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Endangered Species and Irrigated Agriculture, Water Resource Competition in Western River Systems

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Endangered Species and Irrigated Agriculture

Water Resource Competition in Western River Systems

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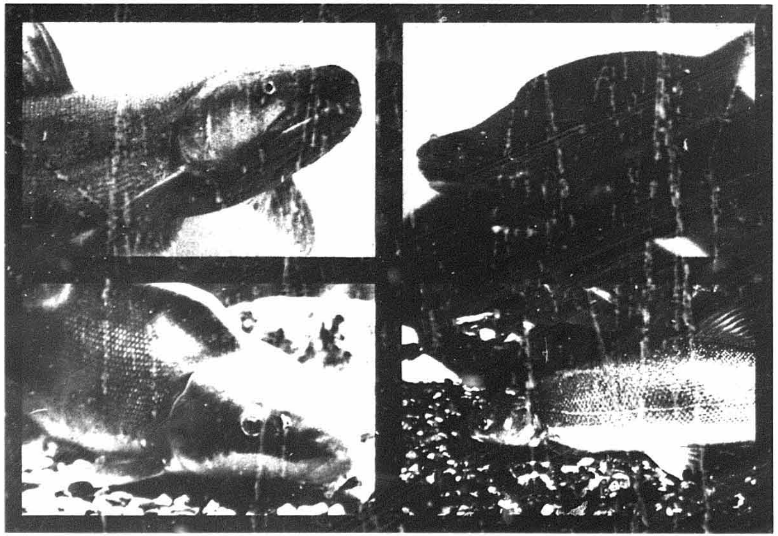

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Endangered Species and Irrigated Agriculture: Water Resource Competition in Western River Systems. By Michael R. Moore, Aimee Mulville, and Marca Weinberg. Natural Resources and Environment Division, Economic Research Service, U.S. Department of Agriculture. Agriculture Information Bulletin No. 720.

Abstract

This report characterizes several aspects of water allocation tradeoffs between fish species listed under the Federal Endangered Species Act and agriculture in the American West. The geographic intersection between endangered/threatened (E/T) fish and agricultural production reliant on surface water for irrigation is identified. Three findings are: (1) 235 counties, representing 22 percent of the West's counties, contain irrigated production that relies on water from rivers with E/T fish, (2) areas generating the highest revenues per acre from crop production are those most dependent on surface water irrigation, and (3) these same areas are also most likely to be drawing water from rivers that contain at least one E/T species.

Keywords: Water allocation, rivers, fish, endangered species, irrigated agriculture, American West, Endangered Species Act

Acknowledgments

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Cover photo of four Colorado River endangered fish species © W. Perry Conway. Clockwise from top left: C[illegible]do squawfish, humpback chub, bonytail chub, and razorback sucker.

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Summary

Endangered and threatened fish species compete with agriculture for water resources in the Western United States. Efforts to protect fish species through habitat improvement may involve restrictions on water withdrawn from rivers and streams for other purposes. A decrease in water available for crop irrigation could impose financial losses on western farmers. This report discusses the threat water development poses to fish species, the financial value of crop production irrigated with surface water, and the geographic intersection between protected fish and irrigated agricultural production in the West.

The Endangered Species Act (ESA) lists 68 western fish species as threatened or endangered, with 86 more species cited as candidates for listing. An *endangered* species is one in danger of extinction throughout all or a significant portion of its range; a *threatened* species is likely to become endangered within the foreseeable future. Extensive damming of rivers and withdrawals of surface water (water from rivers and streams), primarily for irrigation water and hydroelectric power, contributed to the decline of native fish populations in the West as fish lost high-quality habitat.

Agriculture uses 90 percent of all fresh water consumed in the West. Western farmers irrigated almost 81 percent of total U.S. irrigated acres in 1987. Surface water provides over 60 percent of the West's irrigation water.

Twenty-two percent of all counties in the 17 Western States contain cropland irrigated with water from river systems with endangered/threatened fish species. Areas in the West generating the highest revenues per acre from crop production are those most dependent on surface water for irrigation. These areas are also most likely to be drawing water from rivers that contain at least one endangered fish species.

Recovery activities for endangered species increasingly must be reconciled with existing land and water uses. One policy option is to reallocate water from agriculture to fish without compensating farmers. Although farmers would shoulder most of the financial costs, water reallocation should increase endangered fish populations and could consequently reduce public expenditures to acquire habitat. Another policy option is to compensate farmers for water reallocations, which would be consistent with ESA authorization of public expenditures to buy habitat. And it may be cheaper for the Government to purchase water for fish habitat restoration than to implement other recovery methods. This is the type of monetary trade-off likely to be considered when policymakers assess various policy options.

ESA reauthorization creates an important opportunity to reconsider the issue of endangered species recovery and western river management. Originally scheduled to occur by 1993, the 104th Congress will likely consider ESA reauthorization in the 1995-96 legislative term.

Two existing approaches provide alternatives to relying solely on the ESA to protect species. The Northwest Power Act (1980) mandated that fish and wildlife in the Columbia River Basin be treated equally with hydropower and other river uses. An interstate commission was created to implement the mandate. Systemwide river management institutions could be created for other western rivers. Second, directly reforming water allocation rules could be central to an alternative approach. For instance, the Central Valley Project Improvement Act (1992) expands purposes of California's Central Valley Project to include fish and wildlife restoration and protection, and dedicates roughly 1.2 million acre-feet of water to accomplish this.

Endangered Species and Irrigated Agriculture

Water Resource Competition in Western River Systems

Michael R. Moore*
Aimee Mulville
Marca Weinberg

Introduction

Many endangered, threatened, and declining species depend on riverine ecosystems that have been altered by water supply development in the arid western United States. Development of western rivers—the system of dams, reservoirs, and canals that mark the western landscape—was a key element of public and private efforts to settle and shape the West from the mid-1800's through 1980. Several statistics convey the sheer magnitude of western river development:

> From the 1920s through the 1960s, reservoir capacity in the West mushroomed, expanding at the rate of 80 percent per decade... Westwide, more than a million artificial reservoirs, lakes, and ponds store 294 million acre-feet [of water]. This is the equivalent of twenty-two Colorado Rivers backed up behind dams and over former canyons. It is enough to put Montana, Wyoming, Colorado, and New Mexico—an entire tier of states, from Canada to Mexico—under a foot of water (Wilkinson, 1992, p. 259).

River development, however, degraded the habitat of many native fish and wildlife species in these ecosystems. Sixty-eight fish species are listed as endangered or threatened in the 17 Western States.[1] Under the Endangered Species Act of 1973 (ESA), water users may be legally required to conserve or manage their water resources for habitat restoration and recovery of these species. The impact of the ESA on river allocation is one of the great uncertainties in western water resource management (Wilkinson, 1992).[2]

Irrigated agriculture dominates water consumption in the West. Agriculture consumes 90 percent of the total consumption of freshwater resources in the West, with farmers irrigating almost 38 million acres of cropland, pastureland, and rangeland in 1987 (Solley, Pierce, and Perlman, 1993, and U.S. Department of Commerce, Bureau of the Census). Surface water (water diverted from rivers and streams) provides over 60 percent of irrigation water. Because agriculture consumes a dominant share of fresh water, the potential role of irrigation water conservation and reallocation must be considered when planning for species survival in western river systems.

Water resource competition in central California exemplifies competition throughout the West. Significant Federal, State, and private investments were made in water storage and conveyance projects on the Sacramento and San Joaquin Rivers in California's Central Valley (fig. 1). These projects transformed arid land into some of the world's most productive farmland,

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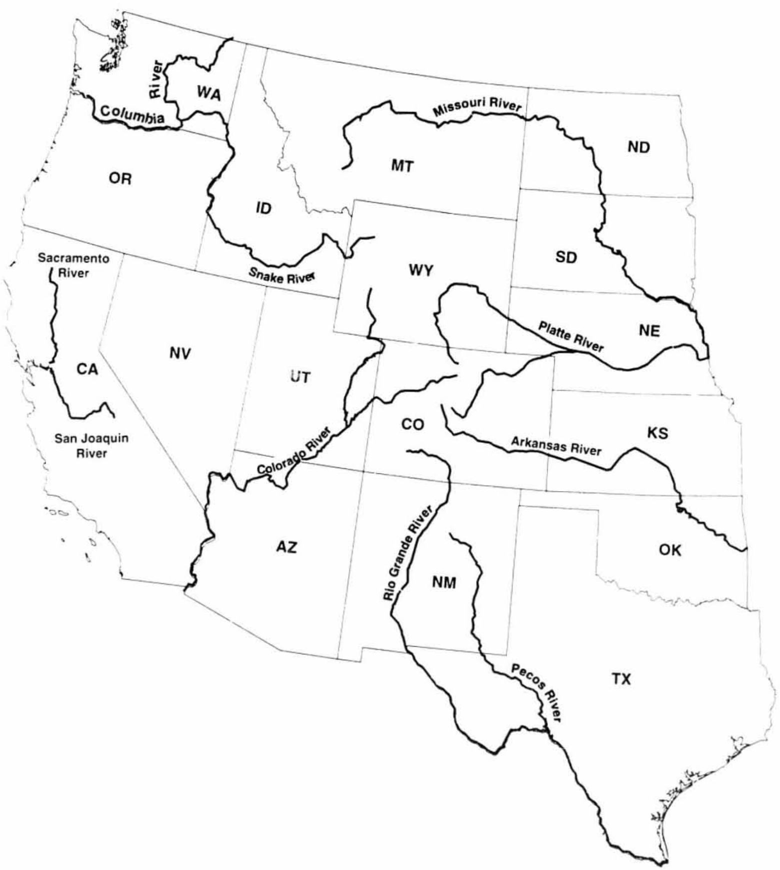
[1] Numbers of endangered and threatened fish species reflect their status as of November 1993.

[2] Wilkinson writes on this topic:

> A fast-emerging matter of federal law [concerning western water] involves the Endangered Species Act... [which] has only begun to play out on western rivers. It may not come to much. The last-resort statute for wildlife may, however, prove to be a sturdy hammer for dislodging long-established extractive water uses that have worked over so many western watersheds and drained them of much of their vitality (p. 283).

Figure 1
Major western rivers



with agriculture diverting roughly 85 percent of the region's developed surface water resources for crop irrigation. However, 27 fish species are declining or extinct in these river systems: three fish species (Sacramento River winter-run chinook salmon, delta smelt, and Little Kern golden trout) are listed as threatened or endangered under the ESA; another 15 fish species either qualify for listing or are in severe decline with serious potential for becoming endangered; and nine fish species are already extinct (Moyle and Morford, 1991; Moyle and Williams, 1990).

The decline in central California fish populations motivated development of new Federal water policy, as well as implementation of existing endangered species law. In 1992, the Central Valley Project Improvement Act (Title 34 of Public Law 102-575) was instituted to improve fishery habitat (and to achieve other water management objectives). In a significant step for a Federal Bureau of Reclamation project, the law designated "fish and wildlife mitigation, protection, and restoration" as an explicit purpose of the Central Valley Project (CVP). To achieve this objective, the law permanently allocated roughly 1.2 million acre-feet of CVP water per year (about 17 percent of CVP contracted water supply) for habitat restoration.[3,4] Reallocation of water currently used by agriculture will likely supply most of the water for habitat in many years. In addition to the water policy reform, new operating rules for the CVP and the California State Water Project were applied in 1993 to comply with the ESA. These primarily involved water pumping restrictions for these projects to protect ESA-listed fish in central California, with a consequent reduction in agricultural water supply. CVP water operations already had been modified under the ESA since 1987 to protect the Sacramento River winter-run chinook salmon.

While the foundation for fish recovery and conservation may be in place in central California, recovery efforts are in their infancy for many other species in western rivers. This report provides a screening analysis of potential conflicts between irrigated agriculture and endangered fish species over water allocation from western rivers. The analysis clarifies the possible impact of the ESA on management and allocation of western rivers.

ESA reauthorization creates an important opportunity to consider the issue of endangered species recovery and western river management.[5] Two widely discussed modifications to the ESA are: (1) requiring additional information on the potential economic effects of recovery plans for endangered or threatened species and (2) expanding the focus of the law from individual species to a broader multispecies or ecosystem approach. This report provides perspective on both modifications. In the context of economic effects, additional economic analysis is needed to quantify water allocation tradeoffs between agriculture and ESA-listed species. The screening analysis conducted here identifies the geographic scope and other parameters for that analysis. Moreover, the focus on western river systems gives immediate context to an approach of ecosystem-based planning for endangered species conservation. Western rivers may provide some of the best opportunities to implement large-scale ecosystem restoration in tandem with endangered species conservation.

Threatened and Endangered Fish Species in the American West

This section inventories the ESA-listed fish species in the West, describes the relationship between river development and habitat degradation, and illustrates the role of improved water-flow conditions in species recovery efforts.

Species Endangerment

A species may be listed as endangered, threatened, or a candidate under the ESA. "Endangered species" is defined as any species in danger of extinction throughout all or a significant portion of its range, while "threatened species" includes any species likely to become an endangered species within the foreseeable future (U.S. Department of the Interior, U.S. Fish and Wildlife Service, 1988). "Candidate species" covers three cases of population status: (1) "a species for which sufficient information currently is on file to support a proposed rule to list as endangered or threatened"; (2) "a species recognized as possibly under threat of extinction, yet more information needs to be collected"; or (3) "a species for which sufficient information is currently available to conclude that it no longer warrants consideration to be listed as endangered or threatened."

[3]An acre-foot of water is the volume of water required to cover an acre of land to a depth of 1 foot; it equals 325,851 gallons.

[4]The figure of 1.2 million acre-feet could increase to over 1.35 million acre-feet early in the 21st century because the new law requires an increase in water supply allocated to wildlife refuges.

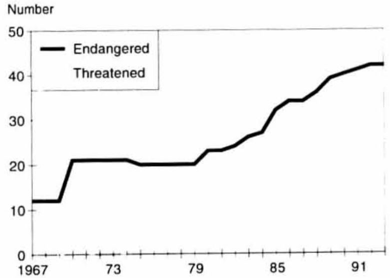
[5]Originally scheduled to occur by 1993, the U.S. Congress will likely consider ESA reauthorization in the 1995-96 sessions.

Inventory of Endangered and Threatened Fish Species

Sixty-eight fish species are currently listed as endangered or threatened in the West (see appendix for additional description).[6] The number has grown steadily over time to reach its current total (fig. 2). The total is cumulative: once formally recognized, a species continues on the list until either the recovery effort is successful (with the threat of extinction diminished markedly) or extinction occurs. Twelve western fish species were on the endangered list in 1967.[7] By 1993, the number of listed species had risen to 42 endangered and 26 threatened. The largest annual increases in the listings occurred in 1970 (9 new listings) and 1985 (10 new listings).

Federal and State Governments began reporting public expenditures on individual ESA-listed species in 1989.[8] The U.S. Fish and Wildlife Service (the lead agency on ESA implementation for terrestrial and freshwater species) aggregated the information, and reported expenditures on "fisheries, refuges, land acquisition, law enforcement, research and regional and field operations for listing, recovery, consultation, environmental contaminant and habitat conservation activities" that could be "reasonably attributed" to individual species (USFWS, 1992). For the 68 western fish species, public expenditures increased nearly 80 percent between 1990 and 1991, from $9.64 to $17.25 million (USFWS, 1992). Individual species receiving large expenditures in 1991 included the Sacramento River winter-run chinook salmon ($5.49 million), Colorado squawfish ($3.67 million), humpback chub ($2.77 million), and Lahontan cutthroat trout ($1.60 million) (see appendix).

Figure 2
Endangered or threatened fish species in the Western United States



Note: An endangered species is one in danger of extinction throughout all or a significant portion of its range; a threatened species is likely to become endangered within the foreseeable future.

Information on government expenditures provides context for the tradeoffs involved in species conservation. The primary tradeoff examined here involves water allocation between endangered and threatened (E/T) fish habitat and irrigated agriculture in the West. Yet, related tradeoffs also exist in terms of public and private monetary impacts of water allocation decisions. For example, one policy option is to reallocate water from agriculture to fish without compensating agricultural producers. Although producers would shoulder a financial burden, water reallocation should improve endangered fish populations and could consequently reduce public expenditures on species conservation. Another policy option is to compensate the agricultural industry for water reallocations, which would be consistent with ESA authorization of public expenditures to buy habitat. It may be cheaper for the Government to purchase water for habitat restoration than to implement other recovery measures. This type of monetary tradeoff may be important to consider when assessing the impact of various policies.

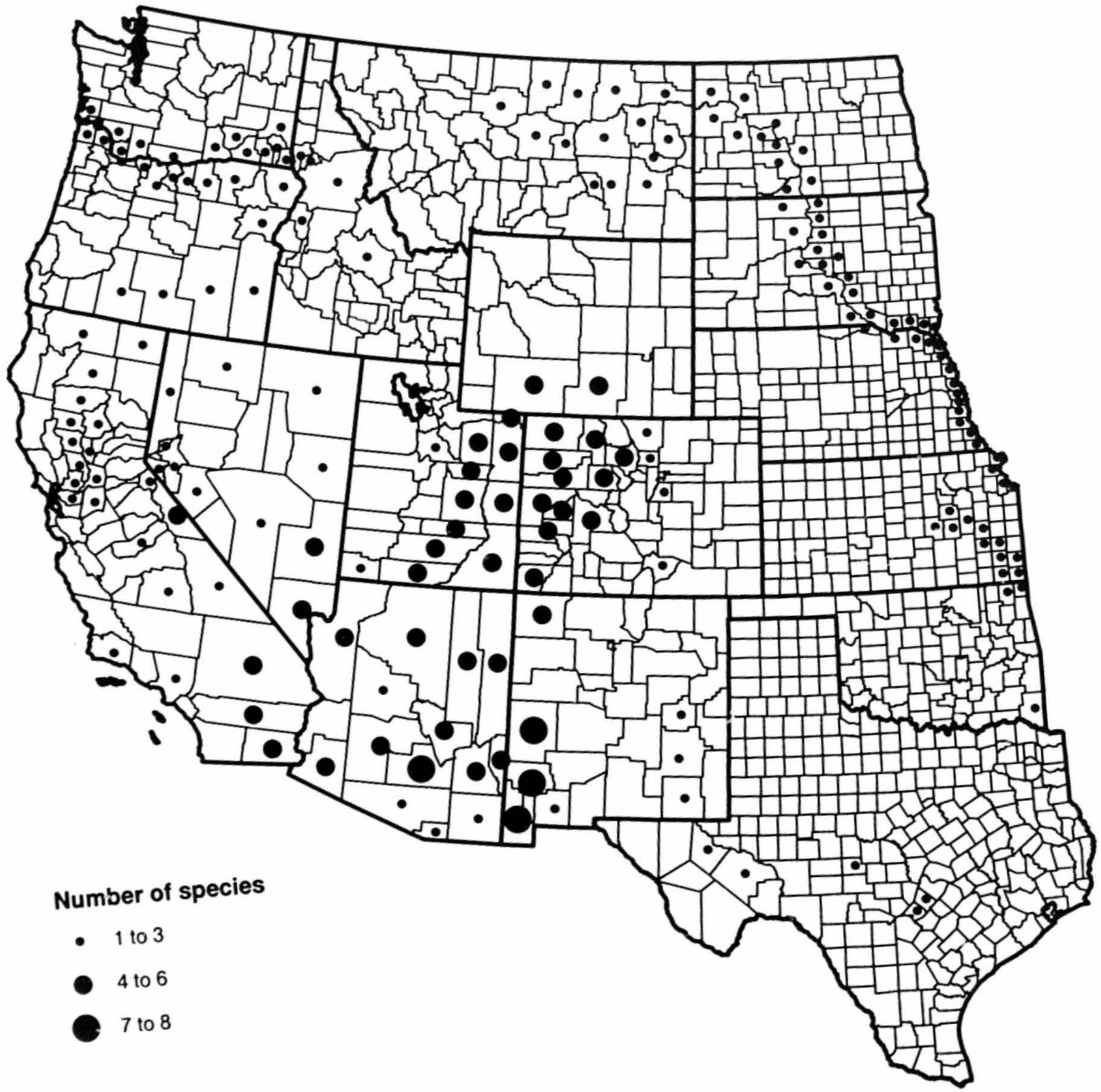
Fifty of the 68 E/T fish species are highlighted for subsequent analysis because of two characteristics: they rely on surface water for habitat and "agricultural activities" was listed as one of the factors in decline of the species (*Federal Register*). Over 18 percent of all counties in the West (198 counties) contain habitat for the highlighted species (fig. 3). Species are unevenly distributed among the States and across every major western river basin. For example, California

[6]This report focuses on ESA-listed species of fish because of their obvious link to water allocation tradeoffs in western river systems. However, other endangered species, including plants and other classes of animals, also rely heavily on riparian ecosystems in the West. For example, Johnson (1989) focused on imperiled animal species in Arizona and New Mexico that rely on riparian zones for habitat. In addition to 26 fish, the Arizona list includes 31 birds, 9 mammals, 9 amphibians, and 5 reptiles. In addition to 23 fish, the New Mexico list includes 19 birds, 8 mammals, 7 reptiles, and 6 amphibians. Reallocating water for instream flows in these States likely would improve habitat quality for many of these species. In this context, the description and analysis of this report present only a partial screen of the endangered species-agriculture water allocation dilemma.

[7]The 1966 Endangered Species Preservation Act and the 1968 Endangered Species Conservation Act were forerunners of the Endangered Species Act of 1973 (Yaffee, 1982).

[8]Public expenditures on a species recovery represent an implicit measure of the minimum economic value that society places on continued existence of the species.

Figure 3
Counties with endangered or threatened fish habitat



Source: *Federal Register*, 1973-93.

contains habitat for 14 E/T species and 30 candidate species, while Washington contains habitat for 3 E/T and 2 candidate species. Across river basins, most E/T species are concentrated in the Colorado River Basin.

Causes of Population Declines

The *Federal Register* reports factors contributing to a species' decline at the time of listing. While more than one factor contributed to the decline of over 95 percent of the species in the dataset, physical habitat alterations are cited in the decline of al 0 species (see box).

Water is diverted from western river systems for agricultural, municipal, and industrial use. Diversions remove water that otherwise would improve habitat quality, alter natural daily and seasonal temperatures and flows, cause fish to be rapidly transported by water flow (entrainment), and compound water quality problems. Water diversions are a factor in the decline of over 70 percent of listed western river fish species. For instance, water diversion for agriculture and urban use is the primary factor in the decline of the delta smelt in the Sacramento-San Joaquin Delta of central California. Once an abundant fish in the delta, the smelt experienced a 90-percent decline in numbers in the last 20 years (*Federal Register*, 1993). Adapted for life in the mixing zone of brackish water and fresh water, the smelt is vulnerable to changes in the proportion of salt to water and the location of the mixing zone. Freshwater diversions shift the mixing zone and its associated smelt populations upstream in the delta, where suitable spawning areas and food sources are scarce. In addition, freshwater diversions are so significant that reaches of the San Joaquin River periodically reverse direction and run back up to the pumping plants rather than into the delta. These reverse flows disorient outmigrating larval and juvenile fish and are considered a factor in smelt mortality as well as in winter-run chinook salmon mortality.

Dams have been an integral part of river development in the West. While dams are a factor in the decline of over 60 percent of E/T fish in western rivers, they are especially troublesome to species with spawning migration routes. For example, dams are the major cause of decline for three salmon species in the Columbia River Basin. Of the Columbia River's 1,240 miles, only 44 miles of natural riverine habitat remain (Moore and Willey, 1991). Dams threaten the survival of E/T species in the Columbia Basin by blocking access to spawning grounds, delaying juvenile outmigration, increasing juvenile mortality in turbines, and weakening adult fish that make repeated attempts to clear dams.

Reservoirs that back up behind dams pose additional threats to native fish species. Reservoirs directly inundate habitat and create conditions favorable to non-native predator and competitor fish species. Releases from reservoirs alter the natural daily and seasonal flow, sediment, and temperature patterns. For instance, reservoirs have severely affected the Little Colorado spinedace, which has habitat in the Little Colorado River Basin. Approximately 150 impoundments exist in this basin, ranging in size from stock tanks to 1,400-acre reservoirs (*Federal Register*, 1987). All but a few small stock tanks are uninhabitable by the spinedace, a stream-dwelling fish. Not only do these reservoirs directly inundate spinedace habitat, they also totally or partially dewater long stretches of downstream habitat.

Watershed disturbances, which include any activities that degrade water quality or habitat, can also harm aquatic environments. Examples include grazing, logging, farming, channelizing, dredging, and development. Livestock trampling and grazing contributed to the decline of over 30 percent of the species in our dataset. Frequently, more than one watershed disturbance threatens a species. Overgrazing, channelizing, and the introduction of non-native species all contributed to the Modoc sucker's endangered status. The sucker was first exterminated from a significant portion of its habitat in northern California due to severe erosion caused by overgrazing of livestock. Then, artificial channeling removed natural barriers in the sucker's remaining habitat, thereby creating access for crossbreeding and predator species.

Physical habitat alterations, especially when severe and widespread, can create environmental conditions vastly different from those for which native fish are adapted. Introduced non-native fish, better adapted to current environmental conditions, frequently pose a threat to the survival of native species. Of the 22 known western river fish species to become extinct in the last 100 years, non-native species were a factor in 19 cases (Miller, Williams, and Williams, 1989). In the Colorado River system, for instance, non-native species now outnumber native fish species. Conversion of the lower Colorado River into a system of dams and diversions not only fragmented, blocked, and inundated habitat, but also transformed miles of warm, turbid stream habitat into a series of reservoirs connected by cold, clear tailwaters. Non-native fish species are stocked for sport fishing. These introduced species prey on native species' eggs and juveniles, compete with native species for food and space, occasionally crossbreed with native species, and introduce new fish diseases and parasites. The upper Colorado River system has 14 native species

Factors in the Decline of Native Fish Species in Western River Systems

Dams	• Block or delay access to spawning, rearing, and feeding grounds • Reduce downstream water flows • Fragment habitat • Alter silt loads • Cause turbine-related mortality of juvenile fish passing through hydropower facilities • Weaken adults trying to pass through, thereby increasing predator success and contributing to reduced fecundity of fish	**Watershed disturbances**	• Water pollution and sedimentation from municipal, industrial, and agricultural activities, which destroy habitat and change stream nutrient loads, turbidity, and temperatures • Channelization and dredging that change natural flow regimes, affecting quality of rearing habitat and removing natural barriers that separate competing, predacious, or crossbreeding species • Erosion from grazing livestock and timber harvesting, which degrades water quality • Trampling by livestock, which alters streambank overhangs and destroys spawning beds
Reservoirs	• Inundate habitat • Create conditions favorable to non-native predator and competitor fish species • Emit irregular releases that alter natural daily and seasonal flows, affecting incubation, growth, and survival of fish downstream	**Non-native species**	• Prey on eggs, juvenile, and adult native species • Compete with native species for food and habitat • Crossbreed with native species • Introduce new fish diseases and parasites
Diversions	• Deplete instream flows and restrict available habitat • Alter natural seasonal and daily temperatures and flows • Cause mortality from entrainment into fields • Compound water quality problems by reducing natural capacity to dilute pollutants • Produce return flows that may carry pollutants, contributing to water quality problems	**Other**	• Groundwater pumping, which lowers water tables and reduces habitat for species dependent on groundwater-fed springs and outflows • Overharvesting • Hatchery-reared fish, which reduce genetic pool, introduce disease, and compete with wild stocks for food and space

and 42 non-native species, while the lower Colorado River system has 27 native species and 37 non-native species. Non-native fish are a factor in the decline of all 14 native lower Colorado River Basin fish species listed as threatened or endangered.

The Role of Water in Species Recovery

Freshwater fisheries require certain volumes of instream waterflow for sustainability. A set of "rules of thumb" define three levels of habitat quality (Tennant, 1975). (1) Ten percent of average flow is necessary to provide short-term survival habitat for most life forms. Rivers in this category are defined as "severely depleted." (2) Thirty percent of average flow will sustain good survival habitat for most life forms. Rivers at 10-30 percent are "under stress." (3) Sixty percent of average flow will provide excellent to outstanding habitat. Rivers with flows of 30-60 percent are termed "degraded." Thus, 30 percent of average annual flow can be considered the minimum quantity necessary to provide a sustainable balance between consumptive and instream uses of water. Given this categorization, river conditions were severely depleted in the southern portions of California and Arizona and under stress in the headwaters of the Platte and Arkansas Rivers (in Wyoming and Colorado), the San Joaquin Valley (California), the Rio Grande (New Mexico and Texas), and in closed basins in Nevada, Utah, and California (Bayha, 1978).

Two cases, involving central California and the Columbia-Snake River Basin, illustrate the specific role of reallocation of irrigation water to improve fishery habitat. The Central Valley Project Improvement Act (CVPIA) requires that roughly 1.2 million acre-feet per year of California's CVP water supply be dedicated to "fish, wildlife, and habitat restoration purposes," in part for improving habitat of fish species that migrate upstream to breed in fresh water (anadromous fish species) (Public Law 102-575). The key water-management requirement involves regulating the volume and timing of flows in both river systems until they pass through the Sacramento-San Joaquin Delta and into San Francisco Bay (Fisher, Hanemann, and Keeler, 1991).

According to the CVPIA, the Secretary of the Interior must implement a least-cost plan to provide water for fish, wildlife, and habitat restoration by the year 2007. Voluntary (compensated) water transfers, voluntary agricultural land retirement, and water conservation requirements must be considered among the plan options (Public Law 102-575, Section 3408). Although not stated in the CVPIA, water allocated for irrigation would probably be used to fulfill the 1.2 million acre-foot requirement when reductions in water use are needed. This conclusion seems likely because, in the CVP, agricultural water use dominates urban and industrial water use by more than 10 to 1 (U.S. Department of the Interior, Bureau of Reclamation, 1990). Further, both the economic value of urban water and the cost of expanding project capacity exceed the value of irrigation water in the Central Valley (Willey and Graff, 1988). Reallocating irrigation water thus would conform to the mandate to develop a least-cost plan for providing water for habitat restoration.

A less central role exists for irrigation water reallocation in the Columbia-Snake River Basin relative to central California. Irrigation water reallocation in the upper Snake River Basin is viewed as only one element of a plan to improve the habitat of three E/T salmon and to increase other anadromous fish populations (Northwest Power Planning Council, 1992). Nevertheless, existing proposals recommend procuring up to 1 million acre-feet per year from irrigators in southern Idaho and eastern Oregon to improve instream flow during inriver salmon migration.[3] Water would be obtained by various means, including "using water efficiencies, market mechanisms, water transactions, and the like" (Northwest Power Planning Council, 1992). However, a permanent recovery plan that includes a precise role for irrigation water reallocation has yet to be adopted in the Columbia River Basin.

Screening Analysis: Overlap of Irrigated Agriculture and Endangered Species Habitat

Nationwide, 46 million acres were irrigated in 1987. This number represented just 15 percent of total harvested acreage, but accounted for 38 percent of the $69 billion in crop sales in that year. The vast majority (81 percent) of irrigated acreage is located in the 17 Western States (Bajwa and others, 1992). Roughly half of irrigated acreage is irrigated with surface water, while the remainder is irrigated with ground water. The Bureau of Reclamation (an agency in the U.S. Department of the Interior) is the largest supplier of irrigation water in the United States. Over 150,000 farms in the 17 Western States receive water from Reclamation annually (U.S. Department of the Interior, Bureau of Reclamation, 1988). Reclamation water is used to irrigate roughly 10 million acres, or half of all surface water irrigated acres in the West. Reflecting higher values associated with irrigated agriculture nationwide, this acreage, which represents only 5 percent of all cropland in the West, accounted for nearly 30 percent of all revenue generated from crop production in Western States in 1987 (U.S. Department of Agriculture, 1992; U.S. Department of Commerce, Bureau of the Census, 1987; U.S. Department of the Interior, Bureau of Reclamation, 1988). The high per acre revenues can be attributed to production of high-value specialty crops and high yields for staple commodities. For example, Reclamation acreage produces 60 percent of the vegetables and 25 percent of the fruits and nuts grown in the country.

[3]See Aillery and others (1994) for an economic analysis of salmon recovery measures in the Columbia River Basin that would affect the agricultural sector.

The Role of Agriculture in Western Water Use

Agriculture diverts and consumes the vast majority of western surface water resources (table 1 and box). Westwide, agriculture accounts for 76 percent of all surface water withdrawals (Solley, Pierce, and Perlman, 1993). The figure is even higher in many States and river basins. For example, approximately 95 percent of withdrawals in the Rio Grande and upper Colorado River basins are for crop irrigation or livestock watering. Ninety-nine percent of surface water withdrawals in Idaho are used for irrigation (table 1). Much of this

Table 1—Irrigation water use and source, by State

State	Irrigation water withdrawals as a share of total surface water withdrawals[1]	Share of total irrigation water withdrawals originating as surface water[2]
	Percent	
Arizona	85	61
California	84	62
Colorado	91	78
Idaho	99	65
Kansas	12	5
Montana	98	99
Nebraska	42	29
Nevada	86	69
New Mexico	95	54
North Dakota	3	52
Oklahoma	14	18
Oregon	82	92
South Dakota	74	64
Texas	23	34
Utah	90	86
Washington	82	88
Wyoming	96	97

[1]"Total surface water withdrawals" include surface water withdrawals by all sectors, including municipal, industrial, irrigation, livestock, mining, and thermoelectric power. [2]"Total irrigation water withdrawals" include withdrawals of ground water and surface water.

Source: Solley, Pierce, and Perlman, 1993.

Water Diversion and Consumption

The diversion of water from river systems and the consumption of water are two related, but distinct, components in agriculturally related disruption of river ecosystems. Water diverted from rivers for irrigation meets several distinct fates. Some portion of water diverted is consumed by crops or evaporates, and thus is no longer available for other uses. Water that is not consumed or does not evaporate (consumptive uses) may seep through diversion canals or root zones, ultimately reentering the river system through lateral flows of ground water. However, the length of time before this water would be available for other uses can vary from region to region, basin to basin, and even within a relatively small section of a single watershed.

In the Snake River Basin in Idaho, for example, where the hydrologic link between surface water and ground water systems is strong, significant portions of diverted water—nearly all water not consumptively used—return to the river, much of it within a relatively short time (Frasier, Whittlesey, and Hamilton, 1992). Thus, it is possible that reductions in irrigation diversions would have minimal longrun benefits for the E/T salmon in the Columbia-Snake River Basin. Only reductions in consumptive uses of water will have a significant impact in increasing the volume of instream river flows in regions where most water not consumptively used rapidly returns to rivers. On the other hand, much of the excess irrigation water applied in California's San Joaquin River Basin enters saline ground water aquifers or is ultimately discharged as agricultural drainage high in salts and potentially containing toxic concentrations of elements such as selenium and molybdenum. Thus, water not consumptively used is lost to future beneficial uses. In this case, reduced diversions may generate significant improvements in habitat for E/T fish, even if consumptive use remains constant or increases.

In areas in which consumptive use is a relatively small proportion of total diversions, it is possible that significant improvements in habitat may be made with only minor modifications in irrigation practices and little or no shifts in commodity production. This is not necessarily the case, however, as the Idaho example illustrates.

water is diverted from the Snake River and its tributaries, and thus is related to habitat for 3 E/T salmon. Similarly, 85 percent of surface water withdrawals in Arizona are used for irrigation; the State also contains habitat for 17 E/T fish. Of the 17 Western States, agriculture accounts for less than 80 percent of surface water withdrawals only in Kansas, Nebraska, North Dakota, Oklahoma, South Dakota, and Texas (States in which significant quantities of ground water are extracted for agricultural purposes).[10] By comparison, agriculture accounts for only 33 percent of surface water withdrawals nationally.

The proportion of total water withdrawn that is actually consumed varies by State, ranging from 32 percent in Idaho to 96 percent in Kansas (Solley, Pierce, and Perlman, 1993). (Data on water consumption, in contrast to water withdrawals, are available only for total water resources rather than independently for surface water and ground water.) Irrigation accounts for the dominant share of water use regardless of whether use is measured by withdrawals or consumption. Westwide, irrigation accounts for 91 percent of total consumptive use of total water resources, ranging from 58 percent in Oklahoma to nearly 100 percent in Idaho (Solley, Pierce, and Perlman, 1993).

Surface Water-Irrigated Agriculture's Potential Role in Species Recovery

In riverine ecosystems, upstream activities nearly always affect the health of downstream habitat. With rivers traversing hundreds or thousands of miles, it is extremely difficult to pinpoint specific areas or practices with distinct implications for species survival. This difficulty is magnified in the case of migratory fish. Therefore, the analysis conducted here is not capable of determining cause and effect. Rather, by identifying areas of geographic intersection between species and agriculture, we find that most E/T fish species overlap, at least in a portion of their range, with areas of extensive irrigation.

Although reallocated irrigation water could be a major water source for fish and wildlife habitat, the potential contribution of agriculture to species recovery varies by river basin and species. Several aspects of this issue are beyond the scope of the analysis. First, because water flows downriver, increasing instream flow at an upstream location may improve downstream habitat quality. Second, in some cases, placement of fish screens on irrigation diversion intakes may be sufficient to aid recovery. Finally, where water quality problems associated with agricultural production contribute to species decline, modifications in chemical use, tillage, or irrigation technology may be required. Nevertheless, reductions in irrigation water use likely would aid in recovery of nearly all E/T fish in the western rivers.

Irrigated Cropland

To assess the geographic relationship between areas of irrigated agriculture and E/T fish species, we map the percentage of cropland that is surface water-irrigated in each county in the 17 Western States (fig. 4).[11,12] We distinguish between counties encompassing or adjacent to species habitat (fig. 3) and counties in which irrigation water is taken from a river containing an E/T species (fig. 4). This distinction, between proximity of irrigated areas to habitat and reliance of irrigated acreage on diversions from rivers that provide habitat, is important because the area in which mitigation and recovery actions are undertaken may not sufficiently describe the areas that would be affected by that action. For example, in California, the winter run of the Sacramento River chinook salmon is endangered by changes in spawning habitat (primarily increased water temperatures and dams) in the upper Sacramento River. Yet efforts to protect this species resulted in reduced water supplies to farms in the San Joaquin Valley, located hundreds of miles south of the spawning habitat.

Twenty-two percent of all counties in the West (235 counties) contain agricultural production that relies on surface water from river systems with E/T fish. That is, irrigated agriculture in these counties may be af-

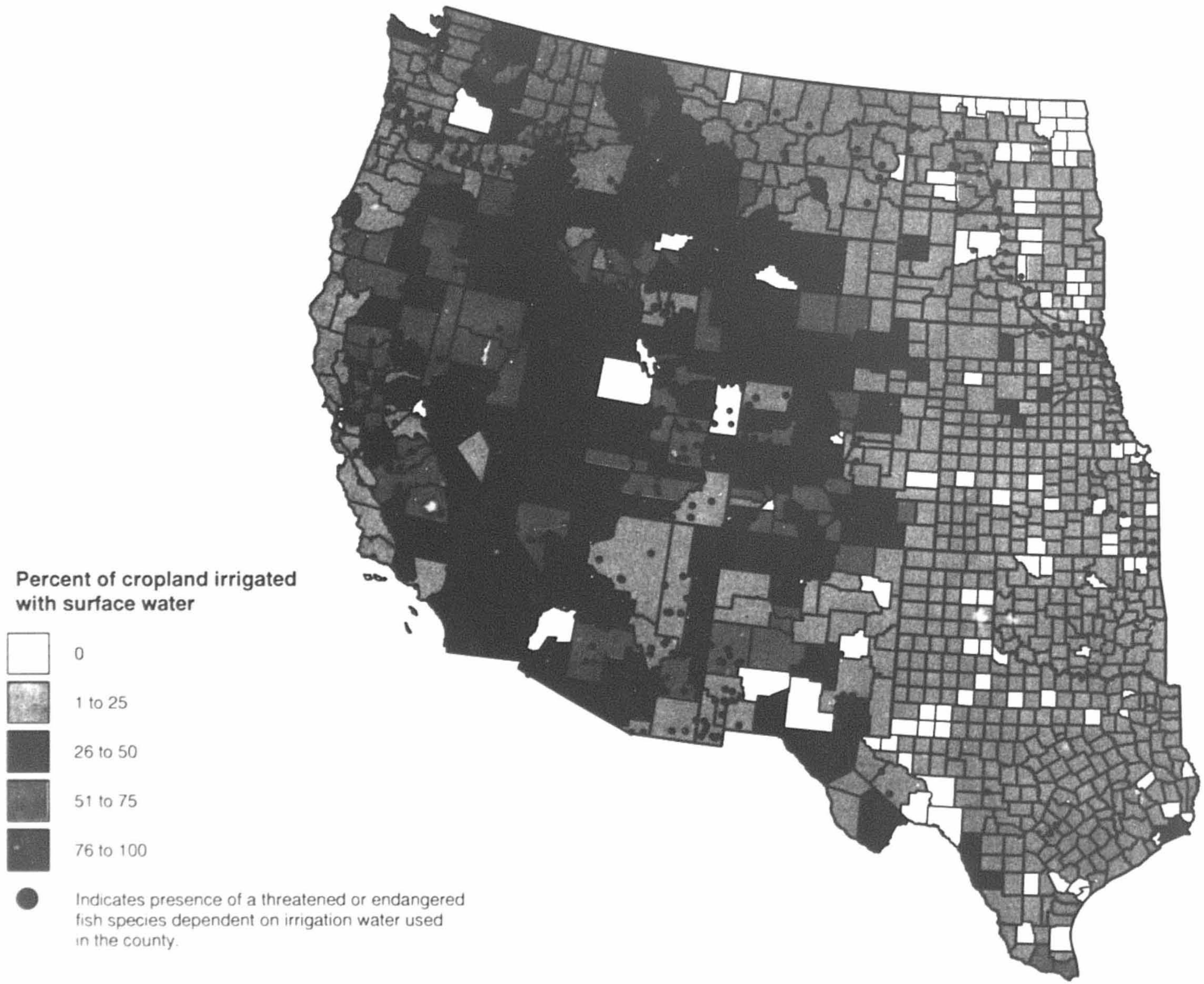
[10]The importance of surface water resources, relative to ground water resources, for irrigated agriculture can also be gleaned from table 1 (column 2). Surface water sources account for more than 85 percent of water used for irrigation in Montana, Oregon, Utah, Washington, and Wyoming. In contrast, surface water accounts for only 5 percent of irrigation water in Kansas, and for less than 35 percent in Nebraska, Oklahoma, and Texas.

[11]Our analysis uses data on the geographic pattern of irrigated agriculture from the 1982 and 1987 *Census of Agriculture* (U.S. Department of Commerce, Bureau of the Census, 1982 and 1987). The 1987 census is used wherever possible. However, the information on the source of irrigation water was gathered only in the 1982 census. Thus, the 1982 data were used to distinguish between surface and ground water-irrigated acres.

[12]The pattern of irrigated agriculture in terms of absolute acreage is generally similar to that presented in figure 4 in percentage terms, although important exceptions do occur. In counties with relatively little agriculture, high percentages would be associated with low acreage levels. Similarly, a few very large counties contain large expanses of irrigated acreage but even larger quantities of nonirrigated acreage, so that percentages are low even though the absolute figure is quite large. The advantage of the percentage figures is that they are not distorted by the absolute size of the county; they are presented here for that reason. Important exceptions are discussed later in this section.

Figure 4

Percent of cropland irrigated with surface water and agricultural land potentially affected by recovery measures for ESA-listed fish species, by county



Sources: U.S. Department of Commerce, 1990, and *Federal Register*, 1973-93.

fected, to some degree, by activities to recover species. These counties contain an estimated 10.35 million acres of cropland irrigated with surface water. Several comparisons provide context: 10.35 million acres exceeds half of all surface water-irrigated acres in the entire West; it exceeds a third of the harvested cropland acres in the 235 counties; and it equals four-fifths of the irrigated harvested cropland acres in these same counties.

The geographic intersection of agriculture and species has two important features. First, high concentrations of E/T fish species correspond with areas of extensive surface water irrigation. Irrigated areas of Idaho, California, Utah, and Colorado best reflect this relationship (fig. 4). The concentration of E/T fish in the Colorado River Basin correlates heavily with high rates of surface water irrigation in Colorado, Wyoming, Utah, and southeastern California. Similar correlations occur in the Columbia River Basin of Idaho, Washington, and Oregon, as well as in the Sacramento and San Joaquin Rivers in central California. Only in the Missouri River Basin, Kansas, and central Texas does the presence of an E/T fish species not correspond to areas of extensive surface water irrigation.

Anadromous fish, such as salmon, highlight the importance of a river-basin perspective. Because these fish migrate great distances between their inland rearing/spawning grounds and the ocean, they may be exposed to a number of different types of hazards. In the case of the Columbia-Snake River Basin, the relationship between extensive irrigated agriculture and E/T species is quite strong in southern Idaho, but is weak in the western portions of Washington and Oregon. Salmon are blocked from migrating to their historical spawning grounds in southern Idaho by Hells Canyon Dam. Nonetheless, surface water diverted and consumed upstream of Hells Canyon is available to aid in the downstream migration of juvenile salmon through the lower Snake River. Reducing irrigation in southern Idaho, consequently, has been proposed as a component of recovery plans for these species (Aillery and others, 1994).[13] In contrast, Oregon and Washington counties bordering the lower Columbia River have relatively little irrigated agriculture; reducing these irrigation activities would probably not contribute greatly to salmon recovery.

Second, nearly all counties reliant on surface water irrigation draw or receive water from rivers inhabited by at least one E/T fish species. Very few counties with greater than 50 percent of cropland acreage irrigated with surface water are free from an E/T species link. Exceptions to the rule typically can be explained. For example, counties in northern Wyoming with a high percentage of cropland acreage irrigated with surface water, but without a potential link to an E/T fish species, generally contain relatively low absolute acreages in crop production and relatively few acres irrigated. Conversely, counties in Texas and New Mexico (in the Pecos River Basin) show a potential link to E/T fish; these counties contain relatively small percentages of surface water-irrigated acreage, yet their absolute acreage is as large as 20,000 acres per county. Similarly, surface water-irrigated acreage in the three counties bordering the Columbia and Snake Rivers at their confluence represent only 14, 29, and 37 percent, respectively, of their total cropland, but contain relatively large amounts of surface water-irrigated acres (80,000; 131,000; and 172,000 acres).

These two features suggest that high concentrations of E/T fish correlate with extensive irrigated agriculture and, in addition, most areas with extensive surface-water irrigation rely on rivers containing habitat for E/T fish. It is therefore likely, with few exceptions, that counties with a relatively large amount—in either percentage or absolute terms—of irrigated agriculture will be affected to some degree by recovery measures undertaken in conjunction with ESA implementation.

The size of the irrigated area and the distinction between percent and absolute levels of irrigated acreage may be important in terms of potential impact on the agricultural economy. Where E/T fish are associated with areas of extensive surface water irrigation, water conservation could produce significant instream flow for fish habitat while keeping each farmer's conservation effort relatively small. However, where E/T fish species are linked to counties with relatively small areas of surface water irrigation, reducing agricultural water use enough to improve fish habitat may prove difficult without significant conservation requirements and production modifications from individual farmers.

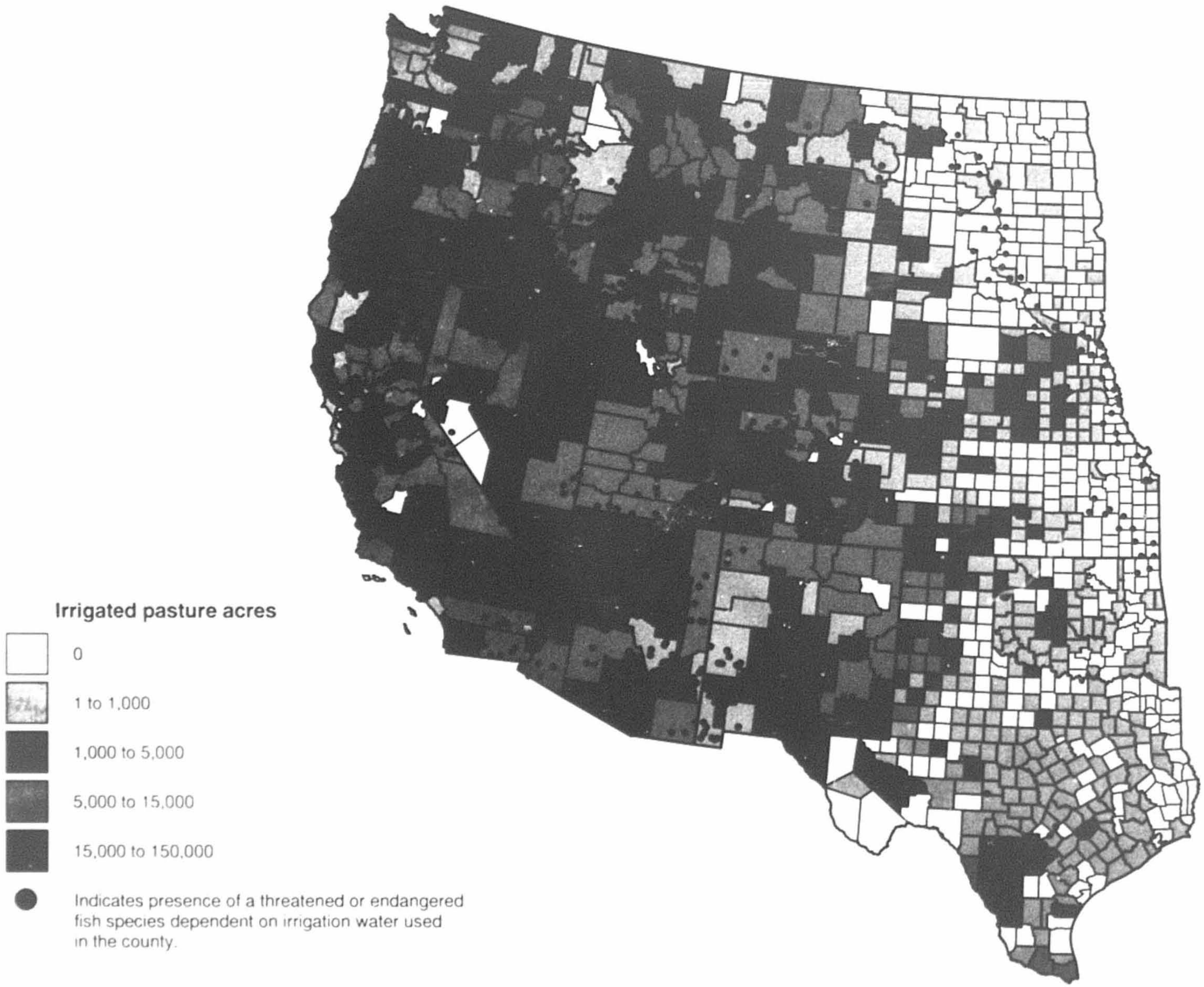
Irrigated Pasture

Irrigated pasture is examined separately from irrigated cropland (fig. 5). Irrigated pasture can harm fish through soil erosion and trampling of spawning beds by grazing livestock, as well as through surface water diversions. Thus, reduced diversions for irrigated pasture may produce both increased instream flows and reduced damage to species from livestock grazing activities. This aspect of our screening involves a weaker link than the cropland screen: damage from grazing occurs

[13] The discussion of Columbia River Basin salmon should not be construed as implying that irrigation activity in southern Idaho is the main cause of salmon population declines. Hazards such as hydroelectric power production and associated dams in the lower Snake and Columbia Rivers likely are more important causes of salmon decline than irrigation in southern Idaho.

Figure 5

Irrigated pasture acreage and agricultural land potentially affected by recovery measures for ESA-listed fish species, by county



Sources: U.S. Department of Commerce, 1990, and *Federal Register*, 1973-93 only where livestock are in immediate proximity to the streams and spawning grounds, but we do not have data on the location of livestock within the county.

As with irrigated cropland, links to E/T species tend to be concentrated in counties with extensive irrigated pasture. The upper Colorado River Basin, the Columbia River Basin, and the Central Valley region of California show this correlation. Likewise, nearly all counties with extensive acreage devoted to irrigated pasture (greater than 5,000 acres of irrigated pasture) are associated with at least one E/T species and, therefore, are likely to be affected to some degree by recovery measures undertaken to protect those species.

Potential Cost to Agriculture of E/T Species Recovery Measures

The cost to agriculture (in terms of reduced revenues, production shifts, and increased costs) of reducing water use may be significant. The value of crop production by surface water-irrigated agriculture varies significantly across the 17 Western States (fig. 6).[14] California generates the highest average, with a value greater than $1,200 per acre. Arizona and Washington rank high, while the Great Plains States, which rely heavily on ground water for irrigation, generate comparatively low values.

To examine county-level differences and to place these values in the context of total value of agricultural production, we studied the geographic distribution of per acre revenues from crop and pasture production activities (fig. 7). Values are presented on a per acre basis to account for differences in county size. Acreages generating revenues greater than $500 per acre are contained primarily in California, southern Arizona, and Washington. Western Oregon, southwestern New Mexico, and the western tip of Texas also contain several counties with high-value production. Each of the high-value regions relies heavily on irrigation with surface water. Other statistics also convey the importance of surface water in generating these high values. On average, only 9 percent of acreage is irrigated in counties with average revenues less than $150 per acre (table 2). In contrast,

[14]The values presented here are gross revenues. The high values that exist for irrigated acreage are partially offset by higher variable costs associated with irrigated production. Compared with farmers who do not irrigate their crops, farmers who do irrigate their crops spend, on average, two to three times as much on agricultural chemicals and energy inputs, five to six times as much on labor, and have twice the value of machinery and equipment and investment in land and buildings (Bajwa and others, 1992). Crop production involves many inputs, with the gross revenues reflecting the contribution of all the inputs. Farmers with lower valued production may have higher profits than irrigated farmers due to lower costs. Although not addressed in this report, the higher chemical use levels associated with irrigated agriculture could imply a water quality link to E/T fish.

Table 2—Distribution of irrigated acreage, by value of production category

Value of crop production	Share of cropland irrigated with surface water	Share of cropland irrigated
Dollars/acre	*Percent*	
0-75	8	10
76-150	9	16
151-500	20	38
501-1,000	57	92
>1,000	69	95

Figure 6

Estimated value of crop production irrigated with surface water, 17 Western States, 1987

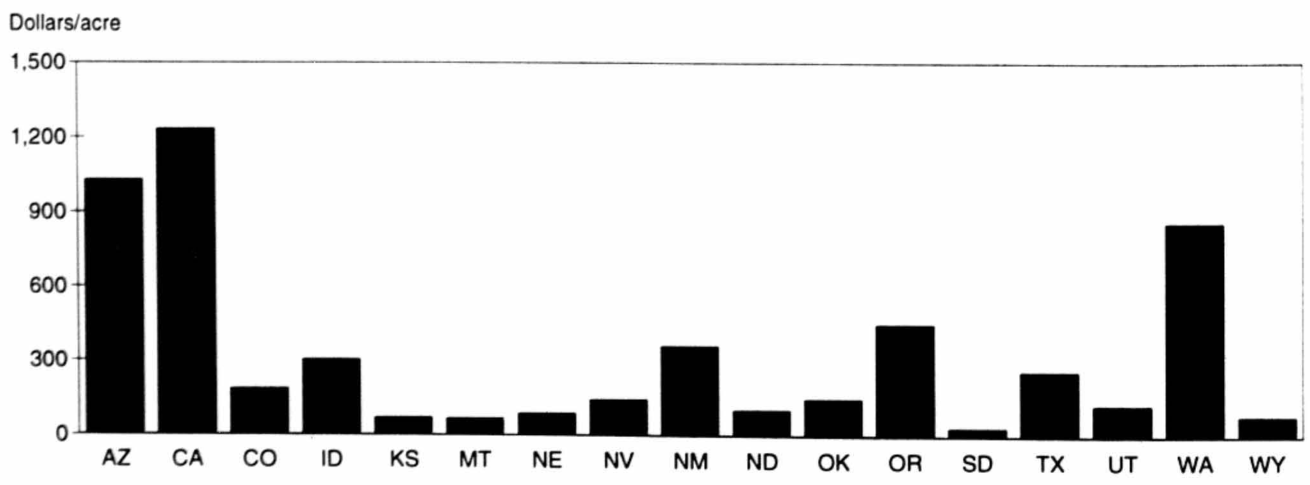
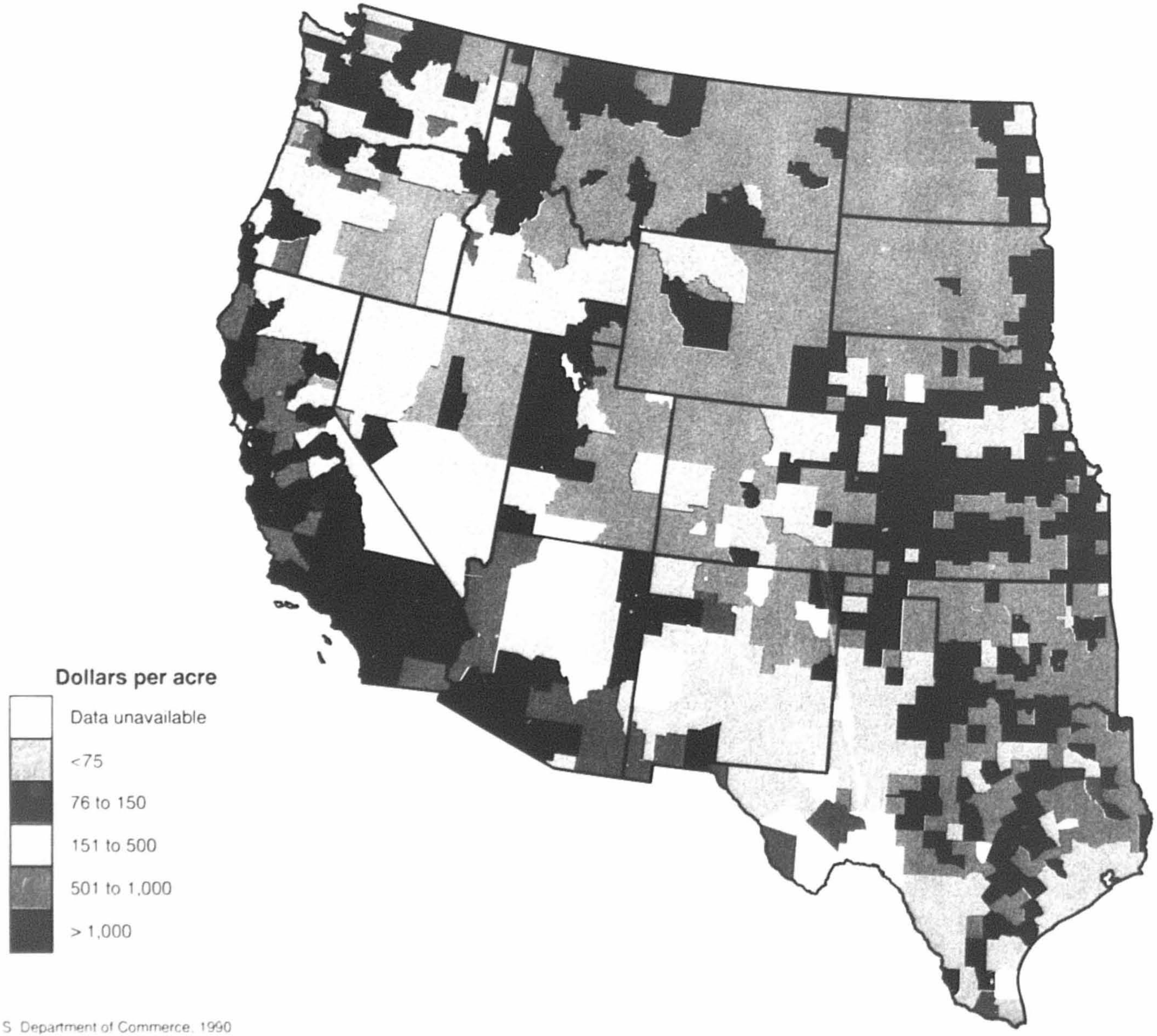


Figure 7

Value per acre of total crop sales, by county



Source: U.S. Department of Commerce, 1990

66 percent of acreage is irrigated with surface water in counties with average revenues greater than $500 per acre.

Reallocating irrigation water to endangered species habitat will probably adversely affect this high-valued agriculture because of its dependence on surface water for irrigation. Likewise, if disruption in water supplies occurs, potential costs are high.

A Single Measure of the Species-Agriculture Relationship

A summary measure of the potential conflict between agricultural output and species recovery is created by combining the county-level data on agricultural value, surface water irrigation, and E/T fish species. Three items are multiplied together to compute the measure: value of agricultural output (dollars per acre), land irrigated with surface water (acres), and E/T fish species conceivably affected by irrigated agriculture in the county (number of species). The measure reflects a premise that the severity of the potential conflict increases with each of the three underlying factors and, moreover, depends on interaction among the three. While the premise is reasonable as a general rule, exceptions are likely to occur.

The measure is translated into index form by dividing by the largest county value of the measure. The index ranges from 0 to 1, with 1 representing counties with significant potential for agricultural output/species recovery conflict. Regions rated relatively high are concentrated in southern Arizona, California, and the Columbia-Snake River Basin (fig. 8). The index value for 14 counties in these regions exceeds 0.15; these 14 counties represent 7 percent of the counties with potential conflicts. In the remaining counties, the possible impact on agricultural output value appears minor, relative to the above-mentioned regions.

The ultimate effect of endangered fish recovery on western irrigated agriculture depends on features of ESA implementation. In practice, four major factors could determine the magnitude of impact on the agricultural sector: the volume of water needed by E/T fish; the extent to which the burden is shared broadly throughout the agricultural sector rather than concentrated on a relatively small number of producers; the effect of agricultural water-supply reductions on agricultural profitability; and the extent to which producers receive financial compensation for their water-supply reductions.

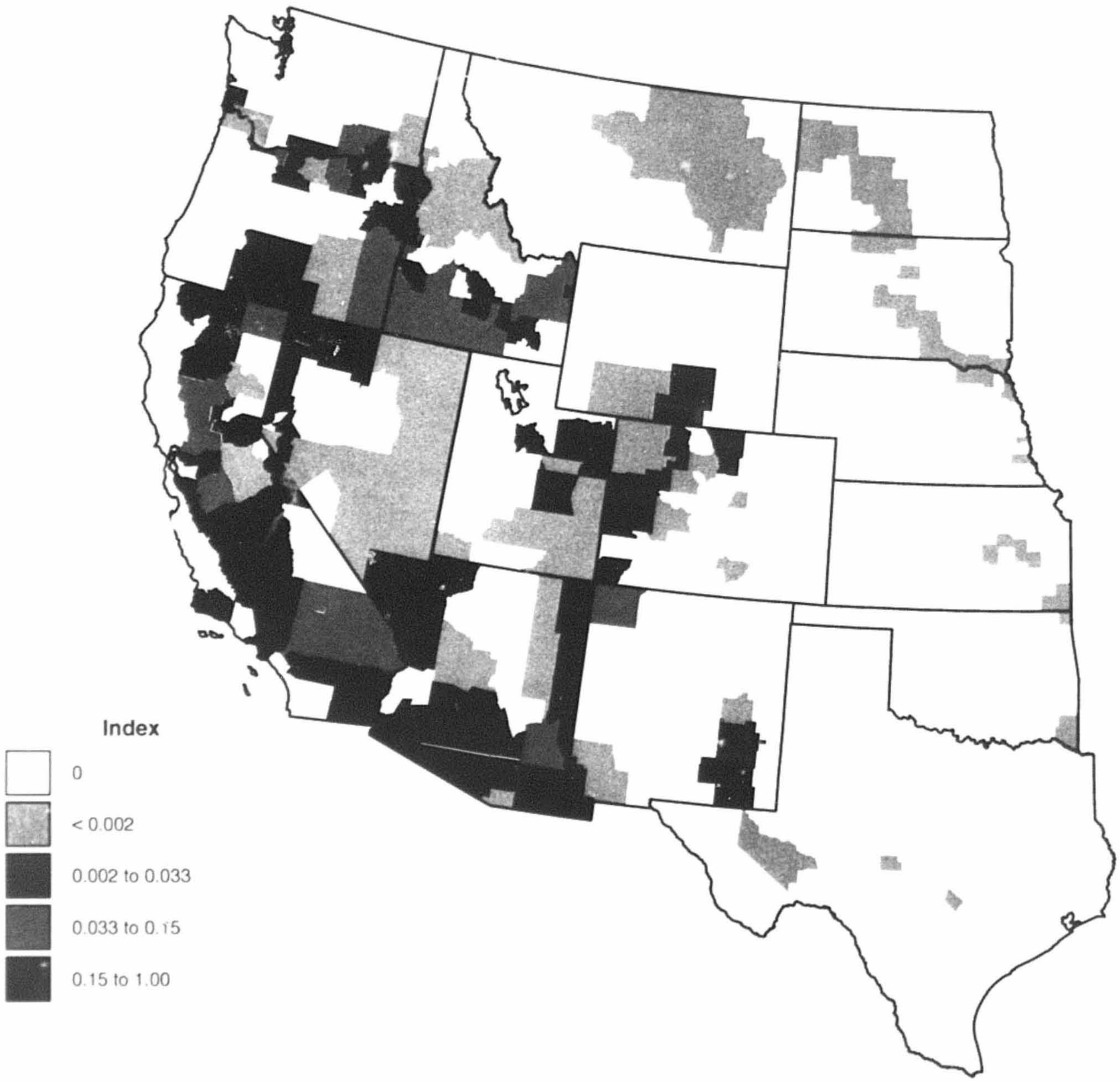
Conclusions

Potential water allocation conflicts exist between endangered fish and irrigated agriculture in the American West. Water development for agriculture is one factor in the decline of most E/T fish species in western rivers. A screening analysis of major geographic intersections between E/T fish habitat and surface water-irrigated agriculture found that: (1) 235 counties (22 percent of the counties in the West) contain irrigated production that relies on water from river systems with E/T fish species, (2) areas generating the highest revenues per acre from crop production are those most dependent on surface-water irrigation, and (3) these same areas are also most likely to be drawing water from rivers that contain at least one E/T species. These three findings have two major implications. First, policies or programs designed to promote irrigation water conservation may be necessary to increase instream flow for habitat improvement. Second, such efforts may significantly reduce agricultural revenue from crop production in some areas of the West. Future research is needed to determine the amount of water required for species recovery in western rivers and the least-cost method of acquiring the water.

The water allocation dilemma between endangered species and agricultural production is reaching a critical stage. Recovery plans have yet to be approved for approximately 60 percent of the 68 western threatened and endangered fish. In addition, 86 western fish listed as candidate species (species awaiting a final listing decision) could swell the numbers of ESA-listed fish. ESA implementation, consequently, could soon mandate actions for fish conservation, with implications for irrigated agriculture throughout much of the West. One possible response to this dilemma would involve proactive policy development. The Bureau of Reclamation, the largest supplier of irrigation water in the West, has recognized that proactive measures could alleviate pressure for more drastic measures that frequently accompany official ESA listing. In its Strategic Plan for Instream Flows, Reclamation notes:

> It will be advantageous for Reclamation and its traditional constituents to cooperate in efforts to support or re-establish plant and animal habitat before species become listed as threatened or endangered. Once listing occurs and critical habitat is identified, the legal requirements for protection and recovery take effect and resulting operational restrictions may severely affect established uses. The prospect of mandated actions creates incentive for a proactive role (U.S. De-

Figure 8
Index of potential conflict between surface-water irrigated agriculture and ESA-listed fish species



partment of the Interior, Bureau of Reclamation, 1992, p. 34-35).

In this light, the ESA creates the potential—either directly through implementation or indirectly through an incentive for proactive measures—for reallocation of water from irrigation to instream flow for habitat improvement.

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Appendix table 1—Western endangered and threatened fish

Species	Year listed and status	Currently occupied habitat	State(s)	Federal expenditures ($1,000) FY1990	FY1991
Yaqui catfish	1984-T	San Bernardino Creek	AZ	33.0	37.5
Ozark cavefish	1984-T	Springfield Plateau caves	OK	29.4	8.1
Bonytail chub	1980-E	Upper/lower Colorado River System	AZ, CA, CO, NV, UT, WY	292.3	243.9
Borax Lake chub	1982-E	Borax Lake	OR	30.0	5.8
Chihuahua chub	1983-T	Mimbres River	NM	18.4	30.2
Humpback chub	1967-E	Upper/lower Colorado River System	AZ, CO, UT	403.6	2,773.0
Hutton Spring tui chub	1985-T	Hutton/Three-eighths springs	OR	.4	1.3
Mojave tui chub	1970-E	Soda Springs	CA	24.0	35.0
Owens tui chub	1985-E	Owens River System	CA	15.4	2.0
Pahranagat roundtail chub	1970-E	Pahranagat River	NV	16.7	36.8
Sonora chub	1986-T	Sycamore Creek System	AZ	2.9	3.0
Virgin River chub	1989-E	Virgin River	AZ, NV, UT	27.8	46.6
Yaqui chub	1984-E	Rio Yaqui Basin	AZ	50.0	0.5
Cui-ui	1967-E	Truckee River/Pyramid Lake	NV	692.6	310.3
Ash Meadows speckled dace	1983-E	Ash Meadows Springs	NV	45.0	10.9
Clover Valley speckled dace	1989-E	Clover Valley Springs	NV	0.1	0.0
Desert dace	1985-T	Soldier Meadows Springs	NV	0.6	13.6
Foskett speckled dace	1985-T	Warner Valley Spring	OR	0.0	0.8
Independence Valley speckled dace	1989-E	Independence Valley Spring	NV	0.1	0.0
Kendall Warm Springs dace	1970-E	Kendall Warm Springs	WY	2.0	0.3
Moapa dace	1967-E	Springs off the Moapa River	NV	54.6	32.5
Fountain darter	1970-E	San Marcos/Comal Rivers	TX	42.7	10.2
Leopard darter	1978-T	Little River	OK	58.4	23.5
Big Bend gambusia	1967-E	Springs in Big Bend National Park	TX	13.3	18.0
Clear Creek gambusia	1967-E	San Sabe River/Clear Creek	TX	2.8	0.0
Pecos gambusia	1970-E	Pecos/Lost Rivers	NM, TX	8.1	17.2
San Marcos gambusia	1980-E	San Marcos River	TX	14.7	4.0
Pahrump killifish	1967-E	Pahrump Valley Springs transplanted	NV	10.5	10.7
Neosho madtom	1990-T	Neosho River	KS, OK	14.2	30.5
Loach minnow	1986-T	Gila River System	AZ, NM	34.5	36.7
Ash Meadows Amargosa pupfish	1983-E	Ash Meadows Spring System	NV	48.0	22.9
Comanche Springs pupfish	1967-E	Springs in the Pecos River drainage	TX	10.0	15.6
Desert pupfish	1986-E	Salton Sea System/Quitobaquito Spring	AZ, CA	53.3	46.3
Devil's Hole pupfish	1967-E	Devil's Hole Spring	NV	54.3	18.7
Leon Springs pupfish	1980-E	Diamond Y Spring and outflow	TX	9.9	18.7
Owen's pupfish	1967-E	Fish Slough Spring System	CA	15.0	0.0
Warm Springs pupfish	1970-E	Ash Meadows Spring System	NV	45.0	22.8
Sacramento River winter-run chinook salmon	1990-E	Sacramento River System	CA	2,306.5	5,487.7
Snake River fall chinook salmon	1992-T	Columbia River System	ID, WA, OR	NA	NA
Snake River spring/summer chinook salmon	1992-T	Columbia River System	ID, OR, WA	NA	NA

Continued—

Appendix table 1—Western endangered and threatened fish—cont'd

Species	Year listed and status	Currently occupied habitat	State(s)	Federal expenditures ($1,000) FY1990	FY1991
Sockeye salmon	1992-E	Columbia River System	OR, WA	NA	NA
Beautiful shiner	1984-T	Rio Yaqui/Guzman basins	AZ, NM	27.0	22.0
Pecos bluntnose shiner	1987-T	Pecos River	NM	33.8	100.4
Delta smelt	1993-T	Sacramento River	CA	NA	NA
Spikedace	1986-T	Gila River System	AZ, NM	35.4	18.7
Big Spring spinedace	1985-T	Meadow Valley Wash	NV	32.5	11.6
Little Colorado spinedace	1987-T	Little Colorado River System	AZ	57.7	876.0
White River spinedace	1985-E	Upper White River Spring System	NV	6.6	17.6
Hiko White River springfish	1985-E	Crystal Springs	NV	8.6	10.3
Railroad Valley springfish	1986-T	Railroad Valley Springs	NV	7.3	14.6
White River springfish	1985-E	Ash Springs	NV	6.5	8.8
Colorado squawfish	1967-E	Upper/lower Colorado River systems	AZ, CA, CO, NM, UT, WY	2,168.6	3,669.5
Unarmored threespine stickleback	1970-E	Santa Clara River System/ San Antonio Creek	CA	23.2	14.2
Pallid sturgeon	1990-E	Mississippi/Missouri/Yellowstone Rivers	KS, MT, NB, ND, SD	268.0	478.2
June sucker	1986-E	Utah Lake and tributaries	UT	30.8	131.4
Lost River sucker	1988-E	Klamath Lake and tributaries	CA, OR	24.7	188.0
Modoc sucker	1985-E	Pit River System	CA	31.4	8.8
Razorback sucker	1991-E	Upper/lower Colorado River systems	AZ, CA, CO, NM, NV, UT	NA	NA
Short-nose sucker	1988-E	Klamath Lake and tributaries	CA, OR	22.9	188.0
Warner sucker	1985-T	Warner Basin Drainage	OR	30.3	55.6
Gila topminnow	1967-E	Gila River System	AZ, NM	159.0	99.3
Apache trout	1975-T	Salt/Verde/Little Colorado River headwaters	AZ	281.2	84.3
Gila trout	1967-E	Gila River System	AZ, NM	27.7	69.1
Greenback cutthroat trout	1978-T	S. Platte/Arkansas River system headwaters	CO	100.5	90.8
Lahontan cutthroat trout	1975-T	Lahontan Basin System	CA, NV	1,645.8	1,597.7
Little Kern golden trout	1978-T	Little Kern River	CA	43.6	1.8
Paiute cutthroat trout	1975-T	Silver King Basin	CA	50.0	41.8
Woundfin	1970-E	Virgin River	AZ, NV, UT	37.0	75.6

NA = Not available. FY = Fiscal year.

Note: Shaded rows are E/T fish without an agricultural link to their status.

Sources: Official listings of 33 individual species that appear in the Federal Register; official Recovery Plans of 32 individual species published by U.S. Fish and Wildlife Service (USFWS) (U.S. Department of the Interior, U.S. Fish and Wildlife Service, miscellaneous recovery plans); official reports to the U.S. Congress made by USFWS (U.S. Department of the Interior, U.S. Fish and Wildlife Service, 1990) and National Marine Fisheries Service (U.S. Department of Commerce, National Marine Fisheries Service, 1991); and USFWS publications on expenditures on species recovery (U.S. Department of the Interior, U.S. Fish and Wildlife Service, 1991, 1992).

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