John Stumbos

California has constructed large hatcheries to compensate for lost spawning habitat, but wild fish populations continue to decline. On the Sacramento River, U.S. Fish and Wildlife Service biologists monitor for salmon and steelhead.

Restoring aquatic ecosystems is a matter of values

Peter B. Moyle

Californians today seem willing to make sacrifices to protect the environment, including paying more — directly or indirectly — for water. There are limits to this willingness, however, and these limits are determined by a combination of underlying value systems and the perceived relationships between costs and benefits. A number of interrelated values, economic and noneconomic, can be invoked to justify devoting water to the protection of fish and other aquatic life. These values can be incorporated into strategies for protecting natural systems, ranging from protecting species to managing large ecosystems. The application of multiple and often conflicting values lies at the heart of CALFED, a multiagency effort to provide assured water supplies to farms and urban areas while also protecting and enhancing aquatic species and habitats. The CALFED Strategic Plan for Ecosystem Restoration for the San Francisco Bay-Delta ecosystem is an example of the kind of broad-based strategy that must be implemented if we are sincere about maintaining natural systems for the benefit of humans and the rest of California's biota in the 21st century and beyond.

When the tiny delta smelt was first proposed for listing as an endangered species in 1989, a newspaper headline screamed "Delta Smelt Threatens Water Supplies." The headline "Water Supply Threatens Delta Smelt" would have been closer to the truth, and in fact better reflects what has become the official attitude toward the smelt. Despite dire predictions, the California economy did not collapse after the smelt — and a succession of other fish species that live in the Sacramento-San Joaquin Delta — were listed as threatened or endangered under federal and state laws. Instead, a truce was declared in the legendary wars among competing interests for Northern California's wa-

ter, initiating a major effort to find ways to protect the environment while assuring water users that water quality and the reliability of supply would be maintained and, most likely, improved.

This uneasy truce represents a major change in attitudes toward the use of California's water. For example, when Friant Dam on the San Joaquin River was built in the 1940s, 50,000 spring-run chinook salmon were left stranded, resulting in the extinction of a distinctive run. Why have public attitudes toward saving fish changed so dramatically in the past 50 years? What justifies protecting small fish that live in the water that drives California's economic engine? How do we protect fish and other aquatic creatures and still provide water for farms and cities? Insights into the answers to these questions can be found by examining what is happening in the Central Valley and the San Francisco Bay-Delta Estuary.

B. Moose Peterson/WRP

Despite dire predictions, the California economy did not collapse after the delta smelt was added to the federal endangered species list.

Change in attitudes

The United States and California have long traditions of protecting fish and wildlife and their habitats. This protection has been mainly within the context of the direct economic value of the animals, especially for hunting and fishing. With the exception of migratory birds, special protection for nonharvested fish and wildlife was largely thought to be unnecessary because there seemed to be plenty of habitat on the margins of private lands and in the vast tracts of public lands. This attitude changed as human population exploded across the landscape, farming and logging increased in scale, and the post–World War II economic boom spewed toxic wastes in huge quantities into our waters, resulting in massive declines of native plants and animals (Kucera and Barret 1995; Pavlik 1995).

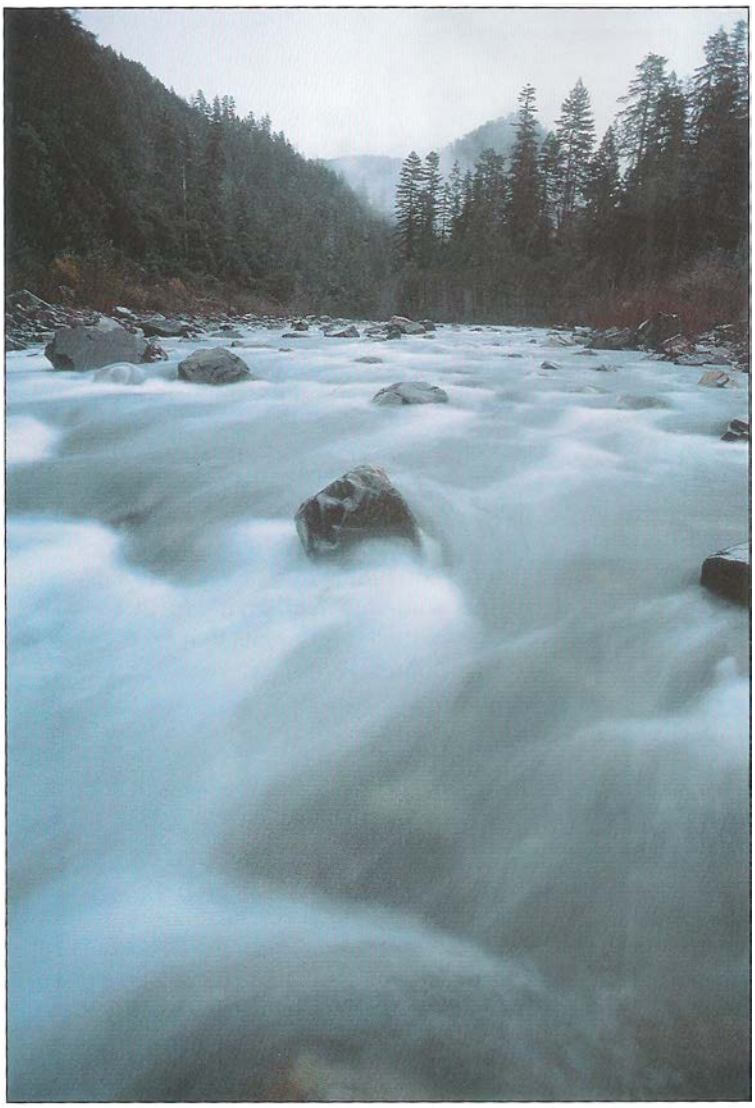
During this era, implicit and explicit promises were made by politicians and engineers that we could build California's hydraulic society (see p. 10), fed by aqueducts from hundreds of dams, and still maintain the diverse wild landscapes, plants and animals that make the state such a desirable place to live. One of the most obvious indicators that these promises were not being kept was the decline of fisheries for chinook salmon, coho salmon and steelhead, despite the construction of large hatcheries to compensate for production lost from natural streams. In the waters of the Central Valley, the decline of salmon has occurred concurrently with the decline of many other native fishes and some desirable non-native species, such as striped bass and American shad.

The decline of fisheries, the presence of foul-smelling, toxic waters, and the loss of spectacular wildlife such as bald eagles, gray whales and cutthroat trout led to the passage of the federal Endangered Species Act in 1973 and Clean Water Act in 1972, both followed by equivalent state acts. These strong laws, still popular with the general public, were essentially responses to public sentiment that high rates of environmental degradation were affecting human health, fisheries and highly visible species such as the bald eagle. The environmental movement, through groups such as the Sierra Club, Environmental Defense and The Nature Conservancy, started its rapid expansion during the 1970s, helping to educate the largely urban public about the importance of environmental protection while often arguing that noneconomic values were as important as economic values. In the 1980s, conservation biology was created as a distinct academic field, giving further credibility to arguments that (1) the environmental crisis was real and severe; (2) conservation of the world's natural systems required changes in

Animals at risk

As of January 2000, the following vertebrates present in the CALFED region were listed as threatened or endangered under the federal Endangered Species Act of 1973. (Thirty-seven plant and six invertebrate species are also listed.)

Steelhead rainbow trout
Winter-run chinook salmon
Delta smelt
Sacramento splittail
Tidewater goby
Red-legged frog
Limestone salamander
Blunt-nosed leopard lizard
Giant garter snake
California condor
California brown pelican
Aleutian Canada goose
Peregrine falcon
California clapper rail
California least tern
Western snowy plover
Northern spotted owl
Salt-marsh harvest mouse
Giant kangaroo rat
San Joaquin kit fox



Phil Schermeister

The Smith River in Northern California is one of the state's last undammed major rivers. During the time that hundreds of dams were constructed in California and across the nation, little attention was paid to the needs of fish.

There is a massive environmental debt to repay in California, which is reflected in the degraded nature of so many of our streams, lakes and estuaries. We can fix things now, or we can wait until conditions get worse and we experience even more strongly the loss of benefits provided by healthy ecosystems.

human value systems; and (3) solutions should be based on the best available science but take into account the importance of humans as an integral part of ecological systems (Meffe and Carroll 1997).

The result was a citizenry more willing to make sacrifices to protect the environment, including paying more, directly or indirectly, for water. There are limits to this willingness, however, and these limits are determined for each individual by a combination of their underlying value system and the perceived relationships between costs and benefits. For example, in the 1990s Californians passed bond issues (e.g., Proposition 204) and influenced federal legislation to spend hundreds of millions of dollars to repair ecological damage to the San Francisco Bay-Delta Estuary and to devote more water for environmental purposes

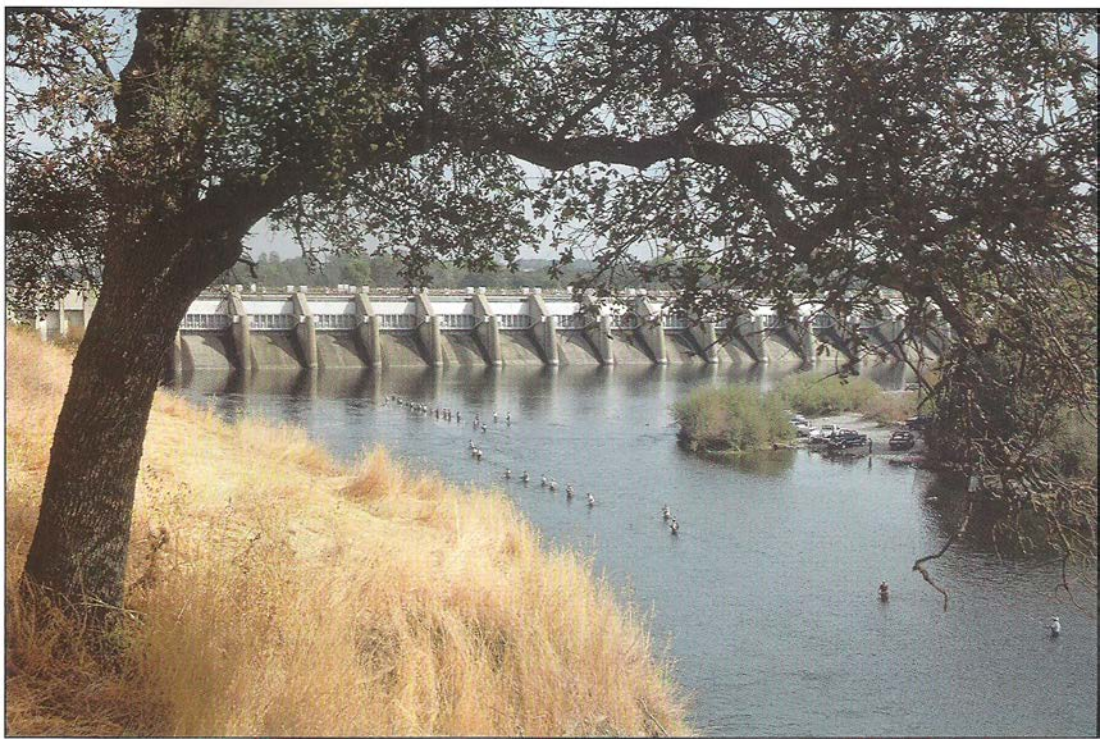
This has resulted in formation of the CALFED Bay-Delta Program, a confederation of 11 state and federal agencies working together (in theory) with local and regional agencies and interest groups to find acceptable solutions to the interconnected problems of improving environmental conditions and the reliability and quality of water supply to agriculture and urban areas. The first stage of the CALFED Bay-Delta program will take 7 years and cost an estimated $4.4 billion, including about $1 billion for ecosystem restoration (McClurg 1999). However, as of January 2000 only $284 million had been appropriated for ecosystem restoration. The total cost is likely to be in excess of $10 billion. How much water and money Californians ultimately are willing to devote to restoration will depend on the short-term success of CALFED in securing more reliable water supplies before the next major drought.

Justifications for protection

Four important interrelated values are often invoked to justify devoting water to the protection of aquatic life in California.

Market values. The easiest way to value water left in streams and lakes is to determine the income generated by goods or services produced by free-flowing streams. On average, commercial salmon fisheries in California generate $8 million to $21 million per year, even with hatchery rearing of large numbers of fall-run chinook salmon. These figures are presumably a small fraction of the potential value if salmon numbers approached pre-1850 levels. Historically, salmon were 10 to 15 times more abundant in the Central Valley than they are today, with the fish divided among four runs that provided nearly continuous in-stream fisheries. In a best-case scenario, salmon fisheries could earn as much as $111 million per year in California, income that would be especially important to small coastal communities (Yoshiyama 1999). The value of recreational and subsistence fisheries for Native Americans also adds substantially to the lost economic value of salmon.

Salmon runs can be viewed as *natural capital*, a bank account of fish that pays high annual interest rates year af-



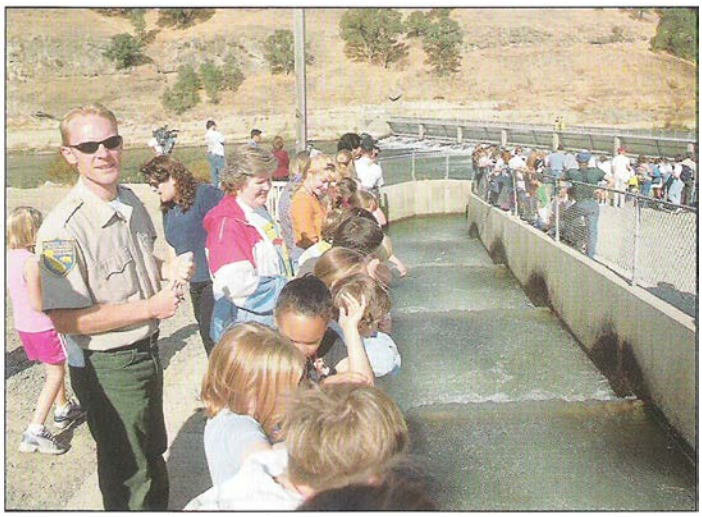
John Stumbos

ter year as new fish enter the fishery. California's extensive system of hatcheries is a recognition of the value of salmon as well as an attempt to replace natural capital with government subsidies. However, the hatchery system has slowed but not stopped the decline of salmon. Thus it has not been a real substitute for the need to increase stream flows and to improve water and habitat quality for salmon spawning and rearing. Similar analyses could be made for the market values of other fisheries, waterfowl hunting or water-oriented recreation.

The problem with relying on market values as the main indicator of worth is that water as a commodity is immensely more valuable than the fish and wildlife that depend on it. This is why Central Valley chinook salmon populations have been allowed to deteriorate to the point where three of the four runs are threatened with extinction and the fourth (the fall run) is propped up by hatchery production. Under this value system, species like Sacramento splittail, which supports only a small recreational/subsistence fishery by Chinese Americans, have negligible value. Clearly such fish *do* have value beyond simple economics, which is why we continue to maintain their populations, even if at reduced levels and through such contentious mechanisms as the Endangered Species Act.

Ecosystem service values. Clean, free-flowing rivers and streams dilute pollutants, filter organic wastes, grow riparian forests (which, in turn protect drinking water supplies from pesticides, sediment and other byproducts of intensive land use), support fishing and other recreational activities, and provide endangered-species habitat and spawning and rearing areas for fish. When these "free" services are lost they must be paid for, such as with improvements to water purification plants or the purchase of bottled water. Such costs are rarely included in the development costs of water or watersheds.

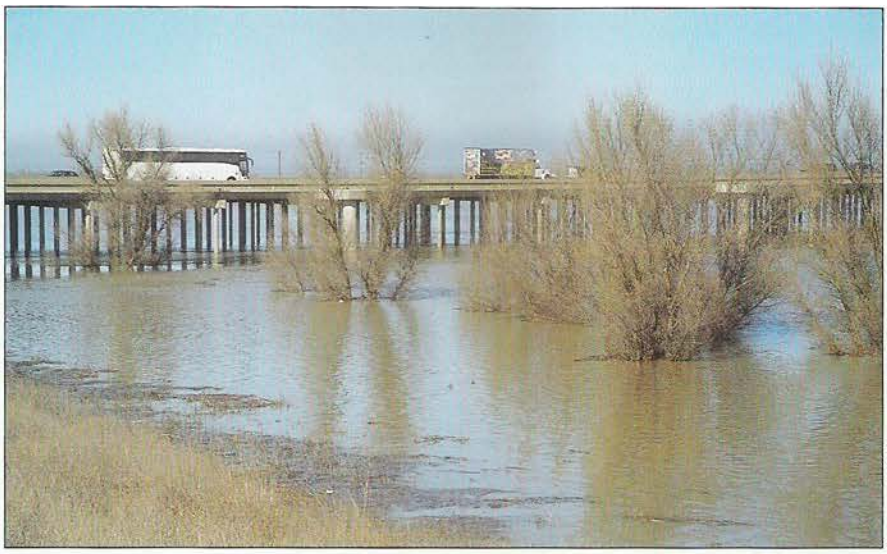
Although dams are essential for the capture and delivery of water to distant cities and farms, they interfere with ecosystem services. For example, dams capture gravel created by the erosion of mountains, preventing its movement into rivers on the valley floor and eliminating the clean, loose gravel that salmon and other anadromous fish need for spawning. As a result, thousands of tons of gravel are periodically mined off-site by various agencies and dumped into Central Valley riverbeds, to provide spawning habitat for chinook salmon below dams (Mount 1995).



John Stumbos

Fish are valued by humans for reasons that go beyond simple economics. *Top*, Anglers work the American River below Nimbus Dam. *Above*, The annual return of salmon to the hatchery's fish ladder is a well-attended public event.

Aquatic ecosystems are also a repository for species that may become unexpectedly valuable. For example, white sturgeon have recently become an important aquaculture species in California, raised not only for meat but also for caviar, which is increasingly valuable as populations of wild sturgeon decline worldwide. Even the endangered delta smelt may someday have direct economic value. Similar species are highly prized as food in Ja-



Suzanne Paisley

The Yolo Bypass may need to be deliberately flooded in the spring to promote spawning of the Sacramento splittail and provide rearing habitat for juvenile salmon.

The Delta in 2025

The following changes are likely to occur by 2025 in the Sacramento-San Joaquin watershed if the CALFED Strategic Plan for Ecosystem Restoration is fully implemented. (These predictions are those of the author.)

1. CALFED will become a quasi-independent agency whose leadership has the authority and willingness to make tough decisions (or else it will cease to exist).

2. Major sections along the Sacramento and San Joaquin rivers, and some tributaries, will be returned to flood plain, although much of the land will still be farmed (on the model of the Yolo Bypass).

3. Construction will have started on a limited version of the peripheral canal, perhaps after major, earthquake-caused levee failures in the Delta. The damage by the earthquakes will be limited, however, because many Delta islands will already have been converted into wetlands or water-storage facilities.

4. A small run (1,000 fish) of chinook salmon will have returned to the San Joaquin River below Friant Dam with no net loss of water to the region's farms and cities. Salmon runs in the San Joaquin system in general, including the Kings, Stanislaus, Tuolumne and Merced rivers, will be sustained at above 20,000 fish per year.

5. Water use by agriculture in the Central Valley will be reduced by 25% through more efficient irrigation practices, water marketing and improved groundwater management as well as the removal of agriculture from large areas of marginal land.

6. Sacramento splittail, spring-run chinook salmon and winter-run chinook salmon will be proposed for removal from the endangered-species list. Delta smelt will remain endangered.

7. Englebright Dam on the Yuba River will be either torn down, modified or slated to be torn down, in order to return chinook salmon, steelhead and Pacific lamprey to the upper Yuba Basin. Prior to this event, smaller dams on other streams will have been removed or made fish-friendly at a rate of two to four per year.

8. The rate of successful establishment of alien aquatic/estuarine species in the region will be less than one per year.

9. Most regulated streams will have flow regimes that are managed (adaptively) to favor native fishes and corridors of riparian forest.

10. Environmental education will be an important part of the curriculum of all schools, from elementary schools to universities.

— *P.B.M.*

pan, and aquaculture techniques being developed to prevent the extinction of delta smelt could lead to this species being "farmed" for food.

Fish, especially native species, are perhaps the best indicators of streams that provide substantial ecosystem services through clean water and natural flow regimes. In fact, the Clean Water Act demands that public waters be fishable (as well as drinkable and swimmable). Similarly, the California Fish and Game Code (Section 5937) states that fish below a dam must be kept in "good condition." In 1996, a successful court case (Putah Creek Council vs. Solano Irrigation District, Sacramento Superior Court No. 515766) accepted the definition that "good condition" means the fish are healthy individuals in self-sustaining populations that are part of natural assemblages of species (Moyle et al. 1998). This definition implies that in general more water needs to be released from dams for downstream services, such as the maintenance of fisheries.

The neglect of ecosystem service values in water development reflects the fact that historically many real, long-term costs of water development have not been included in the price tags of water projects. Thus the destruction of fisheries, aquatic habitats and native fish populations was not originally included in the costs of dam construction, except through the construction of fish ladders and hatcheries. Similarly, the costs of removing agricultural pollutants from drinking water taken from the Sacramento and San Joaquin rivers is not incorporated into the cost of the water to farmers.

Most of the disputes over water use in California today boil down to determining what the true costs of water development have been and who should pay for the costs to society that are not covered by the water users. For example, re-evaluation of the costs and benefits of various water projects is one of the major justifications for removing dams that have caused signifi-

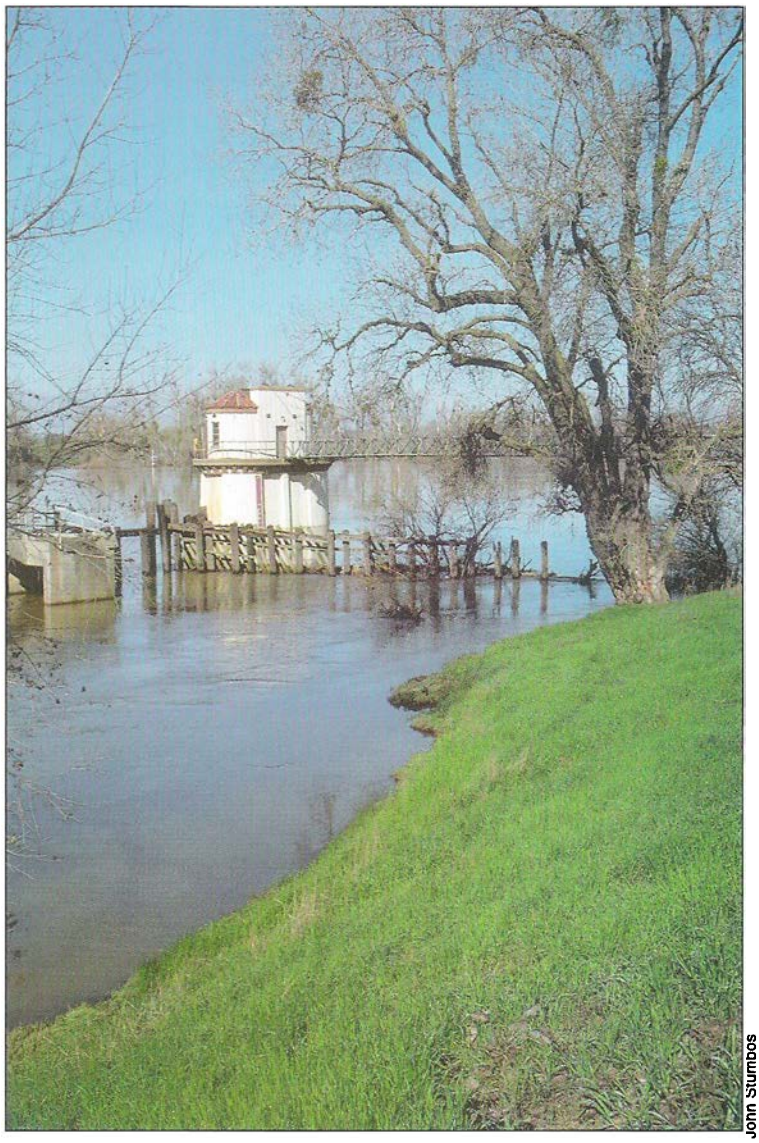
cant environmental damage while providing few benefits. Englebright Dam on the Yuba River has been targeted for removal by environmental groups because it provides relatively small benefits such as capture of hydraulic mining debris and recreation while blocking access of salmon and steelhead to many miles of historic habitat.

Intergenerational values. A major problem with most methods of valuing resources is that the present generation generally has acted as if it "owns" them, with little consideration of their value to future generations (Moyle and Moyle 1995). Indeed, it is difficult to predict what will be valued in the future. In the 1940s, who could have imagined that our present society would place a high value on flows in rivers for recreational rafting or the preservation of obscure species such as delta smelt? Ideally, therefore, we should be placing a high value on *sustainability*, defined as the equitable distribution of resources among generations, to ensure that future generations have the same access to resources as the present generation. To incorporate intergenerational values into our economic system, the *safe minimum standard* can be applied to all species and natural resources, with each species or resource maintained at a self-sustaining level because it may have a high economic value to future generations. As the collapse of fisheries worldwide indicates (Botsford et al. 1997), intergenerational values today are more dream than reality.

Moral values. While market, ecosystem service and intergenerational values attempt to assign economic value to species and natural systems, ultimately we must also rely on non-economic arguments such as those elaborated by philosopher B.G. Norton (1987). The strongest arguments are moral ones, for example that we as humans have no right to eliminate other species from the planet and have an obligation to be good stewards of the land and water (Pister 1997). Indeed, the world's religions all have doctrines that reflect this attitude and there is growing interest among religious organizations in promoting the idea that one purpose of human existence is to take care of the planet and all its inhabitants. Leadership in this area, however, has largely been provided by environmental groups such as World Wildlife Fund or the Wildlands Project (Soulé 2000). In the long run, conservation strategies based on intrinsic moral values are likely to be the most comprehensive and long-lasting.

Protection of natural systems

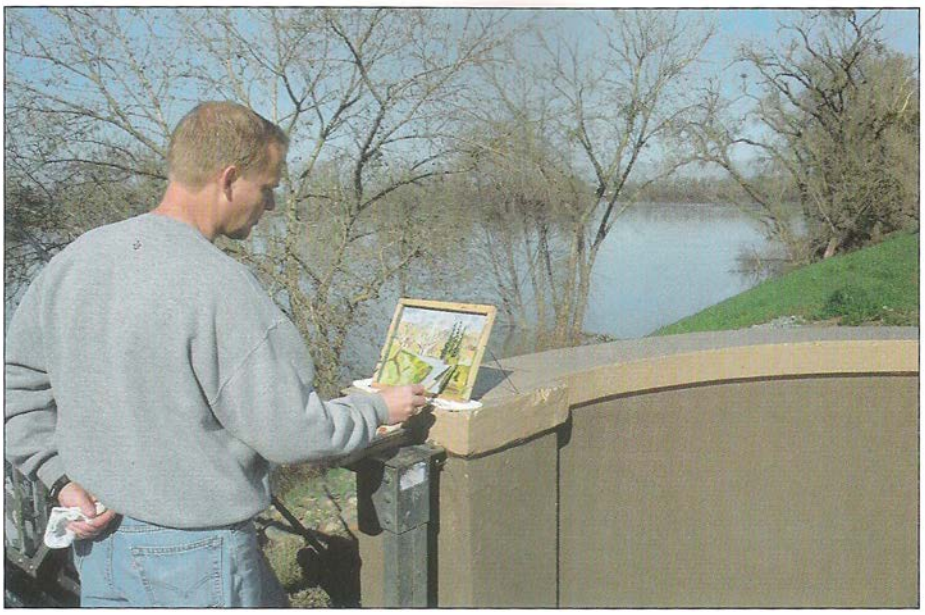
Many strategies are available to protect natural systems, ranging from protecting species to managing entire ecosystems (Moyle and Yoshiyama 1994). One of the most comprehensive strategies produced in California is the Strategic Plan for Ecosystem Restoration for the San Francisco Bay-Delta region, written by a team of scientists for CALFED, including myself and two other UC scientists (1999). The restoration area includes most of the Sacramento-San Joaquin watershed (basically the Central Valley watershed), focusing on the region surrounding and including the estuary and rivers below major dams. The entire area can reasonably be considered an ecosystem in the sense of Likens (1992) as "a spatially explicit unit of the Earth that includes all of the organisms, along with all components of the abiotic environment within its boundaries." The plan is discussed here as an example of the kind of strategy we need to implement if we are sincere about maintaining the sustainability of natural (and human-dominated) systems.



John Stumbos

Why do we need healthy aquatic ecosystems? In addition to the economic value of fisheries and the numerous benefits of well-managed ecosystems, noneconomic values must be considered, such as the need to preserve the environment for future generations.

The CALFED strategic plan was written as a framework for prioritizing actions to restore the ecosystem. Rather than focusing on species, it emphasizes *ecosystem-based management*, the management of watersheds and ecological processes on a large scale. The strategic plan recognizes that ecosystem restoration does not mean re-



John Stumbos

Philosophers, environmental organizations and the world's religions have promoted the doctrine that humans are not entitled to eliminate species from the planet and have an obligation to be good stewards of land and water.

turning the San Francisco Bay-Delta region or most parts of it to pristine condition, for the simple reason that the region is already too altered by human activity for that to be possible:

> Ecosystem restoration does not entail re-creating any particular historical configuration of the Bay-Delta environment; rather it means re-establishing a balance in ecosystem structure and function to meet the needs of plant, animal and human communities, while maintaining or stimulating the region's diverse and vibrant economy.

The plan recommends restoration based on principles of ecosystem-based management identified by the Ecological Society of America (Christensen et al. 1996):

- Long-term sustainability is a fundamental value.
- Management decisions must be based on clearly defined goals and objectives.
- Management decisions must be based on sound ecological models and understanding.
- Complexity and interconnectedness are fundamental characteristics of healthy ecosystems.
- Ecosystems are constantly changing.
- The various aspects of ecosystem structure and function work in time frames and over areas that usually differ from economic and social schedules and boundaries defined by humans.
- Humans are integral parts of *all* ecosystems.
- Ecosystem-based management must be adaptable and accountable, recognizing that management must change as we learn more about how particular ecosystems work.

Goals and objectives of CALFED

The second principle, that management decisions must be based on clearly defined goals and objectives, is extremely important because it ties the other principles to the reality of particular places. Goals and objectives also should be specific enough to be used as measures of progress toward ecosystem restoration. The goals listed in the CALFED strategic plan are:

- Establish self-sustaining populations of all at-risk species in the estuary and watersheds and reverse the downward trends in populations of other native species to avoid more endangered-species listings. *At-risk species* are those listed, or proposed for listing, by state and federal agencies for threatened or endangered status.
- Re-establish natural processes, such as flow regimes in streams, to support natural biotic communities in ways that favor native species.
- Maintain harvestable populations of economically valuable species (including non-native species).
- Protect and restore sustainable examples of all functional habitat types throughout the system.
- Prevent the establishment of additional non-native species and reduce the negative ecological effects of established non-native species.
- Improve water and sediment quality in order to reduce the impacts of toxicants on organisms, including humans.

Each of these goals includes a series of measurable objectives, to provide indications of progress. Objectives for the first goal, for example, would include the attainment of large, self-sustaining populations of delta smelt, Sacramento splittail and winter-run chinook salmon, resulting in their removal from the endangered-species list. The achievement of these objectives, however, would require re-establishing the natural processes that each species requires to complete its life history, such as re-creation of large areas of flood plain that provide habitat for native fishes and other organisms. Thus restoration of splittail may require mechanisms to deliberately flood portions of the Yolo and Sutter bypasses in March and April to promote spawning when flooding does not occur naturally. Harvestable non-native species, such as striped bass and signal crayfish, are also likely to benefit from these actions.

Restoration of natural processes and native species also means that the variety of natural habitat types, such as riparian forest, salt marsh and seasonal sloughs, would be favored. The probability of success will be much higher if invasions by new non-native

continued on p. 24

their mark. The list of projects affected by these and like-minded organizations, such as The Nature Conservancy, includes dam and power-generation projects stalled, toxic chemicals and pesticides restricted, highways rerouted, developments scaled back, and lands and species preserved. Elsewhere, for example Europe and Japan, NGOs have increased in influence; a notable example is their rallying of consumers against the introduction of genetically modified foods into the marketplace.

Today, nonprofit organizations often float the kinds of broad public-policy ideas and initiatives that were once the exclusive domain of the civic-minded business leaders of the past. Likewise, major foundations such as the San Francisco, Hewlett, Packard and Irvine foundations have taken up environmental causes in recent years, promoting "smart-growth" policies or environmental education and justice through generous grants. In mid-1999, the National Network of Grantmakers, which represents 400 foundations that support social change, introduced a campaign called "The Payout Initiative: 1% for Democracy," which encourages foundations to earmark funds for causes such as protecting the environment and fighting poverty.

In the 1970s and early 1980s, litigation was a favorite tool of nonprofit organizations. Freshly minted federal and state legislation such as the National Environmental Policy Act and the California Environmental Quality Act permitted challenges to projects that many California residents saw as unnecessarily destructive to the environment. As federal and state courts became more conservative, however, and government officials and private businesses became more sophisticated in their approaches to project development, litigation has fallen off as the first, or even principal, resort of project opponents.

Instead, other forums have emerged for battles over public policy. Initiatives and referenda, alternative dispute resolution and multistakeholder, collaborative decision-making are among the less conventional means for resolving environmental controversies. Last year, for example, the California Farm Bureau Federation and the Environmental Water Caucus, a coalition representing California nonprofits, engaged in heated head-to-head competition to turn out the most and the best-informed speakers at public hearings on CALFED, the federal-state consortium drafting a new water plan for California.

The alternative visions presented by the Farm Bureau and the EWC at these hearings can be viewed as a metaphor for the major infrastructure and natural-resource dilemmas faced in California. Do we need more dams and canals? How many more highway lanes should be built? Can conservation and efficiency measures do the job instead? Should taxpayers subsidize public-works projects? Can the needs for water, mobility, energy and food be met without additional environmental insult? Indeed, can natural resources devastated by the quest to meet other economic and social objectives now be restored? Can we have it all, prosperity and environmental quality?

No one, of course, knows how these questions will be answered. We do know that in California's future, nonprofit organizations will be squarely in the middle of the struggles to address the state's natural-resource, conservation and infrastructure challenges. For better or worse, they may be even more important in the search for answers than the more traditional sectors from which public leadership sprung in the past.

T. Graff is Senior Attorney, Environmental Defense, and Member, UC President's Advisory Commission on Agriculture and Natural Resources.

continued from p. 22

species are halted and water quality is improved by the reduction of toxic wastes entering the streams. All of these objectives can be quantified, such as the number of acres of a habitat type, the size and age-structure of a fish population, the number of days of natural flooding of riparian areas, the number of additional acres exposed to tidal flushing, and reductions in the rate at which alien species enter the system.

Future in focus: The value of ecosystems

Obviously, achieving these goals and objectives will not be easy. The CALFED program's ultimate success will depend on hundreds of actions, small and large, at hundreds of locations. The goals will be achieved only if there is widespread public support for the values of ecosystem restoration.

First, the public must be convinced that managing the Bay-Delta region on an ecosystem scale will have large economic payoffs in the future, justifying the multibillion-dollar, upfront investment that will likely be required. For example, expanding the flood plain along the Sacramento River (creation of a "meander belt") not only would restore a variety of habitats for native plants and animals (including rearing areas for juvenile salmon), it could also improve the reliability of water supplies to Southern California by increasing the ability of flood-control reservoirs to store water. If the flood plain were larger, reservoirs such as Shasta would not have to be drawn down in winter to capture water for flood control in preparation for big storm events. The nightmare of water managers is to drain a reservoir in winter as a flood-prevention measure and then not have enough rain to refill it. An enlarged flood plain can essentially increase the storage capacity of reservoirs without having to build new dams because the excess water has a place to go.

However, many of the actions taken by CALFED through its member agen-

cies, such as providing water and habitat for delta smelt, must be taken without the immediate expectation of economic gain. The protection of delta smelt must occur because the federal and state endangered-species acts are essentially declarations that it is morally wrong to let a species go extinct when we can prevent it. Fortunately, actions to protect smelt are also likely to have positive benefits to the estuarine ecosystem, which may eventually translate into economic benefits such as improved fisheries for other species or improved water quality at the pumps in the South Delta. If the path envisioned by CALFED's strategic plan is taken, a number of major positive events are likely to occur in the CALFED region (see box, p. 20).

The continued existence of natural systems throughout central California will require an open-minded approach toward environmental protection and ecological restoration, including recognition that we have been borrowing from the future for too long (NHI 1998). There is a massive environmental debt to repay in California, which is reflected in the degraded nature of so many of our streams, lakes and estuaries. We can fix things now, or we can wait until conditions get worse and we experience even more strongly the loss of benefits (spiritual and aesthetic as well as economic) provided by healthy ecosystems. The costs to repair our damaged environment become higher and higher the longer we procrastinate. We should begin the great task of restoration now. The fish — and our descendants — will be appreciative.

B. Moose Peterson/WRP

The endangered California clapper rail is among dozens of plants, birds and animals that must be considered as the CALFED strategic-planning process moves forward. Ecosystem-based management is a fundamental concept in this multistakeholder effort, which seeks to improve the San Francisco Bay-Delta's environment while ensuring the reliability and quality of water supplies to agriculture and urban areas.

P.B. Moyle is Professor of Fish Biology, Department of Wildlife and Fish Conservation, UC Davis. He was a member of the core team that developed the CALFED Strategic Plan for Ecosystem Restoration and is currently a member of the CALFED Interim Science Board. His research is focused on the San Francisco Bay-Delta Estuary and its watershed.

References

Botsford LW, Castilla JC, Peterson CH. 1997. The management of fisheries and marine ecosystems. Science 277:509-15.

CALFED. 1999. CALFED Bay-Delta Program Strategic Plan for Ecosystem Restoration. Sacramento, CA. 49 p. + appendices.

Christensen NL, Bartuska AM, Brown JN, et al. 1996. Report of the Ecological Society of America Committee on the scientific basis for ecosystem management. Ecological Applications 6:665-91.

Kucera TE, Barrett RH. 1995. California wildlife faces uncertain future. Cal Ag 49(6):23-7.

Likens G. 1992. *An Ecosystem Approach: Its Use and Abuse.* Excellence in Ecology series, Book 3. Oldendorf/Luhe, Germany: Ecology Institute. 220 p.

McClurg S. 1999. CALFED and the Delta fix. Western Water, Jan-Feb:4-13.

Meffe GK, Carroll CR. 1997. *Principles of Conservation Biology,* 2nd ed. Sunderland, MA: Sinauer Assocs. 729 p.

Mount JF. 1995. *California Rivers and Streams: The Conflict Between Fluvial Process and Land Use.* Berkeley, CA: UC Press. 359 p.

Moyle PB, Marchetti MP, Baldrige J, Taylor TL. 1998. Fish health and diversity: Justifying flows for a California stream. Fisheries 23(7):6-15.

Moyle PB, Moyle PR. 1995. Endangered fishes and economics: Intergenerational obligations. Env Biology of Fishes 43:29-37.

Moyle PB, Yoshiyama RM. 1994. Protection of aquatic biodiversity in California: A five-tiered approach. Fisheries 19(2):6-18.

[NHI] Natural Heritage Institute. 1998. *An Environmentally Optimal Alternative for the Bay-Delta: A Response to the CALFED Program.* San Francisco. 113 p.

Norton BG. 1987. *Why Preserve Natural Variety?* Princeton, NJ: Princeton University Press. 281 p.

Pavlik BM. 1995. Inventory first step to conserving plant diversity. Cal Ag 49(6):18-22.

Pister EP. 1997. Ethical principles. In: Williams JE, Wood CA, Dombeck MP (eds.). *Watershed Restoration: Principles and Practices.* Bethesda, MD: American Fisheries Soc. 559 p.

Soulé ME. 2000. An unflinching vision: Networks of people for networks of wildlands. Wild Earth 9(4):38-46.

Yoshiyama RM. 1999. A history of salmon and people in the Central Valley region of California. Reviews in Fisheries Science 7:197-239.