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Water Allocation in the American West: Endangered Fish versus Irrigated Agriculture

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ABSTRACT

This research analyzes potential water allocation conflicts between endangered fish species and irrigated agriculture in western river systems. Through geographic and statistical analyses of county-level data sets for all 17 western states, we describe a pattern of mutual dependence on limited water resources. The numbers that characterize the conflict appear large when totaled across the West: 50 fish species listed under the Endangered Species Act are linked to agricultural activity, and 235 counties contain irrigated production that relies on water from rivers with ESA-listed fish. Statistical results show that the number of ESA-listed species in a county correlates positively with the level of agriculture reliant on surface water in the county. Three features of the Reclamation program—its pervasive presence throughout the West, substantial water deliveries to agriculture, and federal-agency responsibilities under the ESA—make it possible to develop a leadership role for the Bureau of Reclamation in species recovery.

I. INTRODUCTION

Implementation of the federal Endangered Species Act (ESA) may prove to be the litmus test of the extent to which existing water-use patterns in the American West can accommodate contemporary environmental values. Many commentators have written of the need to balance traditional western water uses and new demands for instream water for ecosystem protection, river-based recreation, and aesthetic appreciation.[1]

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See Deborah Moore & Zach Willey, *Water in the American West: Institutional Evolution and Environmental Restoration in the 21st Century*, 62 U. COLO. L. REV. 775 (1991); CHARLES F. WILKINSON, CROSSING THE NEXT MERIDIAN: LAND, WATER, AND THE FUTURE OF THE WEST

This need exists alongside a long-dormant tension between the historic state primacy in water law and a recently-exercised federal prerogative to develop environmental and natural resource laws that affect western water rights.[2] This set of needs and tensions is apparent in implementation of the Clean Water Act, the Wild and Scenic Rivers Act, and the ESA, as well as in assertion of federal water rights for public lands.[3]

The ESA poses a particularly difficult test for western water allocation for three reasons. First, the ESA *requires* competing interests to bend, at least to some degree, to the goal of species preservation. The criterion for ESA listing defines a strictly biological standard for invoking the law, with clear procedural guidelines for critical habitat designation and recovery plan development to be followed after listing. Second, the history of western water resource development, in tandem with obligations delineated in the ESA, places the federal government near the center of riverine and riparian species protection in the West. The federal Bureau of Reclamation played a prominent, critical role in western river development. Its responsibilities continue, in the form of managing a vast infrastructure of water projects and supplies throughout the West. Simultaneously, the ESA imposes special obligations on federal agencies for ESA compliance. And third, the absolute number of ESA-listed species reliant on western water resources appears to be large. Sixty-eight fish species are listed as endangered or threatened in the 17 western states,[4] with an additional 86 fish species officially designated as candidate species.[5] Although not addressed systematically in this analysis, many plants and animals from other taxonomic groups also rely on western rivers for critical habitat.[6] In particular, 184 individual species with

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(1992).

2. *See* Lawrence MacDonnell, *Federal Interests in Western Water Resources: Conflict and Accommodation*, 29 NAT. RESOURCES J. 389 (1989); Joseph L. Sax, *The Constitution, Property Rights and the Future of Water Law*, 61 U. COLO. L. REV. 257 (1990); A. Dan Tarlock, *The Endangered Species Act and Western Water Rights*, 20 LAND & WATER L. REV. 1 (1985).

3. On the general issue of western water rights, the ESA, and endangered fish, *see also* James H. Bolin, Jr., *Of Razorbacks and Reservoirs: The Endangered Species Act's Protection of Endangered Colorado River Basin Fish*, 11 PACE ENVTL. L. REV. 35 (1993); Melissa K. Estes, *The Effect of the Federal Endangered Species Act on State Water Rights*, 22 ENVTL. L. 1027 (1992); and SCOTT W. REED, *Fish Gotta Swim: Establishing Legal Rights to Instream Flows through the Endangered Species Act and the Public Trust Doctrine*, 28 IDAHO L. REV. 645 (1991-1992).

4. Western fish species comprise over 70 percent of the ESA-listed fish; fish species, in turn, comprise roughly 25 percent of the ESA-listed animal species. *See* FISH AND WILDLIFE SERVICE, U.S. DEPARTMENT OF THE INTERIOR, ENDANGERED AND THREATENED SPECIES RECOVERY PROGRAM (1990).

5. The information presented on numbers of endangered, threatened, and candidate fish species reflects their status as of August 1993.

6. This article focuses on ESA-listed species of fish because of their obvious link to water allocation tradeoffs in western river systems. However, other endangered species also

habitat affected by federal Reclamation projects and water service areas are either listed or proposed for listing under the ESA.[7]

The role of reallocating water from agriculture to habitat restoration should be assessed when crafting plans for species protection in western river systems. For more than a century, river development and diversion provided the foundation for agricultural settlement of arid lands in the "second opening of the West."[8] Irrigated agriculture now dominates western water consumption, with agricultural use comprising 91 percent of total regional consumption of freshwater resources.[9] Surface water—water diverted from rivers and streams—provides more than 60 percent of the water for irrigated agriculture.[10] The Bureau of Reclamation delivers more than one-third of the surface water consumed by western irrigated agriculture.[11]

Riverine and riparian wildlife, not to mention the rivers themselves, were sacrificed for western river development.[12] For instance, dams or water diversions impede the migration patterns of several endangered fish species: Chinook salmon in both the Columbia River Basin and California's Sacramento River Basin, the cui-ui in Nevada's Truckee River, and the Colorado River squawfish.[13] The link to irrigated agriculture is documented in many cases, with "agricultural activities" recorded as one of the "factors in decline" for 50 of the 68 western ESA-listed fish species.[14]

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rely heavily on riverine and riparian ecosystems in the West. For example, one study concentrated on threatened animal species in Arizona and New Mexico that rely on riparian zones for habitat (where "threatened" is used generally rather than narrowly in the context of ESA listing). AUBREY S. JOHNSON, THE THIN GREEN LINE: RIPARIAN CORRIDORS AND ENDANGERED SPECIES IN ARIZONA AND NEW MEXICO, *in* IN DEFENSE OF WILDLIFE: PRESERVING COMMUNITIES AND CORRIDORS (Gay Mackintosh ed., 1989). In addition to 49 fish species in the two states, the list includes 50 birds, 17 mammals, 15 amphibians, and 12 reptiles. Other examples of ESA species dependent on riparian habitat include the whooping crane and bald eagle. More generally, water development is identified as the cause or potential cause of endangerment of approximately one-third of all ESA-listed plant and animal species. ELIZABETH LOSOS ET AL., TAXPAYERS' DOUBLE BURDEN: FEDERAL RESOURCE SUBSIDIES AND ENDANGERED SPECIES (1993). Thus, the description and analysis of this report presents only a partial screen of the endangered species-agriculture water allocation dilemma.

7. BUREAU OF RECLAMATION, U.S. DEP'T OF THE INTERIOR, PROPOSED ACREAGE LIMITATION AND WATER CONSERVATION RULES AND REGULATIONS 3-85 (1995).

8. WALLACE E. STEGNER, THE AMERICAN WEST AS LIVING SPACE (1987).

9. WAYNE B. SOLLEY ET AL., GEOLOGICAL SURVEY, U.S. DEP'T OF THE INTERIOR, ESTIMATED USE OF WATER IN THE UNITED STATES IN 1990, 13 (1993).

10. *Id.* at 37.

11. BUREAU OF RECLAMATION, *supra* note 7.

12. STEGNER, *supra* note 8, at 50.

13. PETER MATTHIESSEN, WILDLIFE IN AMERICA 271-73 (2d ed. 1987).

14. Thirty-three *Federal Register* issues between 1973 and 1993 contained the official listings of western fish species as endangered or threatened under the Endangered Species

The potential for pervasive conflict between established water uses and endangered species for western river allocation has been recognized for over a decade. In congressional hearings on the 1982 Amendments to the ESA, western water interests raised concerns about the potential for the ESA to modify existing interstate apportionments of rivers and intrastate allocations of water rights.[15] An attempt was made to amend the ESA to make ESA-related water claims secondary to state administrative systems and their established water rights.[16] This effort proved largely unsuccessful, as Section 2 of the law was amended to make only a relatively weak policy statement: "It is further declared to be the policy of Congress that Federal agencies shall cooperate with State and local agencies to resolve water resource issues in concert with conservation of endangered species."[17] Of note, though, is that a parallel ESA policy statement was not attached concerning resolution of land resource issues. Western water interests had left their imprint on the ESA.

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 U.S. Congress will likely consider ESA reauthorization in the 1995-1996 legislative term. Wilkinson provides a recent perspective on the topic:

> A fast-emerging matter of federal law [concerning western water] involves the Endangered Species Act. The Endangered Species Act 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.[18]

The impact of the ESA on river use continues to be one of the great uncertainties in western water resource allocation.

Act. *See, e.g.*, Endangered and Threatened Wildlife and Plants: Determination of Threatened Status for the Delta Smelt, 58 Fed. Reg. 12,854 (1993)(to be codified at 50 C.F.R. § 17).

15. Tarlock, *supra* note 2, at 19.

16. This attempt was to amend the ESA in a manner similar to § 101(g) of the Clean Water Act, which reads

> It is the policy of Congress that the authority of each State to allocate quantities of water within its jurisdiction shall not be superseded, abrogated or otherwise impaired by this chapter. It is further the policy of Congress that nothing in this chapter shall be construed to supersede or abrogate rights to quantities of water which have been established by any State.

Federal Water Pollution Control Act, 33 U.S.C. § 1251(g) (1994).

17. Endangered Species Act of 1973, 16 U.S.C. § 1531(c)(2) (1994).

18. WILKINSON, *supra* note 1, at 283.

This research addresses potential water-allocation conflicts between endangered fish species and irrigated agriculture as a systemic western issue. Section II reports baseline conditions for ESA-listed fish species and irrigated agriculture in the West. It describes several aspects of the protected fish species, including their number and geography. A parallel discussion also occurs on the extent and geography of irrigated agriculture reliant on western surface water, including water developed by the Bureau of Reclamation. Section III conducts a statistical analysis of the relationship between endangered fish species and irrigated agriculture. The analysis uses two west-wide, county-level data sets on the number of ESA-listed fish species, along with several variables on the extent of agriculture, irrigation, and Reclamation water supply in the county. Section IV considers the analytical results in light of developments in federal water policy and ESA implementation, examined through recent experience in central California and the Columbia River Basin. Section V considers two alternative roles for the Bureau of Reclamation in endangered species recovery in western river systems. Section VI summarizes the major findings and conclusions of the research.

II. DIMENSIONS OF ENDANGERED FISH-AGRICULTURE WATER ALLOCATION TRADEOFFS

A. Physical Setting

Freshwater fisheries require certain volumes of instream water flow to be sustained. Thirty percent of average annual flow can be considered the minimum quantity necessary to protect instream water uses.[19] River flows fail to meet this benchmark in the southern portions of California and Arizona, 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.[20] (See Figure 1 for a map of major western rivers.)

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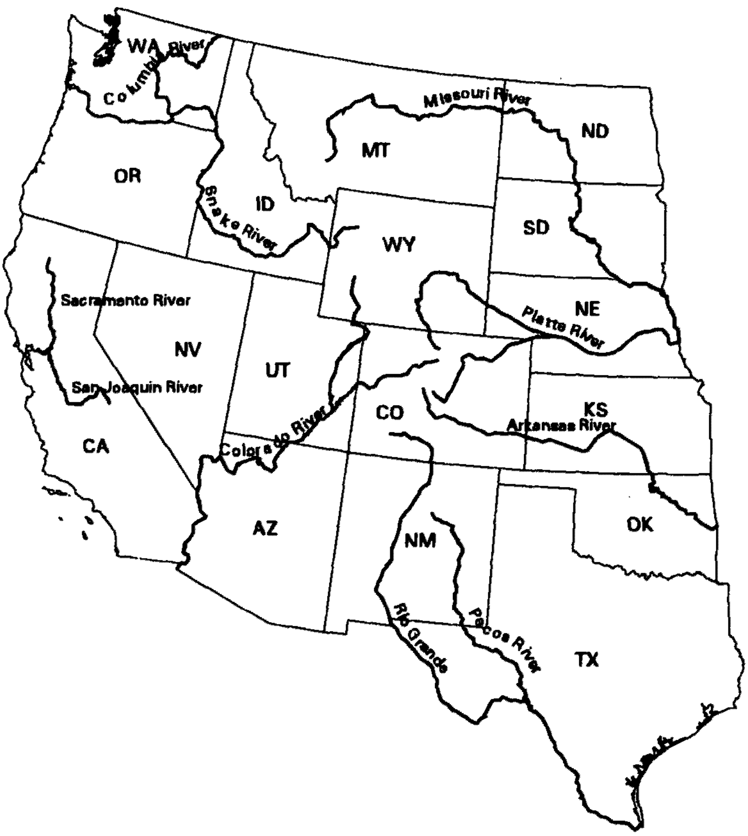
19. KEITH BAYHA, FISH AND WILDLIFE SERVICE, U.S. DEP'T OF THE INTERIOR, INSTREAM FLOW METHODOLOGIES FOR REGIONAL AND NATIONAL ASSESSMENTS 39-40 (1978). The following "rules of thumb" define three levels of habitat quality. One, 10 percent of average flow is necessary to provide short-term survival habitat for most life forms. Rivers in this category are defined as "severely depleted." Two, 30 percent of average flow will sustain good survival habitat for most life forms. Rivers at 10 to 30 percent are "under stress." Three, 60 percent of average flow will provide excellent to outstanding habitat. Rivers with flows of 30 to 60 percent are termed "degraded." DONALD TENNANT, FISH AND WILDLIFE SERVICE, U.S. DEP'T OF THE INTERIOR, INSTREAM FLOW REGIMES FOR FISH, WILDLIFE, RECREATION, AND RELATED ENVIRONMENTAL RESOURCES 19-23 (1975).

20. BAYHA, *supra* note 19, at 43.

One obvious remedy for these conditions is water reallocation from offstream, consumptive uses to instream flow.

In the narrower context of ESA-listed western fish species, factors contributing to decline of a species are reported in the *Federal Register* at the time of formal ESA listing. "Physical habitat alterations"—including

Figure 1. Major Western Rivers



water diversions, dams, reservoirs, channeling, and watershed disturbances—are the most frequently cited factor.[21] "Agricultural activities" are a factor in the decline of almost 75 percent of these species.[22]

B. Endangered and Threatened Fish Species in the West

For purposes of analysis, this research focuses on western fish species protected under the ESA.[23] The ESA-listed fish species, though, are symptomatic of a general decline in ecosystem functioning of the West's rivers. Evidence has accumulated in the biological literature of significant decline of species richness and biodiversity in western aquatic systems.[24] Two examples illustrate the gravity of the problem. First, according to Moyle and Williams' analysis of native fish species in California:

> Of 113 native fishes, 7 are extinct, 14 are officially listed as threatened or endangered, 7 deserve immediate listing, 19 are in serious trouble in their native range and may deserve listing soon if present trends continue, 25 show declining populations but are not yet in serious trouble or naturally have very limited ranges, and 41 appear to be secure. In all, 57 percent of the existing taxa have at least some need of special management if their populations are to continue to exist indefinitely.[25]

Second, Nehlsen et al. identified "214 native naturally-spawning Pacific salmon and steelhead stocks in California, Oregon, Washington, and Idaho that appear to be facing a high or moderate risk of extinction, or are of special concern."[26] In this context, designing efforts toward

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21. For example, *see* Federal Register, *supra* note 14, at 12,858-60.

22. *Id.* at 12,861.

23. For a somewhat related analysis that describes geographic patterns of species endangerment for the United States, *see* CURTIS H. FLATHER ET AL., FOREST SERVICE, U.S. DEP'T OF AGRICULTURE, SPECIES ENDANGERMENT PATTERNS IN THE UNITED STATES (1994).

24. For a general description of the health of aquatic ecosystems in the United States, *see* NATIONAL RESEARCH COUNCIL, RESTORATION OF AQUATIC ECOSYSTEMS: SCIENCE, TECHNOLOGY, AND PUBLIC POLICY (1992). *See also* Peter B. Moyle & Jack E. Williams, *Biodiversity Loss in the Temperate Zone: Decline of the Native Fish Fauna of California*, 4 CONSERVATION BIOLOGY 275 (1990); Willa Nehlsen et al., *Pacific Salmon at the Crossroads: Stocks at Risk from California, Oregon, Idaho, and Washington*, FISHERIES, March-April 1991, at 4; Jack E. Williams et al., *Fishes of North America Endangered, Threatened, or of Special Concern: 1989*, FISHERIES, Nov.-Dec. 1989, at 2; James D. Williams et al., *Conservation Status of Freshwater Mussels of the United States and Canada*, FISHERIES, Sept. 1993, at 6. For an analysis of biodiversity conservation in riverine ecosystems from a global perspective, *see* David J. Allan & Alexander S. Flecker, *Biodiversity Conservation in Running Water*, 34 BIOSCIENCE 32 (1993).

25. Moyle & Williams, *supra* note 24, at 278.

26. Nehlsen et al., *supra* note 24, at 4. A more complete summary of the biological

improving habitat of the ESA-listed fish with the broader view of riverine ecosystem restoration could improve the economic and biological effectiveness of those efforts.

Sixty-eight fish species are listed as endangered or threatened in the 17 western states.[27,28] The appendix lists these species, along with several of their characteristics, including: year listed, status, current habitat, state(s) in which they are found, whether agriculture was a cause of population decline, and 1990 and 1991 government expenditures on recovery. Upon listing a species, ESA procedures require designation of the species' critical habitat and development and implementation of a recovery plan.[29] Recovery plans have yet to be approved for 60 percent of the ESA-listed western fish species.

The number of ESA-listed fish species in the West has grown steadily over time (Figure 2). The number is cumulative: after formal recognition, a species remains on the list until either the recovery effort is successful (with the threat of extinction diminished markedly) or extinction occurs. Twelve western fish were listed as endangered in 1967.[30] The cumulative total then increased over 26 years to 42 endangered and 26 threatened fish species in 1993. The largest annual increases in protected western fish species occurred in 1970 (nine new listings) and 1985 (ten new listings).

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evidence is available in Bureau of Reclamation, *supra* note 7, at 3-79-88.

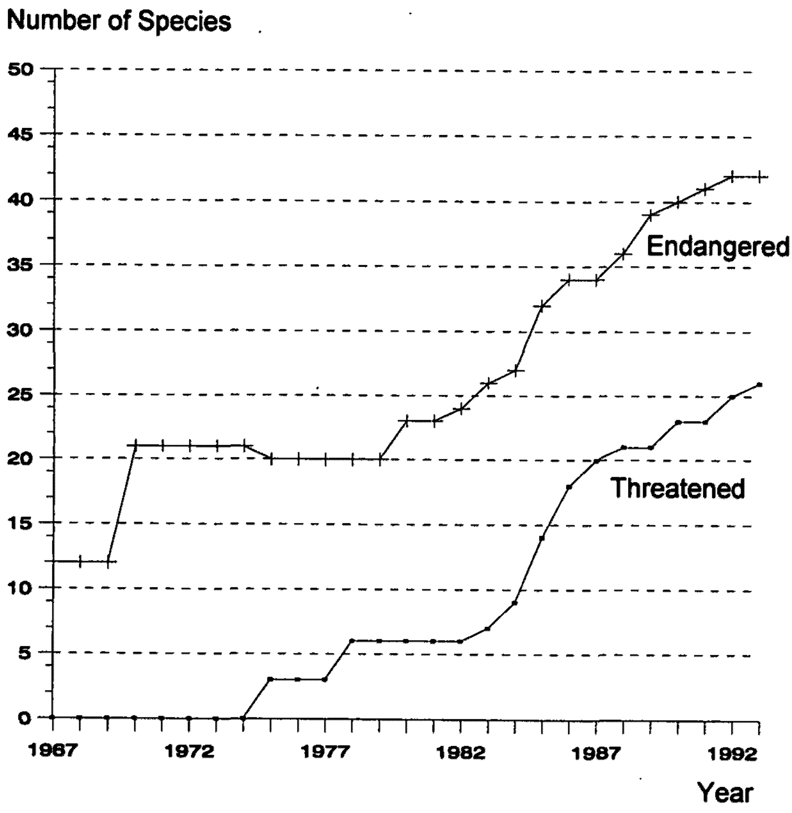
27. Under the Endangered Species Act of 1973, "endangered species" is defined as any species in danger of extinction throughout all or a significant portion of its range, while "threatened species" includes any species likely to become an endangered species within the foreseeable future. 16 U.S.C. § 1532(6),(20) (1994).

28. In addition to the 68 ESA-listed species, 86 western fish species are formally listed as candidate species for possible future listing under the ESA. The numerical total of candidate species is compiled from Endangered or Threatened Wildlife and Plants; Animal Candidate Review for Listing as Endangered or Threatened Species, 56 Fed. Reg. 58,804 (1991). Similarly, 68 western fish are described as being of "special concern." Williams et al., *supra* note 24, at 3. These are species, other than those officially listed as threatened or endangered, that "may become threatened or endangered by relatively minor disturbances to their habitat, or that require additional information to determine their status."

29. Section 3 of the ESA defines critical habitat for a listed species as, "(i) the specific areas within the geographical area occupied by the species . . . on which are found those physical or biological features (I) essential to the conservation of the species and (II) which may require special management considerations or protection; and (ii) specific areas outside the geographical area occupied by the species . . . upon a determination by the Secretary that such areas are essential for the conservation of the species." 16 U.S.C. § 1532(5)(A)(i)-(ii) (1994).Under Section 4, recovery plans must include description of management actions for recovery, along with criteria that would demonstrate successful recovery. 16 U.S.C. S 1533(f) (1994).

30. The 1966 Endangered Species Preservation Act and the 1969 Endangered Species Conservation Act pre-dated the Endangered Species Act of 1973. *See* STEVEN L. YAFFEE, PROHIBITIVE POLICY: IMPLEMENTING THE FEDERAL ENDANGERED SPECIES ACT 39-42 (1982).

Figure 2. Fish Species with Endangered or Threatened Species Status in the Western United States



Public expenditures plus private-sector compliance costs form the total cost of ESA implementation. Federal and state governments began reporting the level of public expenditures on individual ESA-listed species in 1989.[31] For the 68 western fish species, public expenditures

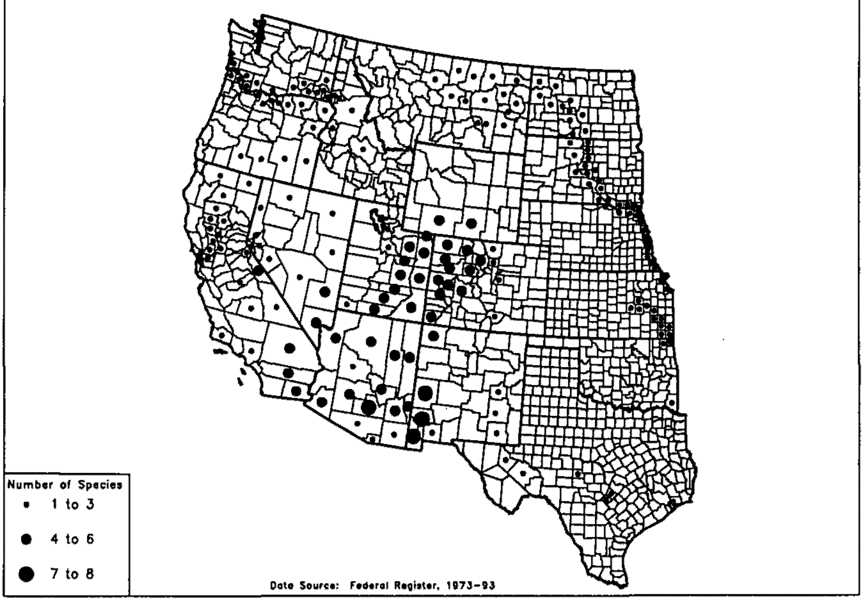
31. The types of activities reported include expenditures on "fisheries, refuges, land acquisition, law enforcement, research and Regional and field operations for listing, recovery, consultation, environmental contaminant and habitat conservation activities" that could be "attributed" to an individual species. FISH AND WILDLIFE SERVICE, U.S. DEP'T OF THE

totaled $9.64 million in 1990, rising to $17.25 million in 1991.[32] 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).[33] The subsequent section investigates, in broad terms, costs that could arise if recovery efforts for protected western fish affected the irrigated agricultural sector.

For subsequent analysis, 50 of the 68 ESA-listed fish species are highlighted because of their direct link to agriculture; these are fish reliant on surface water for which agricultural activities is listed in the Federal Register as a "factor in decline" of the species. This link provides the basis for analysis of the tradeoffs between ESA-listed fish and agriculture.

Figure 3 maps the habitat of these 50 fish species, by county.[34] Each species indicator on the map (as depicted by a dot) simply means

Figure 3: Counties with Endangered or Threatened Fish Habitat



INTERIOR, FEDERAL AND STATE ENDANGERED SPECIES EXPENDITURES: FISCAL YEAR 1991, 3 (1992).

32. FISH AND WILDLIFE SERVICE, *supra* note 31, at Table 1, 5-6. *See* the attached appendix for additional public expenditure data.

33. *Id.* at Table 1, 5-6. See the attached appendix for additional public expenditures data.

34. The geographic data displayed in Figure 3 were obtained from two sources. The primary source was miscellaneous issues of the *Federal Register* between 1973 and 1993,

that the county contains habitat for ESA-listed fish somewhere within its boundaries; the map does not portray a precise geography of habitat. Relatively larger dots represent higher numbers of species with habitat in the county. The map illustrates two interesting items. First, 198 counties—18 percent of all counties in the West—contain habitat for these 50 species. Second, the species are geographically distributed, albeit unevenly, across every state and major river basin in the West. The largest concentration is in the Colorado River Basin, where a majority of protected species reside. California provides habitat for 14 listed fish species, while Washington provides habitat for only 3 listed fish species.

C. *The Intersection Between ESA-Listed Fish Species and Irrigated Agriculture*

Several characteristics provide background on irrigated agriculture in the 17 western states. Nationwide, 46 million acres were irrigated in 1987.[35] The vast majority of irrigated acreage—81 percent of total irrigated acres—is located in the 17 western states.[36] Roughly half of all irrigated acreage is irrigated with surface water, with the remaining acreage irrigated with ground water.[37]

Agriculture withdraws and consumes the vast majority of western surface water resources. In western states, 76 percent of all surface water withdrawals are for agricultural purposes (Solley et al.).[38] The percentage exceeds 80 percent in eleven states and 90 percent in six states (Table 1). The six western states in which agricultural use accounts for less than 80 percent of surface water withdrawals (Kansas, Nebraska,

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which publishes habitat maps in its official notice that a species is being listed. *See, e.g.*, 58 Fed. Reg. 12,854. The secondary source was species-specific recovery plans, which have been completed for some of the western fish species.

35. BUREAU OF THE CENSUS, U.S. DEP'T OF COMMERCE, 1987 CENSUS OF AGRICULTURE, electronic data file.

36. RAJINDER S. BAJWA ET AL., ECONOMIC RESEARCH SERVICE, U.S. DEP'T OF AGRICULTURE, AGRICULTURAL IRRIGATION AND WATER USE 2 (1992).

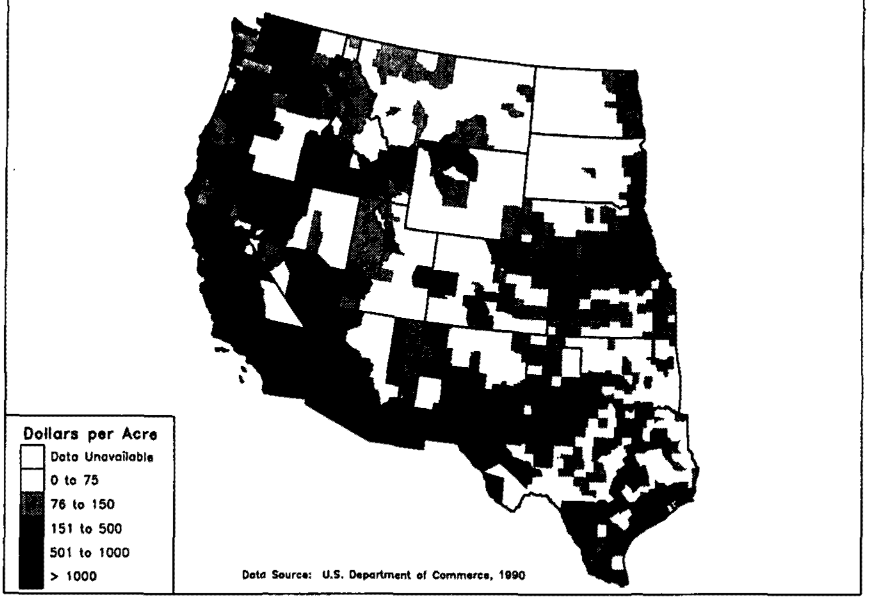
37. BUREAU OF THE CENSUS, U.S. DEP'T OF COMMERCE, 1992 CENSUS OF AGRICULTURE, VOLUME 3, RELATED SURVEYS, PART 1, 1994 FARM AND RANCH IRRIGATION SURVEY 20 (1996).

38. SOLLEY ET AL., *supra* note 9. The proportion of diverted water that is actually consumed varies by state, ranging from 22 percent in Montana to 96 percent in Kansas. The figures are calculated from *id.* at 37. (*See id.* for the distinction between water diversion and consumption). Nevertheless, irrigation accounts for 90 percent of total western water consumption (including both surface and ground water consumption). The figure is calculated from *id.* By state, this figure ranges from 58 percent in Oklahoma to nearly 100 percent in Idaho. These figures are calculated from *id.*

North Dakota, Oklahoma, South Dakota, and Texas) are in the Great Plains region, where irrigators rely heavily on ground water pumping from the Ogallala Aquifer.[39]

High productivity and, relatedly, high gross financial returns are characteristics of irrigated agriculture.[40] The 46 million irrigated acres in 1987 represented 15 percent of total U.S. harvested acreage, yet accounted for 38 percent of the $69 billion in U.S. crop sales.[41] The value of irrigated production, as measured by gross revenue per acre, varies considerably across the western states (Figure 4). Variation in climatic conditions—including length of the growing season and ability to produce high-value crops, such as fruits, nuts, and vegetables—explains much of the variation in value. California, Arizona, and Washington rank significantly higher than the other states, each with a value greater than $800 per acre. The northern Great Plains states report relatively low values.

Figure 4: Value per Acre of Total Crop Sales, by County



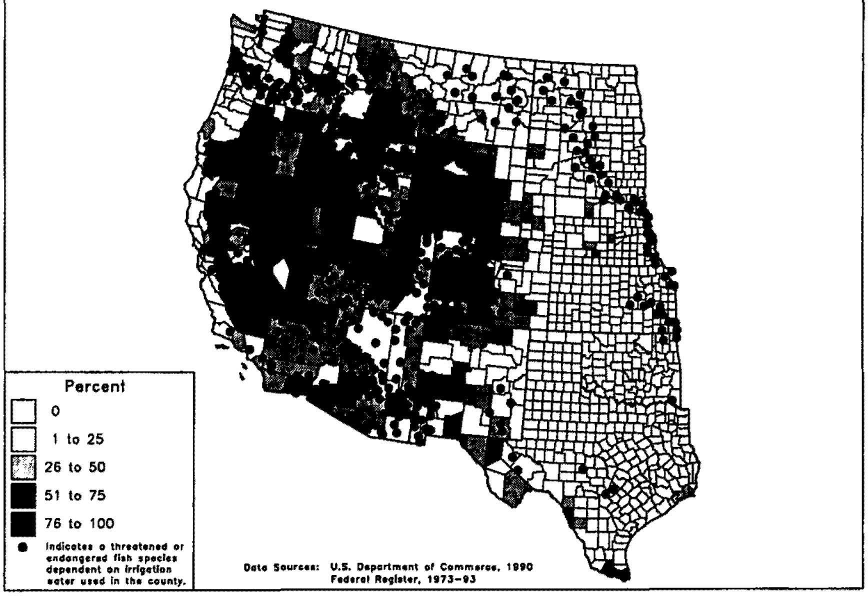
39. DONALD WORSTER, RIVERS OF EMPIRE: WATER, ARIDITY AND THE GROWTH OF THE AMERICAN WEST 313-14 (1985).

40. Higher production costs are also a characteristic of irrigated agriculture. On average, irrigated agriculture spends 2 to 3 times as much as non-irrigated agriculture on agricultural chemicals and energy inputs and 5 to 6 times as much on labor. It is more highly capitalized, with twice the value of machinery and equipment and investment in land and buildings. *See* BAJWA ET AL., *supra* note 36.

41. BAJAWA ET AL., *supra* note 36, at 3.

With this background on irrigated agriculture, we now assess the geographic relationship between areas of irrigated agriculture and ESA-listed fish species in the West. Figure 5 maps the percentage of

Figure 5: Percent of Cropland Surface Water Irrigated and Agricultural Land Potentially Affected by Recovery Measures for ESA-Listed Fish Species, by County



cropland that is irrigated with surface water in each county in the 17 western states. It also has an indicator for each species whose recovery effort may affect irrigated agriculture in that county. We distinguish between counties encompassing or adjacent to species habitat (as depicted in Figure 3) and counties in which irrigation water is taken from a river containing an ESA-listed species (as depicted in Figure 5). This distinction—between the proximity of irrigated areas to habitat and the reliance of irrigated acreage on diversions from rivers that provide habitat is important because the area of mitigation and recovery actions may not sufficiently describe the areas that would be affected by those actions. For example, in California, the Sacramento River winter-run Chinook salmon is endangered by changes in spawning habitat in the upper Sacramento River. Yet efforts to protect this species will likely result in reduced water supplies to farms in the San Joaquin Valley, located hundreds of miles south of the spawning habitat.

Figure 5 also illustrates the general geographic relationship between cropland irrigated with surface water and ESA-listed fish. There are 235 counties, representing 22 percent of the counties in the West, which contain agricultural production that relies on surface water from river systems with ESA-listed fish. That is, irrigated agriculture in this set of 235 counties may be affected, 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 one-half of all surface-water irrigated acres in the entire West; it exceeds one-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.

Two specific features of the geographic intersection of agriculture and species are evident from Figure 5. First, high concentrations of ESA-listed fish species correspond with areas of extensive surface water irrigation. The irrigated areas of Idaho, California, Utah, and Colorado best reflect this relationship. The concentration of ESA-listed fish species in the Colorado River Basin correlates strongly with high rates of surface-water irrigation in Colorado, Wyoming, Utah and southeastern California. This correlation is examined statistically in Section III. Second, nearly all counties reliant on surface-water irrigation draw or receive water from rivers inhabited by at least one threatened or endangered fish species. Very few counties with greater than 50 percent of cropland acreage irrigated with surface water are free from a link to an ESA-listed species.[42] These two features of Figure 5 suggest that, in general, counties with a relatively high portion of irrigated agriculture in percentage or absolute terms—will be affected to some degree by recovery measures undertaken in conjunction with ESA implementation.

The information in Figure 5 and Table 1 provides insight into the potential effects of reallocating irrigation water to endangered species habitat. A high potential for disruption of irrigated agriculture exists because of its dependence on surface water. If disruption in water supplies occurs, the potential costs are high because of the high value of irrigated agriculture. Four of the major factors that could affect the magnitude of the costs to agriculture include: the volume of water needed by ESA-listed fish; the extent to which the burden is shared

42. Exceptions to the rule typically show correlations with absolute, rather than percentage, levels of acreage. For example, counties in northern Wyoming with a high percentage of cropland surface water irrigated, but without a potential link to an ESA-listed fish species, generally have relatively low absolute acreages in crop production and relatively few irrigated acres. Conversely, counties in Texas and New Mexico (in the Pecos River Basin) show a potential link to ESA-listed fish; these counties have relatively small percentages of surface water irrigated acreage, yet the absolute acreage is as large as 20,000 acres per county. Similarly, the three counties bordering the Columbia and Snake Rivers at their confluence represent only 14, 29 and 37 percent of total cropland in the respective counties, but contain relatively large amounts of surface water irrigated acres (80,000, 131,000, and 172,000 acres, respectively).

broadly throughout the agricultural sector rather than concentrated on a relatively small number of producers; individual producer's flexibility to respond to water-supply reductions with relatively minor decreases in profitability; and the extent to which producers receive financial compensation for their water-supply reductions.

D. *The Federal Reclamation Program*

A final dimension of the issue and a recurrent focus of this research involves the role of the federal Reclamation program. The Reclamation program, a program administered by the Interior Department's Bureau of Reclamation, has been a major force in shaping river development in the West since 1902. Reclamation is the largest supplier of irrigation water in the western United States, regularly delivering more than 25 million acre feet (maf) per year to farms.[43] This water irrigates 9-10 million cropland acres, or roughly one-half of all surface-water irrigated acres in the West.[44] Reclamation-served agriculture relies on a vast network of water storage and conveyance projects. Reclamation facilities include: 355 storage reservoirs, 254 diversion dams, 16,047 miles of canals, and 37,193 miles of laterals.[45]

Reclamation controls significant percentages of river flows throughout the West. In the Colorado River Basin, for example, Reclamation delivered over 4.9 maf of water to farms in the upper and lower Colorado River Basin in 1989.[46] The river's average virgin flow equals 13.5 maf. [47] Along the upper Snake River in southern Idaho, Reclamation's Minidoka-Palisades and Boise Projects delivered almost 4.6 maf of irrigation water.[48] The Snake River's natural flow ranges between 5.2 and 12.1 maf in this region.[49] The Middle Rio Grande Project in New Mexico and the Rio Grande Project in New Mexico and Texas delivered over 0.6 maf to farms in 1989.[50] The Rio Grande flows at an average rate of almost 0.8 maf through central New Mexico. Finally, California farmers receive an average of about 7 maf of water from Reclamation's Central

43. BUREAU OF RECLAMATION, U.S. DEP'T OF THE INTERIOR, 1989 SUMMARY STATISTICS: WATER, LAND, AND RELATED DATA 66 (1990).

44. *Id.*

45. *Id.* at 1.

46. *Id.*

47. David H. Getches & Charles J. Meyers, *The River of Controversy: Persistent Issues*, *in* NEW COURSES FOR THE COLORADO RIVER 55 (Gary D. Weatherford & F. Lee Brown eds., 1986).

48. BUREAU OF RECLAMATION, *supra* note 43, at 62.

49. Joel R. Hamilton et al., *Interruptible Water Markets in the Pacific Northwest*, 71 AMERICAN J. AGRIC. ECONOMICS 64 (1989).

50. BUREAU OF RECLAMATION, *supra* note 43, at 62.

Valley Project.[51] Flow levels in the Sacramento and San Joaquin Rivers—the water sources for the Central Valley Project—range between 10 and 40 maf.[52]

Three features of the Reclamation program are important in the context of the ESA. One, the Bureau of Reclamation shares responsibility for ESA implementation—Section 7 of the ESA requires federal agencies to ensure that their actions are unlikely to jeopardize a listed species.[53] Potential conflicts between Reclamation operations and endangered species' recovery must be, and are, addressed in Section 7 consultation proceedings. A 1987 report found that Section 7 consultations exerted little effect on western water projects: "In terms of overall impact, between October 1977 and March 1985 only 68 consultations (out of about 3,200 consultations concerning water development projects) affected the projects with which they were associated. These consultations had varying, but normally limited, impact on the projects' timing, scope, and cost."[54] Nevertheless, this requirement potentially imposes greater restrictions on Reclamation water use, when such use may jeopardize an ESA-listed species, than would be imposed on other water development entities. Consequently, farmers relying on Reclamation water face a greater risk of reductions or disruptions in water supply.

Two, a recent government study documents the physical intersection between Reclamation areas and endangered species.[55] There were 184 federally listed or proposed species associated with Reclamation projects and water service areas in the 17 western states.[56] By state in terms of severity, the numbers are: California, 91, Oregon, 38, and Arizona, Texas, and Utah, 24 each.[57] Section III addresses, in a quantita-

51. Richard E. Howitt & Henry Vaux, *Competing Demands for California's Scarce Water*, *in* WATER QUANTITY/QUALITY MANAGEMENT AND CONFLICT RESOLUTION 271 (Ariel Dinar & Edna Tusak Loehman eds., 1995).

52. JOSEPH L. SAX & ROBERT H. ABRAMS, LEGAL CONTROL OF WATER RESOURCES 435 (1986).

53. Section 7(a)(2) of the ESA reads, "Each Federal agency shall, in consultation with and with the assistance of the Secretary, insure that any action authorized, funded, or carried out by such agency . . . is not likely to jeopardize the continued existence of any endangered species or threatened species or result in the destruction or adverse modification of habitat of such species which is determined by the Secretary . . . to be critical . . . ." 16 U.S.C. § 1536(a)(2) (1994).

54. U.S. GENERAL ACCOUNTING OFFICE, ENDANGERED SPECIES: LIMITED EFFECT OF CONSULTATION REQUIREMENTS ON WESTERN WATER PROJECTS 2-3 (1987).

55. *See* BUREAU OF RECLAMATION, *supra* note 7. This study co-locates endangered species and Bureau of Reclamation projects/service areas to develop the biological context for Section 7 consultations when implementing proposed western reclamation regulations under the Reclamation Reform Act of 1982.

56. *Id.* at 3-85.

57. *Id.* at 3-87.

tive analysis, the relationship between ESA-listed fish species and Reclamation-served agricultural activity.

Three, the pervasive presence of Reclamation projects throughout the West creates the potential for a general Reclamation approach to habitat restoration in western river systems. Sectión V pursues this idea in more detail.

III. Regression Analysis: Correlation Between ESA-Listed Fish Species and Irrigated Agriculture

This section investigates the quantitative relationship between the ESA-listed fish species and the extent of irrigated agricultural activity. A qualitative link between species endangerment and agricultural activity was already established by the Federal Register listings, which specify factors contributing to a species' decline. Figure 5, as described previously, also suggested a geographic relationship between endangered species and irrigated agriculture. Here, we examine the related quantitative issue: does the *number* of protected fish species depend on the level of irrigated agricultural activity? A positive correlation would suggest two items: (1) a higher level of irrigated agriculture may contribute to a greater number of ESA-listed fish species and (2) from a remedial perspective, the irrigated agricultural sector may be in a position to contribute significantly to recovery efforts for the more serious cases of species' endangerment (as measured by a relatively high number of protected fish species).

A. Data, Variables, and Methods

Two data sets are compiled for the regression analysis, a general data set on ESA-listed fish species and west-wide agricultural activity and a narrower data set on ESA-listed fish species and agricultural activity, reliant on Bureau of Reclamation water supplies. Both data sets consist of county-level data. The data on ESA-listed fish species represent the geographic dispersion of the 50 western fish species for which agriculture was a factor in species' decline. The variable formed from these data measures the number of ESA-listed fish species whose recovery could affect irrigated agriculture in that county; this variable ranges between 0 and 8.

The general data set (labeled "Census") uses county-level data on agriculture from the 1982 and 1987 *Census of Agriculture*.[58] This data set contains 1029 observations. The variables are:

58. BUREAU OF THE CENSUS, U.S. DEP'T OF COMMERCE, CENSUS OF AGRICULTURE 1982 and CENSUS OF AGRICULTURE 1987.

ESAFISH—Number of ESA-listed fish species whose recovery could affect irrigated agriculture.
AGPRD—Market value of agricultural products sold.
NIRRACR—Harvested cropland not irrigated with surface water.
PSTRACR—Pastureland and cropland used for pasture and grazing.
IRRACR—Irrigated, harvested cropland whose principal water source is surface water.
IRRACR2—*IRRACR* squared.
BOR—Indicator of whether the county contains cropland served by Bureau of Reclamation water supply.

As mentioned in the previous section, most counties in the West do not contain either ESA-listed fish habitat or agricultural land potentially affected by fish recovery efforts—803 of the 1029 observations on *ESAFISH* take on a value of 0. Table 2 contains descriptive statistics and units of variables in the Census data set.

The second data set (labeled "Reclamation") focuses on counties containing cropland irrigated with Bureau of Reclamation water supplies. It includes 1987 data describing crop production and irrigation on Reclamation-served cropland in the county.[59] This data set contains 199 observations. The definition of *ESAFISH* is identical to before, yet the variable includes only observations from Reclamation counties. *ESAFISH* takes on a value of 0 in 110 of the observations. Other variables in the Reclamation data set include:

CROPREV—market value of crops produced on Reclamation-served cropland.
IRRACR—Reclamation-served irrigated cropland.
PRJDLV—project water delivered to Reclamation-served farms.
PRJDLV2—*PRJDLV* squared.
NPRJDLV—non-project water delivered to Reclamation-served farms.
NPRJDLV2—*NPRJDLV* squared.

Table 2 also contains descriptive statistics and units of these variables.

In the regression analysis, *ESAFISH* serves as the dependent variable in the two equations estimated. *ESAFISH* is an example of "count data," i.e., data in the form of an integer quantity that measures the number of occurrences of an event. Data on recreational trips, for example, frequently come in the form of count data. To account for the integer nature of *ESAFISH*, the Poisson regression model is applied here

59. BUREAU OF RECLAMATION, U.S. DEP'T OF THE INTERIOR, 1987 SUMMARY STATISTICS: WATER, LAND, AND RELATED DATA (1988).

using GRBL econometric software.[60] The Poisson model is a statistical model that explicitly recognizes the integer nature of a dependent variable formed from count data.[61] The Poisson model is estimated using a maximum likelihood technique.

The general specification of the Census equation is

(1) *ESAFISHi = f(AGPRDi, NIRRACRi, PSTRACRi, IRRACRi, IRRACR2i, BORi, _i),*

where *i* denotes observations from the Census data set and _i is a stochastic disturbance term.

The general specification of the Reclamation equation is

(2) *ESAFISHj = g(CROPREVj, IRRACRj, PRJDLVj, PRJDLV2j, NPRJDLVj, NPRJDLV2j, _j),*

where *j* denotes observations from the Reclamation data set and _j is a stochastic disturbance term. Both (1) and (2) are estimated as linear functions of the independent variables.

B. Estimation Results

i. Census data set. Estimation of equation (1) yields a strong set of results (Table 3).

The estimated coefficient of every variable has the expected sign describing its influence on the number of ESA-listed fish species (*ESAFISH*). Only the coefficient on *AGPRD* is not significantly different from 0 at the 0.01 significance level. In this model, the negative coefficient on *NIRRACR* implies that, to the extent that much of the cropland in the county is not irrigated, *ESAFISH* tends to be smaller. The positive coefficient on *PSTRACR* indicates that *ESAFISH* increases as livestock activity increases; this may reflect the degradation of riverine habitat quality with livestock watering and grazing activity in watersheds. The

60. DANIEL M. HELLERSTEIN, U.S. DEP'T OF AGRICULTURE, GRBL: A PACKAGE OF REGRESSION PROGRAMS (1995).

61. *See generally* Daniel M. Hellerstein, *Using Count Data Models in Travel Cost Analysis with Aggregate Data*, 73 AM. J. OF AGRIC. ECON. 860 (1991). The Poisson model imposes the assumption that the mean and variance of the dependent variable are equal. The negative binomial regression model, a more general form of the Poisson, does not impose this assumption. The negative binomial model, however, did not converge to a solution when the data in this study were analyzed.

coefficients on *IRRACR* and *IRRACR2* imply that increased irrigation activity from surface water sources tends to increase *ESAFISH* (positive *IRRACR*), although at a diminishing rate as surface-water irrigated acreage increases (negative *IRRACR2*). Finally, the presence of irrigation with Reclamation water supply in a county (*BOR*) also increases *ESAFISH*.

The main finding of the estimation is simply the strong correlation between *ESAFISH* and agricultural activity. In particular, *IRRACR* serves as a proxy for several effects of irrigation on riverine and riparian habitat quality: water diversions deplete habitat quality; irrigation return flows tend to impair water quality through salinity, nutrient, and pesticide loadings; and dams and reservoirs alter natural river-flow patterns, destroy natural habitat, and can block migrations. From a restoration perspective, a decline in *IRRACR* and offstream water use, accompanied by an increase in instream flow, can contribute to recovery of ESA-listed fish species by reversing this set of harmful impacts on the natural environment.

A second finding relates to the elasticities, each one of which measures the percent change in *ESAFISH* given a one percent change in an independent variable holding all other variables constant. Every elasticity is moderately to highly inelastic. If the model is interpreted literally as showing a causal effect of agricultural activity on *ESAFISH*, the elasticities indicate that irrigation levels, as well as other agricultural activity represented in the independent variables, would have to change significantly to cause a marked decline in ESA-listed fish species.

In equation (1), the dummy variable for the presence of Reclamation activity in a county (*BOR*) has a positive coefficient with statistical significance at the 0.01 level (Table 3). That is, even controlling for surface-water irrigated acreage via *IRRACR*, the number of *ESAFISH* increases with the presence of Reclamation activity. To some degree, this relationship may be associated with a trademark of Reclamation development: construction of storage and diversion dams. Dams, and associated reservoirs, typically harm native fish habitat. Estimating equation (2) with the Reclamation data set enables closer examination of the role of the Reclamation program.

ii. Reclamation data set. The estimation of equation (2) with the Reclamation data set generally yields statistically significant relationships between *ESAFISH* and Reclamation activity. Four of the variables (*IRRACRE, PRJDLV, PRJDLV2, NPRJDLV*) are significant at the 0.01 level, and two (*NPRJDLV2* and the intercept) are significant at the 0.10 level. *CROPREV* has the only estimated coefficient that is not significantly different from 0 at the 0.10 level. The negative coefficient on *IRRACR* indicates that *ESAFISH* declines as irrigated acreage increases. This is slightly counterintuitive: after controlling for water supply, one might expect the scale of irrigated acreage to exert little effect on *ESAFISH*. The water supply variables show similar curvature properties as the irrigated acreage variables in the Census data set. Coefficients on the linear terms, *PRJDLV* and *NPRJDLV*, are positive, while coefficients on the squared terms, *PRJDLV2* and *NPRJDLV2*, are negative.

As with the first regression, the elasticities of *ESAFISH* relative to the independent variables in the Reclamation data set are moderately to highly inelastic.

The water supply variables provide the most interest. They are measures of on-farm irrigation water use on Reclamation-served cropland. The strong statistical significance of *PRJDLV* and *PRJDLV2* (significant at the 0.01 level) indicates a link to *ESAFISH*. Levels for non-project surface water supply (*NPRJDLV*) are much lower than those for project water supply, with a mean for *NPRJDLV* of only 11,706 acre-feet per Reclamation county relative to a mean for *PRJDLV* of 127,600 acre-feet. Nevertheless, the two variables for non-project supply correlate quite strongly with ESA-listed fish species.

Overall, the quantitative analysis answers the section's original question in the affirmative: the number of protected fish species correlates positively with the level of irrigated agricultural activity. This evidence suggests that irrigation water conservation—with reallocation to instream flow for habitat improvement—could be an important element of endangered fish species recovery programs in the West.

IV. The Endangered Fish Species-Irrigated Agriculture Nexus: Recent Developments in Government Policies and Programs

This section consists of two short case studies on recent developments in central California and the Columbia River Basin. The case studies complement the quantitative analysis by providing concrete illustrations of fish-agriculture water allocation tradeoffs.

A. Federal Water Policy Reform in Central California

Significant federal, state, and private investments were made in water storage and conveyance projects on the Sacramento and San Joaquin River systems in California's Central Valley. These projects transformed arid land into some of the world's most productive farmland, with agriculture consuming the vast majority of the region's developed water resources in its complete reliance on irrigation.[62]

62. CALIFORNIA DEP'T OF WATER RESOURCES, 1 CALIFORNIA WATER PLAN UPDATE 49 (1994).

However, 22 fish species are declining or have gone 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;[63] 16 additional fish species either qualify for listing or are in severe decline with real potential for becoming endangered; and three fish species have already gone extinct.[64]

The Bureau of Reclamation's Central Valley Project (CVP) is integral to agriculture in central California. The CVP consists of 20 dams and more than 500 miles of major canals. Its agricultural service area encompasses 2.6 million acres, the largest of any single Reclamation project.[65] In an average year, CVP irrigation water supply equals 6.6 maf,[66] or more than 95 percent of CVP water deliveries. Revenue from the sale of crops produced with CVP water typically exceeds $3 billion per year.[67] This equals 5 percent of the value of U.S. crop production.

The decline in central California's fishery influenced passage of new federal water policy for the CVP. In 1992, the Central Valley Project Improvement Act (CVPIA) was instituted to improve fishery habitat, in addition to achieving several other water management objectives. [68] In a significant step for a Reclamation project, the law designated "fish and wildlife mitigation, protection, and restoration" as an explicit purpose of the CVP.[69] To achieve this objective, the law permanently allocates 0.8 maf of CVP water in normal water-supply years (almost 20 percent of CVP contracted irrigation water supply) for restoration of fish habitat.[70]

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63. The official status of the Sacramento River winter-run Chinook salmon changed from threatened to endangered on January 4, 1994. 59 Fed. Reg. 440 (1994). A proposal to list the Sacramento splittail (a fish endemic to California's Central Valley) as threatened was made on January 6, 1994. 59 Fed. Reg. 862 (1994).

64. *See* Moyle & Williams, *supra* note 24, at 282-84.

65. BUREAU OF RECLAMATION, *supra* note 43, at 166.

66. The 6.6 million acre-feet of irrigation water supply splits into 4.3 maf for CVP agricultural contractors and 2.3 maf for water rights holders and exchange contractors. Water rights holders and exchange contractors are senior to CVP agricultural contractors, and thus receive CVP water supply with greater certainty. For example, CVP water supply in 1994 was below average because of low precipitation during the 1993-94 winter. Water rights holders and exchange contractors received 75 percent of full supply in 1994, while CVP agricultural contractors received only 35 percent of full supply. *See* BUREAU OF RECLAMATION & FISH AND WILDLIFE SERVICE, U.S. DEP'T OF THE INTERIOR, IMPLEMENTATION OF THE CENTRAL VALLEY PROJECT IMPROVEMENT ACT 8 (1994).

67. BUREAU OF RECLAMATION, *supra* note 43, at 166.

68. Central Valley Project Improvement Act, Pub. L. No. 102-575, § 3402, 106 Stat. 4706 (1992).

69. *Id.* at 4714.

70. The Ninth Circuit Court of Appeals recently held that the federal government's reduction of 1993 irrigation water supplies did not violate the terms of the plaintiff's CVP water service contracts decision where the reduction was made to meet the requirements of the ESA and CVPIA. *O'Neill v. United States*, 50 F.3d 677 (9th Cir. 1995).

This water is intended to address several aspects of fishery improvement. For example, the CVPIA states that the water would contribute both to addressing obligations under the ESA and, more generally, to achieving a goal of doubling natural populations of the region's anadromous fish species.[71] The key water-management requirement for Central Valley fish species involves regulating the volume and timing of flows in both the Sacramento and San Joaquin River systems until they pass through the Sacramento-San Joaquin Delta and into San Francisco Bay.[72]

Reallocation of agricultural water will likely supply most of the water for fish habitat. Although the CVPIA does not specify this explicitly, most observers believe that, in years when water-use reductions are required to meet the 0.8 maf requirement, most or all of the reductions would come from irrigation water use. This conclusion follows directly from the existing pattern of CVP water allocation, in which agricultural use dominates urban and industrial water by over a 10-to-1 ratio.[73] In addition, the CVPIA requires the Secretary of the Interior to implement by the year 2007 a least-cost plan to replace the 0.8 maf allocated to fish habitat.[74] Voluntary water transfers, voluntary agricultural land retirement, and water conservation requirements must be among the options considered for the plan.[75] Both the economic value of urban water use and the cost of expanding project capacity exceed the value of irrigation water in this region.[76] Thus, relying primarily on reduced irrigation water use appears consistent with a least-cost plan for acquiring 0.8 maf of water.

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71. Central Valley Project Improvement Act § 3406. Debate is on-going regarding the intent of the fish and wildlife water allocation provision in relation to water allocations for species listed under the ESA. Interpretations of the CVPIA vary from the view that all water used to protect ESA-listed fish should be counted against the 800,000 acre-feet of water set aside in the CVPIA to the view that water quantities attributable to implementation of the ESA should be independent of the 800,000 acre-feet. The act is ambiguous on this point, containing provisions in support of both views. In practice, the answer may lie between the opposing views. In the act's first year, approximately one-half of the 800,000 acre-feet was used to protect ESA-listed fish. For example, 300,000 acre-feet were attributed to the temporary shut-down of a major CVP water pumping facility because of excessive takings of endangered winter-run Chinook salmon; the shut-down resulted in water-supply reductions to many farmers using CVP water. *Id.*

72. Anthony C. Fisher et al., *Integrating Fishery and Water Resource Management: A Biological Model of a California Salmon Fishery*, 20 J. OF ENVTL. ECON. AND MGMT. 234 (1991).

73. BUREAU OF RECLAMATION, *supra* note 43.

74. Central Valley Project Improvement Act § 3408(j).

75. *Id.*

76. Zach Willey & Thomas Graff, *Federal Water Policy in the United States—An Agenda for Economic and Environmental Reform*, 13 COLUMBIA J. OF ENVTL. L. 335 (1988).

B. *Salmon Recovery in the Columbia River Basin*

Salmon populations in the Columbia River Basin have declined severely as a result of fish harvesting and river development activities. Populations of salmon and steelhead have fallen to roughly 20 percent of the peak level of 10-16 million spawning adults per year.[77] Wild and naturally spawning salmon are at 2 percent of historic levels. Since 1991, three Snake River salmon runs have been listed as threatened or endangered under the ESA,[78] with an additional 10 salmon runs considered in critical condition.[79]

The primary fish-agriculture nexus in the Columbia River system occurs in the upper Snake River Basin (composed of southern Idaho and east-central Oregon). This region is one of the major areas of irrigated agriculture in the United States, with roughly three million acres irrigated with surface water and almost one million acres irrigated with ground water.[80] The majority of the irrigated acreage is in hay, wheat, and barley production, although the region is important nationally in production of Irish potatoes and sugar beets.[81] The Bureau of Reclamation operates nine water projects in the upper Snake River Basin.[82] These projects deliver water to one-half of the region's surface-water irrigated acres: about 1.5 million acres regularly receive more than 5 maf of Reclamation water.[83] The Minidoka-Palisades Project in southern Idaho contains over one million of these acres.[84]

One salmon recovery measure under consideration involves flow augmentation from the upper Snake River to improve hydrologic conditions for juvenile salmon migration through the lower Snake and

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77. Michael C. Blumm & Andy Simrin, *The Unraveling of the Parity Promise: Hydropower, Salmon, and Endangered Species in the Columbia Basin*, 21 ENVTL. L. 657, 663 (1991).

78. The National Marine Fisheries Service formally listed the Snake River sockeye salmon as endangered on November 20, 1991, and the Snake River spring/summer-run Chinook salmon and fall-run Chinook salmon as threatened on April 22, 1992. On August 18, 1994, the two runs of Chinook salmon were converted from threatened to endangered under an emergency interim rule. NAT'L MARINE FISHERIES SERVICE & NAT'L OCEANIC AND ATMOSPHERIC ADMIN., U.S. DEP'T OF COMMERCE, PROPOSED RECOVERY PLAN FOR SNAKE RIVER SALMON I-6 (1995).

79. Nehlsen et al., *supra* note 24, at 11.

80. Joel R. Hamilton & Norman K. Whittlesey, Contingent Water Markets for Salmon Recovery (Feb. 1992) (unpublished report, University of Idaho and Washington State University).

81. BAJWA ET AL., *supra* note 36; MARCEL P. AILLERY ET AL., ECONOMIC RESEARCH SERVICE, U.S. DEP'T OF AGRICULTURE, SALMON RECOVERY IN THE PACIFIC NORTHWEST: A SUMMARY OF AGRICULTURAL AND OTHER ECONOMIC EFFECTS 4 (1994).

82. BUREAU OF RECLAMATION, *supra* note 43, at 60, 63.

83. *Id.*

84. *Id.* at 145.

Columbia Rivers. The Northwest Power Planning Council[85] recommended a minimum of 0.427 maf per year in flow augmentation from the upper Snake River, with additional augmentation of 1 maf by 1998, for a total of 1.427 maf.[86] These two levels of flow augmentation were studied in an economic evaluation of the Snake River salmon recovery plan that was proposed by the Snake River Salmon Recovery Team.[87] To achieve these two targets, 0.127 to 1.127 maf in flow augmentation would be acquired from the irrigated agriculture sector in the upper Snake River Basin.[88] Meeting the 1.127 maf target would reduce irrigation water supply by over 15 percent in the basin.

The Bureau of Reclamation has been assigned responsibility for acquiring water from irrigators in the upper Snake River Basin. The Northwest Power Planning Council originally directed Reclamation and the Bonneville Power Administration to share equally the cost of acquiring the necessary water resources to meet the flow augmentation targets.[89] However, using its authority to recover the three endangered Snake River salmon, the National Marine Fisheries Service (NMFS) designated Reclamation solely responsible for acquiring 0.427 maf per year from 1995-97, and additional water as needed after 1998, particularly in low-flow years.[90] Reclamation agreed to these terms.[91]

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85. The Northwest Power Planning Council was created by the Pacific Northwest Electric Power Planning and Conservation Act (1980) to effect the act's mandate of treating fish and wildlife on an equal basis with hydropower and other traditional river uses.

86. NORTHWEST POWER PLANNING COUNCIL, 1994 COLUMBIA RIVER BASIN FISH AND WILDLIFE PROGRAM 5-21 (1994).

87. DANIEL D. HUPPERT & DAVID L. FLUHARTY, NAT'L MARINE FISHERIES SERVICE, U.S. DEP'T OF COMMERCE, ECONOMICS OF SNAKE RIVER SALMON RECOVERY: A REPORT TO THE NAT'L MARINE FISHERIES SERVICE (1995). *See also* Hamilton & Whittlesey, *supra* note 80 and AILLERY ET AL., *supra* note 81. The Snake River Salmon Recovery Team was a seven-member group appointed by the National Marine Fisheries Service in 1992 to develop independent recommendations for a Snake River recovery plan. Its final recommendations were made in May 1994.

88. HUPPERT & FLUHARTY, *supra* note 87, at 3-40.

89. NORTHWEST POWER PLANNING COUNCIL, *supra* note 86, at 5-32. Bonneville Power Administration markets hydroelectricity produced at the eight major mainstream dams on the lower Snake and lower Columbia Rivers. These dams are viewed as a major contributor to the decline of the Snake River salmon fishery. NAT'L MARINE FISHERIES SERVICE & NAT'L OCEANIC AND ATMOSPHERIC ADMIN., *supra* note 78, at V-2-2 to V-2-4.

90. NAT'L OCEANIC AND ATMOSPHERIC ADMIN. & NAT'L MARINE FISHERIES SERVICE, U.S. DEP'T OF COMMERCE, BIOLOGICAL OPINION: REINITIATION OF CONSULTATION ON 1994-1998 OPERATION OF THE FEDERAL COLUMBIA RIVER POWER SYSTEM AND JUVENILE TRANSPORTATION PROGRAM IN 1995 AND FUTURE YEARS 99-100 (1995) (Endangered Species Act—Section 7 Consultation); NAT'L OCEANIC AND ATMOSPHERIC ADMIN. & NAT'L MARINE FISHERIES SERVICE, *supra* note 78, at V-2-25.

91. BUREAU OF RECLAMATION, U.S. DEP'T OF THE INTERIOR, BUREAU OF RECLAMATION'S RECORD OF DECISION IMPLEMENTING ACTIONS PURSUANT TO

Voluntary water transfers appear to be the method for acquiring water from irrigators in the region. The Northwest Power Planning Council originally suggested that both incentive and regulatory programs be considered as mechanisms for obtaining water for flow augmentation. Some close observers recommended water acquisition through expansion of voluntary water markets in the region.[92] Reclamation, under guidance from NMFS, is pursuing an approach of purchasing water from willing sellers.

V. CONSIDERING RECLAMATION'S ROLE IN SPECIES RECOVERY

At this juncture, we alter course from description of current events to consideration of future approaches to recovery of endangered fish species. This section considers possible roles for the federal Reclamation program at the interface of the water-species-agriculture issue in the West. Two alternatives are characterized. One approach is reactive, in which the Bureau of Reclamation responds to its ESA obligation not to jeopardize listed species. A second approach is proactive, involving the Bureau of Reclamation as a leader in ecosystem restoration activities that would address the health of multiple species, including those not presently endangered.[93]

A certain context is pertinent to this section: namely, the Bureau of Reclamation's transition from a water development organization to a water management organization. Beginning in the late 1980s, Reclamation initiated a planning process to redefine the agency's mission in the contemporary era of western water management.[94] That effort defined the principles, objectives, and program opportunities that would create a water resource management agency. Reclamation's Strategic Plan (1992) describes a subsequent stage of the process.[95] It includes five pillars of the Reclamation mission, including one dedicated broadly to "protecting

BIOLOGICAL OPINIONS OF MARCH 1, 1995 11 (1995).

92. Hamilton & Whittlesey, *supra* note 80; Ray Huffaker et al., *Institutional Feasibility of Contingent Water Marketing to Increase Migratory Flows for Salmon on the Upper Snake River*, 33 NAT. RESOURCES J. 671 (1994).

93. The National Research Council recently proposed a proactive approach to aquatic ecosystem restoration in the United States. NATIONAL RESEARCH COUNCIL, *supra* note 24. The council devised a "National Aquatic Ecosystem Restoration Strategy" that would be financed by a surcharge on hydropower sales from federal facilities. *Id.* at 350-376.

94. BUREAU OF RECLAMATION, U.S. DEP'T OF THE INTERIOR, ASSESSMENT '87: A NEW DIRECTION FOR THE BUREAU OF RECLAMATION (1987).

95. BUREAU OF RECLAMATION, U.S. DEP'T OF THE INTERIOR, RECLAMATION'S STRATEGIC PLAN A LONG-TERM FRAMEWORK FOR WATER MANAGEMENT, DEVELOPMENT, AND PROTECTION (1992).

the environment."[96] Most recently, a director of the Bureau of Reclamation, Commissioner Daniel P. Beard, emphasized again the paramount importance of environmental considerations in the new, reformed Reclamation program.[97]

A. *Reclamation in a Reactive Mode: Using ESA Consultations to Influence Water Project Development and Operation*

One approach to protection of ESA-listed species in western rivers involves using the ESA Section 7 interagency consultation process to influence Bureau of Reclamation activities. Section 7 consultations currently are the primary way for Reclamation to participate in ESA implementation. They place the agency in a reactive mode of considering whether listed species might be jeopardized by construction or operation of Reclamation projects.

The consultation process appeared to function effectively in influencing the nature and scale of water project development in two river basins, the upper Colorado River and Platte River.[98] In a study of consultations related to western water projects between 1977 and 1985, GAO found that, while no consultations resulted in project termination, they modified 38 projects in the upper Colorado Basin and two major projects in the Platte Basin.[99] The consultation process also was employed to impose a water depletion fee on new projects in the upper Colorado Basin. Forty six projects paid these fees in the 1981-86 period;[100] the fees continue, at the one-time rate of $10 per acre-foot, as part of the official Recovery Implementation Program for Endangered Fish Species in the Upper Colorado River Basin.[101] Fee revenues are ear-

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96. Environmental protection, under the Bureau of Reclamation's *Strategic Plan*, consists of water management for instream flows, fish and wildlife resources, recreational opportunities, and water quality. *Id.* at 10-15. In late 1992, particular elements of the strategic plan were specified in two draft implementation plans. BUREAU OF RECLAMATION, U.S. DEP'T OF THE INTERIOR, BUREAU OF RECLAMATION, AN IMPLEMENTATION PLAN FOR FISH AND WILDLIFE RESOURCES (1992); BUREAU OF RECLAMATION, U.S. DEP'T OF THE INTERIOR, AN IMPLEMENTATION PLAN FOR INSTREAM FLOWS (1992). These two implementation plans articulate commitments to fulfilling the Bureau's Section 7 obligations under the ESA, collaborating with federal and state wildlife management agencies on endangered species protection, and searching for opportunities to improve aquatic habitat through modifications in reservoir operations and other Reclamation operations.

97. DANIEL P. BEARD, BUREAU OF RECLAMATION, U.S. DEP'T OF THE INTERIOR, BLUEPRINT FOR REFORM: THE COMMISSIONER'S PLAN FOR REINVENTING RECLAMATION 1-2 (Nov. 1, 1993).

98. U.S. GENERAL ACCOUNTING OFFICE, *supra* note 54.

99. *Id.* at 17-18.

100. *Id.* at 29.

101. FISH AND WILDLIFE SERVICE, U.S. DEP'T OF THE INTERIOR, RECOVERY IMPLEMENTA-

marked for Colorado River endangered fish recovery.

The ESA consultation process has the strength of assigning clear leadership responsibility to the fisheries agencies, USFWS and NMFS. They are responsible for developing scientifically-based "reasonable and prudent alternatives" for other federal agencies to undertake to avoid placing a protected species in jeopardy of extinction.[102]

B. Reclamation in a Proactive Mode: Elevating Fish and Wildlife Resources to a **Project Purpose**

The proactive approach contrasts distinctly to operating solely within the context of the ESA consultation process: instead of posing the question of whether Reclamation activity might *jeopardize* a listed species, it poses the question of how Reclamation activity can contribute to *avoidance* of additional ESA-listings.

In both central California and the Columbia River Basin, as described previously, external events thrust the Bureau of Reclamation into a decidedly proactive role. Under the CVPIA, Reclamation is responsible for implementing several provisions geared toward improving fish populations, including water reallocation to instream flow for habitat improvement and water price surcharges earmarked for a habitat restoration fund.[103] In the Columbia River Basin, the NMFS directed Reclamation to acquire at least 0.427 maf of water per year from irrigators in the upper Snake River Basin, with the water earmarked to augment river flows for salmon migration.[104] In both cases, the water reallocations should improve populations of fish species whose populations are declining yet not endangered, as well as assisting the ESA-listed species.

The argument for a proactive role for the Bureau of Reclamation depends on three points. One, the biological evidence cited earlier suggests that species decline and endangerment are serious concerns in the West's riverine ecosystems. Two, a proactive role creates flexibility to restore ecosystems rather than to manage for individual species. Many observers correctly criticize the ESA's individual-species approach as piecemeal. A multi-species or ecosystem approach to species protection in western rivers appears desirable on both biological and economic grounds. Three, proactive measures may alleviate pressure for more drastic measures that frequently accompanies official ESA listing. In its *An Implementation Plan for Fish and Wildlif Resources*, Reclamation makes

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TION PROGRAM FOR ENDANGERED FISH SPECIES IN THE UPPER COLORADO RIVER BASIN 4-6 (1987).

102. YAFFEE, *supra* note 30, at 97-98.

103. *See supra*, text accompanying notes 49-50.

104. *See supra*, text accompanying notes 61-66.

this point explicitly:

> 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.[105]

These general points make an intuitively appealing case for a proactive approach by Reclamation to habitat restoration in western river systems.

The CVPIA provides a feasible model for a proactive approach on a Western scale.[106] Several CVPIA elements pertaining to fish and wildlife conservation, and endangered species protection in particular, could be replicated across Reclamation projects:

- mandate fish and wildlife conservation as an explicit purpose of each Reclamation project,
- allocate water to fish and wildlife (where allowed by state water law),
- establish a Reclamation Fish and Wildlife Restoration Fund dedicated to acquiring
- water, land, and management resources for fish and wildlife conservation, and
- finance the fund through modest charges paid by recipients of Reclamation water and power supplies (for example, the CVPIA increases irrigation water prices by up to $6 per acre-foot).

As with the CVPIA, the U.S. Congress would need to authorize or direct the Bureau of Reclamation to develop a fish and wildlife recovery program of this scope.

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105. BUREAU OF RECLAMATION, AN IMPLEMENTATION PLAN FOR INSTREAM FLOWS, *supra* note 96, at 34-35.

106. John B. Loomis, *Water Transfer and Major Environmental Provisions of the Central Valley Project Improvement Act: A Preliminary Economic Evaluation*, 30 WATER RESOURCES RES. 1865 (1994). Another example of proactive water management is in the Yakima River Basin in Washington. A major Bureau of Reclamation project provides water service to roughly 370,000 irrigated acres in the Yakima Basin. BUREAU OF RECLAMATION, *supra* note 96, at 34-35. Presently, the basin does not contain any ESA-listed fish species (although the basin's stocks of coho salmon, sockeye salmon, and the summer run of Chinook salmon are extinct. Nehlsen, *supra* note 24. In 1994, the U.S. Congress enacted the Yakima River Basin Water Enhancement Project, Pub. L. No. 103-434, § 12, 108 Stat. 4526 (1994). One purpose of the law is to restore the basin's anadromous fishery. Among other measures, the act requires that water savings of 110,000 acre-feet per year be dedicated to improving fish and wildlife habitat.

VI. CONCLUDING COMMENTS

The decline of natural aquatic ecosystems in the American West is one legacy of a century of river development for water and power supply. This article extracts two fundamental elements related to this legacy—fish species protected under the ESA and irrigated agriculture served by surface water sources—for analysis. The ESA provides the final "safety net" for wildlife when other protections afforded by wildlife policy or resource use regulations prove insufficient. More broadly, the ESA offers one tool to achieve, perhaps, ecosystem protection. Endangered fish species, through the legal imperative to allocate resources to their recovery, may create conditions to improve the natural functioning of western river ecosystems—much as the spotted owl may help to preserve the Pacific Northwest's ancient forests.

Our focus on irrigated agriculture stems from several facts. Irrigated agriculture dominates surface-water consumption in the West. Moreover, in basin after basin, empirical evidence shows that agriculture uses more water than would be the case in an economically efficient allocation of the resource across economic sectors. Finally, in many areas of the West, irrigation water conservation will be necessary to increase instream water flow for fish habitat improvement.

Three principal descriptive and analytical results emanated from the Western perspective developed here. First, the numbers that describe the potential conflict seem large when totaled across the West: 50 ESA-listed fish species are linked to agricultural activity; 235 counties, representing 22 percent of the counties in the West, contain irrigated production that relies on water from rivers with these ESA-listed species; and another 86 western fish species are officially designated as candidate species for listing. Second, the western scale permitted a statistical analysis of the agriculture-endangered fish species relationship using two county-level databases. Analysis of both databases found that the number of ESA-listed fish species in a county correlated positively with the level of irrigated agriculture reliant on surface water in the county. In particular, the number of species depended positively on water-supply levels of the Bureau of Reclamation. Finally, the western perspective—as well as individual case studies of central California and the Columbia River Basin—focused attention on the federal Reclamation program. Its pervasive presence throughout the West and specific responsibilities under the ESA will lead to Reclamation involvement in the recovery of many, if not most, ESA-listed western fish species. Perhaps more important, though, is the proactive role that could be defined for the Bureau of Reclamation in ecosystem protection and restoration of western river systems. A program designed to avoid the endangered species of tomorrow, while protecting the endangered fish of today, could minimize the cost and disruption inherent in resolution of western water allocation conflicts.

The western perspective highlights common elements of water allocation conflicts between endangered fish species and irrigated agriculture across the western rivers. At the same time, it ignores details related to individual species or river segments, information that would be important for ascertaining the exact tradeoffs present in individual river basins. The analysis thus serves as a screening device, with additional quantitative research needed on the topic.

Table 1. Surface Water Withdrawals for Irrigated Agriculture, 17 Western States

	Surface water withdrawals for irrigation, 1990	Irrigation water withdrawals as a percentage of total surface water withdrawals, 1990
	(1,000 acre-feet)	(%)
Arizona	3,640	85
California	19,300	84
Colorado	10,100	91
Idaho	13,500	99
Kansas	224	12
Montana	9,990	98
Nebraska	1,950	42
Nevada	2,190	86
New Mexico	1,840	95
North Dakota	96	3
Oklahoma	121	14
Oregon	7,060	82
South Dakota	281	74
Texas	3,250	23
Utah	3,460	90
Washington	5,920	82
Wyoming	7,760	96

Data source: Solley, et al., 1993.

Table 2. Variables in Westwide County-level Data Sets

			Standard
Variable	*Units*	*Mean*	*Deviation*
	1. Census data set[1]		
ESAFISH[2]	number of species	0.48	1.13
AGPRD	$1,000	58317	1.098E05
NIRRACR	acres	1.044E05	1.149E05
PSTRACR	acres	4.176E05	5.101E05
IRRACR	acres	18485	51065
IRRACR2	acres squared	2.947E09	2.290E10
BOR[3]		0.190	0.393
	2. Reclamation data set[4]		
ESAFISH[5]	number of species	1.11	1.56
CROPREV	dollars	3.968E07	1.199E08
IRRACR	acres	52814	87989
PRJDLV	acre-feet	1.276E05	2.592E05
PRJDLV2	acre-feet squared	8.313E10	4.704E11
NPRJDLV	acre-feet	11706	51409
NPRJDLV2	acre-feet squared	2.767E0	92.020E10

1 The Census data set contains 1029 observations.
2 803 of the observations on *ESAFISH* are 0 in the Census data set. The mean for *ESAFISH* is 2.19 when these observations are removed.
3 *BOR* is a dummy variable that takes a value of 1 when a county contains cropland served by Bureau of Reclamation water supply.
4 The Reclamation data set contains 199 observations.
5 110 of the observations on *ESAFISH* are 0 in the Reclamation data set. The mean for *ESAFISH* is 2.47 when these observations are removed from the Reclamation data set.

Table 3. Poisson Model Estimates, Dependence of ESA-Listed Fish *Species on Agricultural Activity in the West*[1]

1. Census data set

Variable	**Estimated Coefficient**	***t*-ratio**	**Elasticity[2]**
AGPRD	4.184E-07	0.98	0.02
NIRRACR	-3.703E-06	-5.95	-0.39
PSTRACR	2.582E-07	4.39	0.11
IRRACR	9.238E-06	6.02	0.16[3]
IRRACR2	-1.741E-11	-3.87	
BOR	0.637	5.62	0.12
Constant	-0.989	-11.77	
LLF[4]	-986.03		

2. Reclamation data set

Variable	**Estimated Coefficient**	***t*-ratio**	**Elasticity[2]**
CROPREV	1.237E-09	1.25	0.05
IRRACR	-5.496E-06	-2.99	-0.29
PRJDLV	3.413E-06	6.08	0.41[3]
PRJDLV2	-8.093E-13	-3.89	
NPRJDLV	8.430E-06	2.55	0.09[3]
NPRJDLV2	-2.166E-11	-1.74	
Constant	-0.153	-1.62	
LLF[4]	-306.82		

1 Dependent variable is *ESAFISH,* the number of ESA-listed fish species in the county whose recovery could affect irrigated agricultural activity.

2 The elasticity formula for the Poisson regression model is _X, where _ is the estimated coefficient and X is the independent variable. (Footnote 3 to the table discusses an exception to this formula for the case of an independent variable that enters both in linear and squared terms.) Each independent variable is evaluated at its mean value for the elasticities reported here.

3 The elasticity formula for the Poisson regression model when a variable enters both in linear and squared terms is (_1X + 2_2X2), where _1 is the estimated coefficient for X and _2 is the estimated coefficient on X2.

4 Value of the log-likelihood function for the regression.

APPENDIX:

WESTERN ENDANGERED AND THREATENED FISH

Several sources of information are used in compiling the appendix: 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).

SPECIES	YEAR LISTED AND STATUS	CURRENTLY OCCUPIED HABITAT	STATE	AG LINK	FEDERAL EXPENDITURES ($1,000)	
					FY1990	FY1991
YAQUI CATFISH	1984-T	SAN BERNARDINO CREEK	AZ	YES	33.0	37.5
OZARK CAVEFISH	1984-T	SPRINGFIELD PLATEAU CAVES	OK	YES	29.4	8.1
BONYTAIL CHUB	1980-E	UPPER AND LOWER COLORADO RIVER SYSTEM	AZ CA CO NV UT WY	YES	292.3	243.9
BORAX LAKE CHUB	1982-E	BORAX LAKE	OR	YES	30.0	5.8
CHIHUAHUA CHUB	1983-T	MIMBRES RIVER	NM	YES	18.4	30.2
HUMPBACK CHUB	1967-E	UPPER AND LOWER COLORADO RIVER SYSTEM	AZ CO UT	YES	403.6	2773.0
HUTTON SPRING TUI CHUB	1985-T	HUTTON SPRING THREE EIGHTHS SPRING	OR	YES	.4	1.3
MOJAVE TUI CHUB	1970-E	SODA SPRINGS	CA	YES	24.0	35.0
OWENS TUI CHUB	1985-E	OWENS RIVER SYSTEM	CA	YES	15.4	2.0
PAHRANAGAT ROUNDTAIL CHUB	1970-E	PAHRANAGAT RIVER	NV	YES	16.7	36.8

SPECIES	YEAR LISTED AND STATUS	CURRENTLY OCCUPIED HABITAT	STATE	AG LINK	FEDERAL EXPENDITURES ($1,000)	
					FY1990	FY1991
SONORA CHUB	1986-T	SYCAMORE CREEK SYSTEM	AZ	YES	2.9	3.0
VIRGIN RIVER CHUB	1989-E	VIRGIN RIVER	AZ NV UT	YES	27.8	46.6
YAQUI CHUB	1984-E	RIO YAQUI BASIN	AZ	YES	50.0	0.5
CUI-UI	1967-E	TRUCKEE RIVER PYRAMID LAKE	NV	YES	692.6	310.3
ASH MEADOWS SPECKLED DACE	1983-E	ASH MEADOWS SPRINGS	NV	YES	45.0	10.9
CLOVER VALLEY SPECKLED DACE	1989-E	CLOVER VALLEY SPRINGS	NV	YES	0.1	0.0
DESERT DACE	1985-T	SOLDIER MEADOWS SPRINGS	NV	YES	0.6	13.6
FOSKETT SPECKLED DACE	1985-T	WARNER VALLEY SPRING	OR	YES	0.0	0.8
INDEPENDENCE VALLEY SPECKLED DACE	1989-E	INDEPENDENCE VALLEY SPRING	NV	YES	0.1	0.0
KENDALL WARM SPRINGS DACE	1970-E	KENDALL WARM SPRING	WY	YES	2.0	0.3
MOAPA DACE	1967-E	SPRINGS OFF THE MOAPA RIVER	NV	YES	54.6	32.5
FOUNTAIN DARTER	1970-E	SAN MARCOS RIVER COMAL RIVER	TX	YES	42.7	10.2
LEOPARD DARTER	1978-T	LITTLE RIVER	OK	YES	58.4	23.5
BIG BEND GAMBUSIA	1967-E	SPRINGS IN BIG BEND NATIONAL PARK	TX	NO	13.3	18.0
CLEAR CREEK GAMBUSIA	1967-E	SAN SABE RIVER CLEAR CREEK	TX	YES	2.8	0.0
PECOS GAMBUSIA	1970-E	PECOS RIVER LOST RIVER	NM TX	YES	8.1	17.2
SAN MARCOS GAMBUSIA	1980-E	SAN MARCOS RIVER	TX	NO	14.7	4.0

SPECIES	YEAR LISTED AND STATUS	CURRENTLY OCCUPIED HABITAT	STATE	AG LINK	FEDERAL EXPENDITURES ($1,000)	
					FY1990	FY1991
PAHRUMP KILLIFISH	1967-E	PAHRUMP VALLEY SPRINGS *TRANSPLANTED??	NV	YES	10.5	10.7
NEOSHO MADTOM	1990-T	NEOSHO RIVER	KS OK	YES	14.2	30.5
LOACH MINNOW	1986-T	GILA RIVER SYSTEM	AZ NM	YES	34.5	36.7
ASH MEADOWS AMARGOSA PUPFISH	1983-E	ASH MEADOWS SPRING SYSTEM	NV	YES	48.0	22.9
COMANCHE SPRINGS PUPFISH	1967-E	SPRINGS IN THE PECOS RIVER DRAINAGE	TX	YES	10.0	15.6
DESERT PUPFISH	1986-E	SALTON SEA SYSTEM AND QUITOBAQUITO SPRING	AZ CA	YES	53.3	46.3
DEVIL'S HOLE PUPFISH	1967-E	DEVIL'S HOLE SPRING	NV	YES	54.3	18.7
LEON SPRINGS PUPFISH	1980-E	DIAMOND Y SPRING AND OUTFLOW	TX	YES	9.9	18.7
OWEN'S PUPFISH	1967-E	FISH SLOUGH SPRING SYSTEM	CA	YES	15.0	0.0
WARM SPRINGS PUPFISH	1970-E	ASH MEADOWS SPRING SYSTEM	NV	YES	45.0	22.8
SACRAMENTO WINTER RUN CHINOOK SALMON	1990-E	SACRAMENTO RIVER SYSTEM	CA	YES	2306.5	5487.7
SNAKE RIVER FALL CHINOOK SALMON	1992-T	COLUMBIA RIVER SYSTEM	ID WA OR	YES	NA	NA
SNAKE RIVER SPRING/SUMMER CHINOOK SALMON	1992-T	COLUMBIA RIVER SYSTEM	ID OR WA	YES	NA	NA
SOCKEYE SALMON	1992-E	COLUMBIA RIVER SYSTEM	ID OR WA	YES	NA	NA

SPECIES	YEAR LISTED AND STATUS	CURRENTLY OCCUPIED HABITAT	STATE	AG LINK	FEDERAL EXPENDITURES ($1,000)	
					FY1990	FY1991
BEAUTIFUL SHINER	1984-T	RIO YAQUI AND GUZMAN BASINS	AZ NM	YES	27.0	22.0
PECOS BLUNTNOSE SHINER	1987-T	PECOS RIVER	NM	YES	33.8	100.4
DELTA SMELT	1993-T	SACRAMENTO RIVER	CA	YES	NA	NA
SPIKEDACE	1986-T	GILA RIVER SYSTEM	AZ NM	YES	35.4	18.7
BIG SPRING SPINEDACE	1985-T	MEADOW VALLEY WASH	NV	YES	32.5	11.6
LITTLE COLORADO SPINEDACE	1987-T	LITTLE COLORADO RIVER SYSTEM	AZ	YES	57.7	876.0
WHITE RIVER SPINEDACE	1985-E	UPPER WHITE RIVER SPRING SYSTEM	NV	YES	6.6	17.6
HIKO WHITE RIVER SPRINGFISH	1985-E	CRYSTAL SPRINGS	NV	YES	8.6	10.3
RAILROAD VALLEY SPRINGFISH	1986-T	RAILROAD VALLEY SPRINGS	NV	YES	7.3	14.6
WHITE RIVER SPRINGFISH	1985-E	ASH SPRINGS	NV	YES	6.5	8.8
COLORADO SQUAWFISH	1967-E	UPPER AND LOWER COLORADO RIVER SYSTEM	AZ CA CO NM UT WY	YES	2168.6	3669.5
UNARMORED THREESPINE STICKLEBACK	1970-E	SANTA CLARA RIVER SYSTEM SAN ANTONIO CREEK	CA	YES	23.2	14.2
PALLID STURGEON	1990-E	MISSISSIPPI MISSOURI YELLOWSTONE	KS MT NB ND SD	YES	268.0	478.2
JUNE SUCKER	1986-E	UTAH LAKE AND TRIBUTARIES	UT	YES	30.8	131.4
LOST RIVER SUCKER	1988-E	KLAMATH LAKE AND TRIBUTARIES	CA OR	YES	24.7	188.0
MODOC SUCKER	1985-E	PIT RIVER SYSTEM	CA	YES	31.4	8.8

SPECIES	YEAR LISTED AND STATUS	CURRENTLY OCCUPIED HABITAT	STATE	AG LINK	FEDERAL EXPENDITURES ($1,000)	
					FY1990	FY1991
RAZORBACK SUCKER	1991-E	UPPER AND LOWER COLORADO RIVER SYSTEMS	AZ CA CO NM NV UT	YES	NA	NA
SHORT-NOSE SUCKER	1988-E	KLAMATH LAKE AND TRIBUTARIES	CA OR	YES	22.9	188.0
WARNER SUCKER	1985-T	WARNER BASIN DRAINAGE	OR	YES	30.3	55.6
GILA TOPMINNOW	1967-E	GILA RIVER SYSTEM	AZ NM	YES	159.0	99.3
APACHE TROUT	1975-T	HEADWATERS OF THE SALT, VERDE AND LITTLE COLORADO RIVERS	AZ	NO	281.2	84.3
GILA TROUT	1967-E	GILA RIVER SYSTEM	AZ NM	YES	27.7	69.1
GREENBACK CUTTHROAT TROUT	1978-T	HEADWATERS OF SOUTH PLATTE AND ARKANSAS RIVER SYSTEMS	CO	YES	100.5	90.8
LAHONTAN CUTTHROAT TROUT	1975-T	LAHONTAN BASIN SYSTEM	CA NV	YES	1645.8	1597.7
LITTLE KERN GOLDEN TROUT	1978-T	LITTLE KERN RIVER	CA	YES	43.6	1.8
PAIUTE CUTTHROAT TROUT	1975-T	SILVER KING BASIN	CA	YES	50.0	41.8
WOUNDFIN	1970-E	VIRGIN RIVER	AZ NV UT	YES	37.0	75.6