# CHAPTER 36

# RESTORING DIVERSITY IN SALT MARSHES

**JOY B.ZEDLER**

Professor of Biology, San Diego State University, San Diego, California

**A**long the U.S. coastline, development has reduced the area of coastal wetlands and endangered certain wetland-dependent species. Despite the threats to biodiversity, development of wetland habitat is still permitted by regulatory agencies if project damages can be mitigated by improving degraded wetlands or creating new wetlands from uplands. For example, the California Coastal Act allows one-fourth of a degraded wetland to be destroyed if the remaining three-fourths is enhanced. The expectation is that increased habitat quality will compensate for decreased quantity.

The concept sounds reasonable, but biodiversity is continuing to decline. Why? First, the process allows a loss of habitat acreage. Second, there is no assurance that wetland ecosystems can be manipulated to fulfill restoration promises. The magnitude of the problem is well illustrated by examples from southern California, where more than 75% of the coastal wetland acreage has already been destroyed, where wetland-dependent species have become endangered with extinction, and where coastal development pressures rank highest in the nation. This chapter reviews several restoration plans and implementation projects and suggests measures needed to reverse the trend of declining diversity.

## RESTORATION PLANS

Several large development projects in southern California wetlands have recently been approved by the California Coastal Commission (see Figure 36–1). Three federally endangered species are affected by such projects: the California least tern *(Sterna albifrons browni),* light-footed clapper rail *(Rallus longirostris levipes),* and salt marsh bird's beak (*Cordylanthus maritimus* spp. *maritimus;* see Figure 36–2).

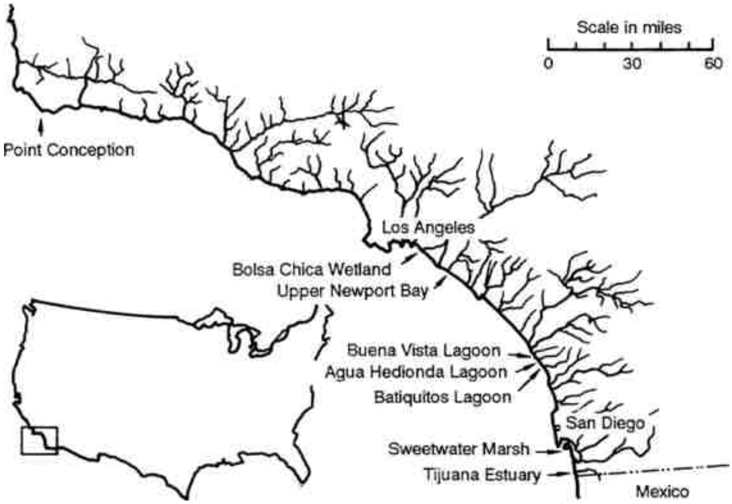


FIGURE 36–1 Sites of some coastal development projects in southern California. In all, there are 26 coastal wetlands between Point Conception and the Mexico-U.S. border.

FIGURE 36–2 The salt marsh bird's beak grows near the upper wetland edge. As an annual plant, its seeds germinate after winter rainfall to maintain the population; as a hemiparasite, its seedlings grow roots that can attach to those of other plants, thereby increasing its supplies of water and nutrients. Photo by J.Zedler.

There would also be an impact on the Belding's Savannah sparrow *(Passerculus sandwichensis beldingi),* which is listed as endangered by the state, and on several plant species of regional concern (Ferren, 1985).

## Projects That Show Losses in Wetland Area

At Bolsa Chica Wetland, more than 1,200 acres (480 hectares) of lagoonal wetland will be reduced to 951 acres (366 hectares) of restored wetland (California State Coastal Conservancy, 1984). Mitigation plans are not final, but the draft concept includes cutting an ocean inlet to serve a new marina. Inland from the marina are sites for restored wetlands with controlled tidal flushing. Uplands designated as "environmentally sensitive habitat areas" that lie within the lowland area and that will be destroyed during development are to be relocated adjacent to the restored wetland in a bluff-edge (linear) park. The draft concept plan accommodates development, but does not ensure maintenance of biodiversity. The restoration activities are based on the assumption that habitat values can be created and moved about at will.

In Los Angeles Harbor, about 400 acres (160 hectares) of shallow water fisheries habitat will be filled to construct new port facilities. At this project site, there is no habitat available to be restored—all the wetlands have been filled or dredged. Thus, off-site mitigation has been approved. Batiquitos Lagoon, more than 80 miles (130 kilometers) south of Los Angeles, will be dredged to create deep-water habitat and increase tidal flushing. According to plans (California State Coastal Conservancy, 1986), the net loss of aquatic habitat in Los Angeles will be mitigated by altering (not increasing) habitat elsewhere. The dredging of Batiquitos Lagoon will remove sediments and, at least temporarily, solve the occasional problems of algal blooms (odors and fish kills after sewage spills). However, maximizing tidal flushing at Batiquitos Lagoon (to replace fisheries habitat in Los Angeles Harbor) will destroy existing salt marsh habitat (Figure 36–3) and reduce the area of shallow water and mudflat habitat. The mitigation plan contains two strikes against biodiversity—the loss of area and the loss of existing functional wetland types.

At Aqua Hedionda Lagoon, about 14 acres (5.6 hectares) of wetland were filled to build a four-lane road. The mitigation plan (U.S. Army Corps of Engineers, 1985) promised to enhance diversity and increase the functional capacity of the lagoon. Brackish-water ponds were planned for a wetland transitional area (itself a rare habitat type); a 2-acre (0.8-hectare) dredge spoil island was to be built for bird nesting; and a 7-acre (2.8-hectare) debris basin was proposed within a riparian area to reduce sedimentation into the lagoon. Flaws in the plan became clear when construction of the brackish ponds began. Pits were dug to a depth of 6 feet (1.8 meters) without encountering groundwater. Areas that were modified included transition habitat, pickleweed marsh (Figure 36–4), brackish marsh, and riparian habitat. The wetland lost both acreage and habitat quality.

All these projects show a net loss in wetland habitat area. Proponents argue that the lost areas are already degraded. However, they could be enhanced to maintain biodiversity. The fact that four wetland-dependent species have become endangered in Southern California while coastal wetlands have shrunk by 75% indicates a cause-effect relationship. There is some minimum area required to support regional biodiversity and a limit to the number of species that can be packed into individual wetlands. Populations are dynamic; some migrate and use several wetlands, whereas others experience local declines and must reinvade from another refuge. The need to maximize area available for wetland species is indicated by population declines that have followed human disturbance and environmental catastrophes.

Several species may be lost simultaneously if a wetland experiences multiple catastrophes. At Tijuana Estuary, the combination of destabilized dune sands (following long-term trampling), the winter storms of 1983, dune washovers, and channel sedimentation led to closure of the ocean inlet in April 1984. The drought of 1984 coincided with an 8-month nontidal period. The population of endangered light-footed clapper rails dropped from about 40 pairs to 0 and did not fully recover after tidal flushing was restored (16 pairs were present in 1987). In addition, there were major declines of three salt-marsh plant species—cordgrass *(Spartina foliosa),* annual pickleweed *(Salicornia bigelovii),* and sea-blite *(Suaeda esteroa)*—and none has recovered to pre-1983 levels. This salt marsh has shifted from the region's most-diverse to a species-poor wetland (Zedler and Nordby, 1986).

FIGURE 36–3 Salt flats may appear to have low habitat value, but many unusual insects, some of them threatened with extinction, are found only in these open areas. In the winter, runoff and high tides inundate the areas, and they become highly productive ecosystems. What appears to be barren in summer is heavily used by shorebirds and dabbling ducks in winter, as migrants visit the flats and feed on the abundant insects and algae. Photo by J.Zedler.

FIGURE 36–4 Pickleweed marsh may seem monotonous, but close inspection will reveal a variety of insects, invertebrates, and dozens of species of microscopic algae. Individuals and trails of the California horn snail *(Cerithidea californica)* are visible in the tidal pool. Photo by J.Zedler.

Maintenance of the region's resources through years of wet and dry periods, with and without closure to tidal flushing, requires that each habitat type be maintained at several different wetlands so there will be refuges during periods of environmental extremes. Further losses in habitat area cannot be justified.

## Projects That Replace Functional Wetland Habitat with Modified Wetland Habitat

Some restoration projects retain acreage but exchange one type of habitat for another. In these cases, functional wetland habitats may be destroyed in order to create some other habitat type. Following are some examples.

The City of Chula Vista's Bayfront Development Plan calls for several developments near and in the last major salt marsh within San Diego Bay (90% of the Bay's wetland has already been developed). The plan includes a multistory hotel and a nature center to be built on an island that is surrounded by Sweetwater Marsh and San Diego Bay. Residential and commercial buildings would surround the marsh. To provide access, three roads are to be built over the wetland. The plan will also require modification of the wetland for the construction of debris basins. Wetland restoration is planned to mitigate impacts. The U.S. Fish and Wildlife Service has concluded that portions of the project jeopardize the following endangered species: California least tern, light-footed clapper rail, California brown pelican *(Pelicanus occidentalis),* and salt marsh bird's beak.

At Los Cerritos Wetland near Los Angeles, a complicated plan (California State Coastal Conservancy, 1982) proposes development of some wetland in exchange for an equal area of wetland creation. In all, 129 acres (51.6 hectares) of wetland will be retained. Some dikes that now prevent tidal flushing will be breached; some new areas will be graded to allow tidal flow. The restored wetlands will be divided into four segments and surrounded by high-density urban uses. Buffers between the wetland and development are as narrow as 25 feet (7.5 meters) for much of the project. A main concern is that existing wetland habitat will be lost and that the artificially created replacements cannot guarantee maintenance of biodiversity.

At Upper Newport Bay, a sediment control plan within a California State Ecological Reserve has received wide political support, in part because dredging in the upper bay reduces sedimentation in the lower bay's marina. Sedimentation in the upper bay is a long-term threat to the marsh habitat, but sudden changes in hydrology may have a negative impact on the habitat of endangered species. Upper Newport Bay has the highest density of light-footed clapper rails in the state of California and some of the region's most robust cordgrass vegetation. Shallow-water and transitional habitats are being traded for deeper channels, and the value of the new habitats to biodiversity is uncertain.

At Buena Vista Lagoon, sediment control measures were also taken. Shallow-water areas were deepened, and dredge spoils were placed alongside them in the wetland. The dredge spoil islands became hypersaline, bricklike substrates that have not developed the desired vegetation or significantly improved the status of the least tern population.

## CONCLUSIONS CONCERNING RESTORATION PLANNING

Several observations on the status of restoration plans can be made:

- Many large projects result in a loss of wetland acreage.
- Mitigation measures for lost habitat often involve changing one type of wetland habitat into another, rather than creating wetland from upland habitat.
- Proposed projects are planned and reviewed individually rather than with a regional perspective. While cumulative impacts may be considered, there is no regional coordination to set priorities and guide decision making. There is no way to ensure that the wetlands with the greatest potential for maintaining clapper rails will be managed for clapper rails.
- There is no single source of information on restoration projects, no center that keeps records on changes in biodiversity to ensure that resource agencies are aware of changes in individual wetlands, no comprehensive monitoring programs to assess changes in biodiversity (although some endangered species are censused annually), and no mechanism to require suitable and comparable methods for the few monitoring programs that have been planned.

## IMPLEMENTATION OF RESTORATION PROJECTS

To enhance, restore, or create wetland habitat requires manipulation of the physical environment (especially the topography and the degree and timing of fresh- and seawater influence) as well as the biota (e.g., by introducing target species and eliminating undesirable ones). Research in this area is just beginning; most of the work has been done on a trial-and-error basis, and the evaluation criteria are not yet standard.

### Assessing Success

Restoration success must be measured in time scales that relate to the species being managed and to the periodicity of extreme environmental conditions characteristic of the region. Successful creation of clapper rail habitat cannot be measured by censusing mortality of cordgrass a few weeks after transplantation. Rather, such projects need to be followed at least until clapper rails establish breeding populations. Measures of restoration success must be done within spatial scales that relate to whole ecosystems. The degree to which breaching a dike and restoring tidal flushing can enhance a lagoon must be measured beyond channel biota and water quality, because there will also be substantial impacts on intertidal marshes. Likewise, dredging to improve fish diversity cannot be considered successful if endangered birds become extinct in the process. In short, restoration success must be measured at the ecosystem level and with long-term evaluation. To date, this has not been done.

### Summary of Trials

All the projects described above incorporate some element of habitat creation or restoration, for which there are no guaranteed benefits to threatened species. Many projects have been designed to restore wetlands and mitigate losses, but in no case have ecosystem functions been duplicated, nor have endangered species been rescued from the threat of extinction. Projects to reduce sedimentation have as one goal the creation of fish and benthic invertebrate habitat (sometimes to provide food for the California least tern). Marsh restoration projects have focused on vegetation used by target bird species (cordgrass for clapper rails, pickleweed for Belding's Savannah sparrows).

While some wetland plant species can be transplanted successfully and others will invade voluntarily given suitable conditions (Zedler, 1984), there are only a few cases where the marsh ecosystem has been monitored for several years (Broome et al., 1986; Homziak et al., 1982) and no example of a threatened species that has been increased as desired. Attempts to restore wetlands in southern California have generally failed to attract target species. In a few cases, the California least tern has nested on dredge spoil islands —but not always where its use was planned. One briefly successful site was an 80-acre (132-hectare) island in south San Diego Bay, which was planned for salt marsh and fish habitat.

### Conclusions Concerning Implementation

Four observations on the status of wetland habitat restoration in southern California can be made.

- Selected plant species (e.g., cordgrass) can be transplanted successfully.
- No plant or animal populations have been taken off the endangered list as a result of restoration projects.
- Wetland restoration assessments have not been made for entire ecosystems but have been limited to one or a few target species.
- No studies have been conducted to determine the minimum wetland area or configuration of multiple wetlands required to maintain regional biodiversity.

Therefore, it is premature to conclude that an artificial tidal wetland can develop and replace the functions of a natural one. Furthermore, there is no evidence that restoration of degraded wetland habitat can compensate for lost habitat area.

## PROSPECTS FOR THE FUTURE

To restore biodiversity in the nation's coastal wetlands, we must understand the factors controlling these ecosystems and develop the ability to modify them to meet desired management goals. We must make substantial advances in ecotechnology—the scientifically sound manipulation of ecosystems to maintain natural diversity and achieve specific management objectives. The field is relatively new in ecology. Only one journal, *Restoration and Management Notes,* and a few books focus on the topic. Although most of the work in this area concerns disturbed ecosystems, all ecosystems need some management to maintain their natural hydrology as well as air and water quality.

Ecosystems of greatest concern tend to be those whose areas have been reduced and whose species are threatened with extinction. Rare species are difficult to study, because the conditions that allowed them to thrive no longer exist. Manipulative experimentation, required to establish cause-effect relationships, cannot always be done without threatening the endangered populations even further. Bringing animals or plants (even seeds) into the laboratory may reduce field populations to levels that jeopardize population recruitment. Thus, maintenance of biodiversity must be based on an understanding of the factors that control the ecosystems in which rare species persist—the type of long-term, ecosystem-level research now funded by the National Science Foundation, the National Oceanic and Atmospheric Administration through its Sea Grant Program, and other agencies. A new research emphasis could allow major advances to be made in wetland ecotechnology. I recommend manipulative experimentation, first in replicate mesocosms (medium-size artificial ecosystems), followed by experimental restoration at the ecosystem level. This approach was adopted by the U.S. Environmental Protection Agency in their research plan for the nation's wetlands (Zedler and Kentula, 1985).

Ecosystem-level experiments have not been incorporated into wetland restoration projects. The contention that artificial or restored wetlands can maintain biodiv ersity must be tested. Every restoration project can include experimentation in its design, e.g., to provide different tidal flows; to test different hydroperiods, salinities, and nutrient inputs; to use different transplantation regimes; or to vary the width of buffer zones, with treatments appropriately replicated. Detailed, long-term evaluation of the experiments will document success or failure to maintain natural diversity. In either event, we will learn whether it can be done and why it succeeds or fails. The present practice of poorly planned, unreplicated, undocumented *trials* leads mainly to *errors* whose causes cannot be identified. Only as our understanding of factors controlling wetland ecosystems improves can we ensure the restoration and maintenance of biodiversity.

## ACKNOWLEDGMENTS

Research on wetland restoration was funded in part by NOAA, National Sea Grant College Program, Department of Commerce, under grant number NA80AA-D-00120, project number R/CZ-51, through the California Sea Grant College Program, and in part by the California State Resources Agency.

## REFERENCES

Broome, S.W., E.D.Seneca, and W.W.Woodhouse, Jr. 1986. Long-term growth and development of transplants of the salt-marsh grass *Spartina alterniflora*. Estuaries 9:63–74.

California State Coastal Conservancy. 1982. Los Cerritos Wetlands: Alternative Wetland Restoration Plans Report. State of California—Resources Agency, State Coastal Conservancy, Oakland. 49 pp. +appendixes.

California State Coastal Conservancy. 1984. Staff Presentation for Public Hearing: Bolsa Chica Habitat Conservation Plan. State of California—Resources Agency, State Coastal Conservancy, Oakland. 31 pp. +exhibits.

California State Coastal Conservancy. 1986. Batiquitos Lagoon Enhancement Plan Draft. State of California—Resources Agency, State Coastal Conservancy, Oakland. 183 pp. +appendixes.

Ferren, W., Jr. 1985. Carpinteria Salt Marsh. Publication #4, Herbarium, University of California, Santa Barbara, Calif. 300 pp.

Homziak, J., M.S.Fonseca, and W.J.Kenworthy. 1982. Macrobenthic community structure in a transplanted eelgrass *(Zostera marina)* meadow. Mar. Ecol. Prog. Ser. 9:211–221.

U.S. Army Corps of Engineers. 1985. Public Notice of Application for Permit, Application No. 85–137-AA. U.S. Army Corps of Engineers, Los Angeles District. 13 pp.

Zedler, J.B. 1984. Salt Marsh Restoration: A Guidebook for Southern California. Report No. T-CSGCP-009. California Sea Grant, La Jolla, Calif. 46 pp.

Zedler, J.B. In press. Salt marsh restoration: Lessons from California. In J.Cairns, ed. Rehabilitating Damaged Ecosystems. CRC Press, Boca Raton, Fla.

Zedler, J.B., and M.Kentula. 1985. Wetland Research Plan. Corvallis Environmental Laboratory, U.S. Environmental Protection Agency, Corvallis, Oreg. 118 pp.

Zedler, J.B., and C.S.Nordby. 1986. The Ecology of Tijuana Estuary: An Estuarine Profile. U.S. Fish Wildl. Serv. Biol. Rep. 85(7.5). 104 pp.