminating low-value water uses would also reduce aquifer recharge and downstream return flows. In fact, the reason that large amounts of water are now available to the water bank in some years is probably because of past improvements in irrigation efficiency — the same efficiency changes that are a cause of the reduced flows at Thousand Springs. Such an expansion of the water bank would free up little new water for fish in the long run unless it actually reduces irrigation consumptive use, for which farmers would demand a price well above the present water bank price. Still, there might be benefits to keeping more of the water in reservoirs so that flows could be managed for salmon.

Certainly, if it is decided to look for more water in southern Idaho, the water bank should be considered carefully. It might be possible to change the present bank to make it more responsive to fish needs, and it might be worthwhile expanding the bank to get more control over flows. If ESA compliance pushes us that far, option markets for stored water might be an efficient way to move water from agricultural consumptive use to fish use.

Irrigated acreage retirement

Although both the water option market and the water bank show promise, they face a number of institutional, legal, and practical problems. Another alternative is to permanently retire some presently irrigated land, using the released water to augment flows for salmon. This might be accomplished in several ways. The market alternative would be to purchase irrigation water rights from willing sellers and then retire the appurtenant land. An option that some farmers fear, though it is not being openly proposed, is the more draconian method of taking the water by fiat, perhaps an ESA-based court order. (It remains unclear whether these fears have legitimacy based on the precedent of the endangered Sacramento River chinook, on whose behalf federal legislation recently transferred 800,000 af of irrigation water to instream use.) Either method would involve costs: The market would require that farmers be paid for their water; diversion by fiat would impose the cost of lost incomes on the farmers. Either way, estimating the cost comes down to estimating the value of water to agriculture.

Water is one of the essential inputs to agriculture in southern Idaho. Estimates of the value of water tend to vary greatly because they depend on many variables such as location, type of crops, method of irrigation, and method of calculation. Estimates range from $170/af for potatoes to a negative $37/af for pasture in the Boise Project.[29] Farmers have in most recent years been quite willing to sell substantial amounts of water at a low $2.75/af rate offered through the water bank. The NMFS Economics Technical Committee estimated that irrigation water was worth between $50 and $80/acre, or $25 to $40/af.[30]

It is assumed that under a market-based land retirement program, marginal farms would be the first purchased. The value of water for a marginal farm might be much less than for an average or typical southern Idaho farm; the $25 to $40/af (or lower) values would probably be market clearing. In the worst-case scenario, where water is taken by fiat in a nonmarket setting, then the average-farm-based estimates of water value might be applicable. In such a scenario, it would be left to the blunt forces of the priority doctrine to sort out which farmers received the remaining available water. However, even in this case one would expect water markets, such as the present water banks, to develop and to move water from the lowest value irrigation uses to higher value ones. Also, the more water needed for salmon, and the more land that would have to be retired, the higher the price sellers would demand.

If water rights are purchased and land permanently retired to release water for salmon flows, more water would be released downriver, increasing hydropower output. Because permanent land retirement would release water in all years, not just dry ones, the power generated would be a mixture of firm and surplus power, so it would be less valuable per unit of water than the predominantly firm power resulting from the dry-year option water market. These power benefits probably wouldn't cover the full cost of purchasing the water rights, but they could partly defray the purchase costs.

Acreage retirement schemes have several major pitfalls. The first is the usual difficulty in defining and enforcing property rights to water in the Snake River basin, where both water measurement and control are rudimentary. The second is that land retirement also reduces aquifer recharge and downstream return flows, negating part of the flow benefits. The third is the difficulty of preventing irrigation expansion in the Snake River basin that might nullify any retirement plan.

Using market-based programs in combination

The NMFS Economics Technical Committee looked at the possibility of using the water bank, the option market, and acreage retirement in combination to supply water needed for salmon passage. Table 3 addresses the two flow-augmentation scenarios considered: 427,000 af and 1.427 maf of water from southern Idaho. In addition three probabilities of interruption at each augmentation level were examined.

Table 3.—Alternative scenarios for obtaining southern Idaho water.

Flow alternatives

1) 427,000 af — short-run proposal
2) 1.427 maf — long-run proposal

Frequency of delivery

1) Driest 10 percent of years
2) Driest 25 percent of years
3) Every year

Huppert; NMFS Economics Technical Committee

The first scenario would take water from irrigation in the driest 10 percent of all years. It was assumed that the water bank could supply only 80,000 af in these years because farmers would have little excess water to commit to the water bank. The second scenario assumed interruption in the driest 25 percent of all years. In this scenario it was assumed that the water bank could provide 110,000 af. Finally, for the extreme case in which water is needed in all years, an acreage retirement scenario was included. In the 100 percent interruption scenario, the yield from the water bank would vary by year since all available water bank water would be used.

A summary of these flows appears as Table 4.* Column 1 shows the interruption probability for farmers. Column 2 indicates the water that could be supplied from the water bank, and column 3 shows how much water would have to come from an option market or land retirement. Column 4 indicates the reduced crop acreage resulting from the option market. Each crop acre

Table 4.—Water supplied by farmers in the year of interruption.

Interruption frequency (%)	Water from water bank (af)	Water from option market, retired land (af)	Acreage affected by market (acres)	Reduced aquifer recharge (af)	Flows for power (af)
	For 427,000 af of water supplied for fish:				
10	80,000	347,000	115,667	115,667	231,333
25	110,000	317,000	105,667	105,667	211,333
100	239,185	187,815	93,907	62,395	187,815
	For 1.427 maf of water supplied for fish:				
10	80,000	1,347,000	449,000	449,000	898,000
25	110,000	1,317,000	439,000	439,000	878,000
100	239,185	1,187,815	593,908	395,938	1,187,815

Huppert; NMFS Economics Technical Committee

* The *annualized* flows are as follows:

Interruption frequency (%)	Water from water bank (af)	Water from option market, retired land (af)	Acreage affected by market (acres)	Reduced aquifer recharge (af)	Flows for power (af)
	For 427,000 af of water supplied for fish:				
10	8,000	34,700	11,567	11,567	23,133
25	27,500	79,250	26,417	26,417	52,833
100	239,185	187,815	93,907	62,395	187,815
	For 1.427 maf of water supplied for fish:				
10	8,000	134,700	44,900	44,900	89,800
25	27,500	329,250	109,750	109,750	219,500
100	239,185	1,187,815	593,908	395,938	1,187,815

was assumed to divert 3 af of water.* Thus for the 10 percent and 25 percent scenarios, the affected acreage is one-third the needed water volume. A long-run viewpoint, however, must be taken in the 100 percent interruption land retirement scenario. Consumptive use at 2 af/acre, rather than diversions at 3 af/acre, is used to compute the affected acreage. The reduction in aquifer recharge due to the reduction in diversions to the affected acreage can be seen in column 5. Finally, the additional hydropower flows created by the option market can be seen in column 6.

The NMFS report valued power from flow augmentation as a weighted average of firm power valued at 3.9 cents/kwh and nonfirm power valued at 1.0 cent/kwh.** These average values can be seen in Table 5.

Agriculture costs were estimated at $2.75/af for sales from the water bank, the established price then paid for water bank water. For the option market, the value of water was $80/acre/year except for the 100 percent interruption scenario. In this case it was assumed that marginal irrigated land could be permanently retired at a cost of $50/acre/year.

Table 5.—Value of power generated by augmented flows (weighted averages, firm and nonfirm rates).

Interruption frequency (%)	% Firm power (@3.9¢/kwh)	% Nonfirm power (@ 1¢/kwh)	Weighted average rate (¢/kwh)
10	100	0	3.90
25	60	40	2.74
100	20	80	1.58

Huppert; NMFS Economics Technical Committee

* This ratio of diversions to consumptive use was used in the NMFS Economics Technical Comittee report. Actual diversions to consumptive use in southern Idaho appear to be much higher in some cases.

** The Northwest Power Planning Council estimates the nominal firm power rate at 7.7 cents/kwh, which is the avoided cost for a 40-year resource acquired in 1995; or 3.9 cents/kwh in real, levelized terms, assuming 5 percent annual inflation, 40-year life of facilities, a 3 percent discount rate, and a combination of tax and tax-exempt financing.[31] The nonfirm power rate was estimated at 1 cent/kwh by the NMFS Economics Technical Committee.[32]

These weighted averages, reflected in the NMFS Economic Report, are considerably less than those used in the 1992 Hamilton and Whittlesey study, which priced firm power at 5.85 cents/kwh. These lower rates substantially reduce the estimated electrical power values resulting from the option market.

The annualized results are shown in Table 6. For the 10 percent and 25 percent probabilities in both the 427,000 af and 1.427 maf cases, power revenues exceed farmer costs. Farmer costs exceed power benefits in the 100 percent interruption scenarios. These results suggest that the water bank and option market combination might be a feasible way to get additional flow augmentation water for fish in occasional years, and that power revenues might pay most or all of the costs. On the other hand, if augmentation water is needed for fish in all years, the power benefits from a land retirement and water bank combination program probably will not be adequate to compensate farmers, and additional funding from other sources will be needed.

Table 6.—Net costs and benefits of combination scenarios (millions of dollars per year).

Interruption frequency (%)	Agricultural losses	Power gains	Net income change
	For 427,000 af target flow:		
10	0.947	1.376	0.429
25	2.189	2.208	0.019
100	6.265	4.512	-1.753
	For 1.427 maf target flow:		
10	3.614	5.343	1.729
25	8.855	9.175	0.320
100	31.265	28.616	-2.649

Huppert; NMFS Economics Technical Committee

Conclusions

The apparent choice between river drawdown and flow augmentation is an underlying theme of this publication. While other actions also are under discussion, a final recovery plan for imperiled salmon stocks in the Columbia and Snake River system is likely to contain elements of augmentation, drawdown, or perhaps both. Each alternative is being vigorously advocated as the best way to help juvenile salmon on their downstream migration. Drawdown advocates argue that this approach will increase the velocity of water and thus aid juvenile salmon migration without requiring any additional water. Critics argue that drawdown will have dire consequences for barge transportation, recreation, and power generation activities along the lower Snake River. If the objections to drawdown prevail, this greatly increases the likelihood that additional water for flow augmentation will be sought from southern Idaho. Alternatives being discussed mention the possibility of obtaining 1 maf or more of augmentation water from southern Idaho. This publication has addressed some of the strategies that might be used to obtain this water.

Perhaps the most important conclusion is that irrigation efficiency improvements will not make any new water available for fish flow augmentation, although improvements may make it easier to shape short-run flows for fish. Because the Snake River basin water supply is now fully appropriated, especially in dry years, little water is available for salmon flow augmentation unless crop consumptive use is reduced. This is unfortunate. It would be relatively easy to rally public support to "stop wasteful use of water to help salmon." It will be a lot more difficult to rally the concerned parties in a program to move water away from crop use to fish use.

If society makes the policy choice that such fundamental shifts in water use are necessary, then market mechanisms based on the current structure of water rights certainly offer a possible way to accomplish the shift. More fundamental changes in water rights, addressing some of the equity concerns associated with water markets, would be politically very difficult.

Our analysis suggests it may be feasible to obtain significant amounts of water for fish in dry years from an option market, perhaps in combination with use of the water bank or land retirement. The estimates presented in this publication suggest that if this marketed water can be used to generate power rather than spilled, then hydropower revenues might fund most of the farmer costs of flow augmentation, so long as augmentation water is not needed in all years. However, if water is needed every year, farmer costs are substantially more than power value. Note that serious institutional and hydrologic issues would have to be addressed before any of the market alternatives could be implemented.

Many potential actions to aid the recovery of endangered salmon imply serious consequences for those affected. Too frequently, southern Idaho irrigation has been left off the list of potentially affected constituencies. Hopefully this publication has set the stage for more detailed discussion of the linkage between flow augmentation and southern Idaho water use.

Notes

[1] For a discussion of the likely impacts of river drawdowns, see Joel R. Hamilton, Mike Martin, and Ken Casavant, "Lower Snake River Drawdown on Barge Transportation: Some Observations." University Task Force on Salmon and the Columbia River System, Pacific Northwest Extension Publication PNW 406, Feb. 1992.

[2] Letter to Rolland Schmitten, National Marine Fisheries Service, from the Columbia–Snake Rivers Main-stem Flow Coalition, 16 Dec. 1991.

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[4] Testimony of Dale C. Pearson, Oregon Trout, before the Joint Congressional Oversight Committee Hearing on Endangered Species Petitions on the Columbia and Snake Rivers, June 1990.

[5] "In 1992, only one sockeye returned to Redfish Lake — named lonely." Idaho Falls, Idaho, *Post Register*, 10 Sept. 1992.

[6] Presentation by Randy Hardy, Bonneville Power Administration, at a conference, "Endangered Species Act: On the Road to Recovery?" Coeur d'Alene, Idaho, 9-10 Nov. 1992.

[7] Keep in mind that fish recovery efforts are ongoing. Any costs incurred to save the fish under the ESA must be compared to what would have been spent in the absence of the ESA. For a discussion of this issue, see Norman K. Whittlesey, "Defining 'With' versus 'Without' Conditions for ESA Salmon Recovery." Discussion draft, Department of Agricultural Economics, Washington State University.

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[12] Letter to Garth Griffin, National Marine Fisheries Service, from Andy Brunelle, special assistant for natural resource issues to the Governor of the State of Idaho, 20 Feb. 1992.

[13] "Sea mammals threaten salmon." Moscow, Idaho, *Daily News,* 28 Sept. 1992.

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Other Salmon and the Columbia River Task Force Publications

This publication is one of several published as Pacific Northwest Extension publications for the University Task Force on Salmon and the Columbia River System. Other publications produced by the Task Force are listed below.

Salmon and the Columbia River System, J. Barron and G. Thorgaard, Pacific Northwest Extension publication PNW 362, April 1991 (Oregon State University, Corvallis), 75¢

The Effect of Lower Snake River Drawdown on Barge Transportation: Some Observations, J. Hamilton, M. Martin, and K. Casavant. Pacific Northwest Extension publication PNW 406, February 1992 (Washington State University, Pullman), 50¢

Alternative Actions for Restoring and Maintaining Salmonid Populations on the Columbia River System, L.M. Eisgruber, *ed.* Pacific Northwest Extension publication PNW 407, March 1992 (Oregon State University, Corvallis), $2.00

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