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Adaptive Management of Coastal Ecosystems Designed to Support Endangered Species

Joy B. Zedler*

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INTRODUCTION

Federal policy mandates the mitigation of damage to wetlands caused by dredging and filling. When a particular project such as the widening of a freeway or the dredging of a flood control channel destroys the wetland habitat of endangered species, the wetlands must be restored or recreated. Success in restoring these species and their habitat can be measured by the creation of a self-sustaining ecosystem in which active management is no longer required to keep the population levels within the mitigation goals.

This is not an easy task, nor one for which "how-to" manuals exist. Ecosystems are not static; it is difficult to devise a mitigation plan that accounts for all contingencies. Hence, adaptive management approaches offer a way to inform regulatory oversight with ongoing scientific study. Through this more fluid approach to ecosystem

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management, damaged sites can be brought into compliance with mitigation criteria.

I

ADAPTIVE MANAGEMENT

Adaptive management is an attractive term with a wide range of meanings and applications. It has been most notably used in the past to describe the setting of catch quotas in fisheries management.¹ More recently, however, the term has taken on a broader meaning, describing the incorporation of scientific research into the management process to create a tool for ecosystem management.²

Under this approach, management needs to define which questions require scientific exploration, while data from the resulting experiments and monitoring programs are used to direct management action. Under this cooperative model of ecosystem management, managers and scientists interact regularly to exchange information. As it processes new data, the management team can adjust and update plans to reflect changed ecological conditions. The expected result is better management—specifically, the more rapid achievement of ecosystem management goals.

II

ADAPTIVE MANAGEMENT AND THE ENDANGERED
SPECIES ACT

Ecosystem management usually has very loosely defined goals, such as sustaining biodiversity in the longterm. Rarely must a habitat manager track populations or vegetation types to show that they meet specific standards each year. The exception, however, occurs in the mitigation arena, where damage to wetlands must be compensated to the extent that there is no net loss of wetland acreage and function. When endangered species are jeopardized, the Endangered Species Act (ESA)³ requires the establishment of mitigation agreements be-

1. See John M. Volkman & Willis E. McConnaha, *Through A Glass Darkly: Columbia River Salmon, The Endangered Species Act and Adaptive Management*, 23 ENVTL. L. 1249, 1255-56 (1993) (describing the evolution of adaptive management from its use in Fisheries management to set harvest levels, to being applied to salmon recovery in the Columbia River Basin).

2. See generally A. Dan Tarlock, *Environmental Law: Ethics or Science*, 7 DUKE ENVTL. L. & POL'Y F. 193, 205-06 (1996) (referring to a recent National Research Council-National Academy of Sciences study describing adaptive management as "involv[ing] a decision-making process based on trial, monitoring and feedback . . . [and] recogniz[ing] the imperfect knowledge of interdependencies existing within and among natural and social systems, which requires plans to be modified as technical knowledge improves. . . .").

3. 16 U.S.C. §§ 1531-1543 (1997).

tween regulators and mitigators, indicating what must be done to replace or compensate for lost habitat and ecosystem functions.

Specifically, under section 7(a)(2) of the ESA, federal agencies must consult with the Fish and Wildlife Service (FWS) to ensure that their actions are “not likely to jeopardize the continued existence of any endangered species . . . or result in the destruction or adverse modification of habitat.”⁴ If the FWS finds that a project would jeopardize endangered species or their habitat, it must issue an opinion specifying “reasonable and prudent alternatives” that would sufficiently mitigate the adverse effects of the project.⁵

It is here that the cooperative nature of adaptive management holds the most promise. In order for a regulatory agency such as the FWS to judge whether mitigators have achieved successful levels of compliance with mitigation criteria, the agency may look to scientific data for guidance. The following case study shows a unique collaboration between the FWS and scientists at the Pacific Estuarine Research Laboratory (PERL) to monitor tidal wetlands in San Diego Bay. These wetlands were created to compensate for the destruction of habitat of three endangered species.

III

THE SAN DIEGO BAY TIDAL WETLANDS PROJECT

In 1984, work began on three federal projects—the construction of a flood control channel in the flood plain of the Sweetwater River and the construction and improvements of certain interstate freeways⁶—that damaged wetlands at San Diego Bay and affected the habitat of certain endangered species. The California Department of Transportation (Caltrans) was in charge of the construction of the projects, with funding from the Army Corps of Engineers (the Corps) and the Federal Highway Administration (FHWA).⁷ The FWS issued an opinion establishing initial mitigation requirements, listing nine measures of compensation for the wetland habitats that had been destroyed or adversely modified by the projects.⁸

About five years after the initial mitigation criteria had been set, the Sierra Club and the League for Coastal Protection filed a complaint under the citizen suit provision of the ESA,⁹ claiming that the Corps was not following the FWS mitigation requirements.¹⁰ The

4. 16 U.S.C. § 1536(a)(2) (1997).

5. See 16 U.S.C. § 1536(b)(3)(A) (1997).

6. See *Sierra Club v. Marsh*, 816 F.2d 1376, 1378 (9th Cir. 1987).

7. See *id.*

8. See *id.* at 1379.

9. 16 U.S.C. § 1540(g) (1997).

10. See *Sierra Club*, 816 F.2d at 1381.

court held that the Corps had violated the ESA by "allowing destruction or adverse modification of [endangered species'] habitat without first ensuring the acquisition and preservation of the mitigation lands."¹¹ The court then granted an injunction halting work on the projects, ruling that the FWS could reinitiate the consultation process with the Corps.¹²

After the suit, the FWS established a more detailed set of mitigation criteria.¹³ The Agency determined that the projects jeopardized populations of three endangered species: the California least tern (*Sterna albifrons browni*, a migrant bird that nests near the three projects and that feeds on small fishes in shallow-water habitats), the salt marsh bird's-beak (*Cordylanthus maritimus* ssp. *maritimus*, a hemiparasitic annual plant that grows in the upper intertidal marsh), and the light-footed clapper rail (*Rallus longirostris levipes*, a year-round resident bird that nests in the lower intertidal marsh). The Agency also stipulated that about twenty-eight acres of wetland should be excavated from former dredge-spoil fill at the site and that the created wetlands should provide the following ecosystem functions (standards for assessing mitigation compliance are abbreviated here):

1. For the tern: Tidal channels with seventy-five percent of the fish species and seventy-five percent of the number of fishes found in natural channels for two years.
2. For the bird's-beak: A re-introduced population of at least five patches, each with at least twenty plants, increasing or stable for three years.
3. For the clapper rail: Seven home ranges, each at least two to four acres in size and each having tidal channels with forage species for rail feeding, high marsh as a high-tide refuge, and low marsh for nesting, with tall cordgrass (*Spartina foliosa*) that is self-sustaining for three years. Rail forage was to include seventy-five percent of the invertebrate species and seventy-five percent of the number of invertebrates found in natural channels for two years.

A significant aspect of these criteria was that the mitigation sites had to meet and sustain the FWS standards for more than one year.

In 1989, when the first mitigation site was four years old, Caltrans hired PERL to assess conditions under the mitigation standards. PERL began biological monitoring of ecosystem attributes that would

11. *Id.* at 1386.

12. *See id.* at 1389.

13. *See* U.S. Fish and Wildlife Service, Biological Opinion 1-1-78-F-14-R2, The Combined Sweetwater River Flood Control and Highway Project, San Diego County, California (1988); Letter from Wally Steucke, Acting Regional Director, U.S. Fish and Wildlife Service, Portland, Oregon to Colonel Tadahiko Ono, District Engineer, Los Angeles District, Army Corps of Engineers, (March 30, 1988) (on file with author).

allow the FWS to judge whether or not Caltrans and the Corps were meeting the mitigation requirements. Caltrans required PERL to submit annual written reports of findings. In addition, PERL met annually with the FWS, Caltrans, and the Corps to discuss the results of ecosystem monitoring and research, identify the standards that had been met, and clarify future tasks.¹⁴

IV ECOLOGICAL STUDIES

The main challenge facing the mitigators was the restoration of habitat for the three endangered species in a highly modified site. The mitigation site was in an urbanized area, sandwiched between freeway improvements, major power lines and an old rail-road track—not a pristine system. They achieved the following results.

A. Tern Forage

Fish use of the constructed channels rapidly met the standards for tern forage. In the first year, there were slightly fewer species than required by FWS, but there were enough individuals. In the next two years, there were enough species and individuals and the FWS judged the fish portion of the mitigation project to be in compliance with requirements. Still, we at PERL were concerned that the constructed channels might not function the same as the more complex tidal creek networks of natural wetlands.

B. Bird's-Beak Reintroduction

The reintroduction of bird's-beak was first attempted by seeding the species to a remnant of high marsh on one of the constructed-marsh islands. Plants grew and flowered, but few seed capsules were produced. Because the plant is an annual, it must grow from seed each year, so seed production is essential to long-term sustainability. We suspected that there might be an inadequate number of pollinators on the isolated island, because bees require upland habitats for nesting, and the constructed marsh islands were fully inundated by the highest tides. At the subsequent annual meeting, we raised the issue and recommended that future seeding trials take place in Sweetwater Marsh proper, a large natural marsh with adjacent upland. This was approved. Next, about eighty plots, each 0.25m² in area, were

14. Specifically, PERL scientists met annually with the Caltrans biologists, the FWS Representatives of both the Carlsbad Field Office and the Sweetwater Marsh National Wildlife Refuge, and with Corps representatives. Each year, data were presented on monitored attributes plus research studies generated by PERL with funding from the California Sea Grant Program.

sowed with bird's-beak seed collected at the nearest natural donor site, Tijuana Estuary. The five required "patches" each consisted of multiple seeded plots.

To test factors important for seed production, Lorraine Parsons experimentally demonstrated that hand-pollination and nitrogen addition could increase flowering and seed capsule set, offering managers tools with which to increase seed production.¹⁵ These were not implemented, however, as the population flourished for three years, and the reintroduction effort was judged in compliance in 1995. A strict reading of the standards might not have allowed compliance, because the five patches that were being monitored for compliance did not all increase in numbers for the full three-year period. However, because our field work went beyond the minimum requirement for monitoring, and because we were developing an understanding of factors controlling population growth, we recommended that the reintroduction be judged in compliance. We knew there were nearly 14,000 plants overall—well over the 100 required—and that high interannual variability in population density was normal. The FWS agreed with our recommendation.

C. Clapper Rail Habitat

Bringing the constructed salt marsh into compliance for clapper rail nesting habitat has proven more difficult. Early on, we recognized some shortcomings of the site. One of my graduate students compared the constructed site with a natural-marsh reference site in 1987 and showed that the excavated wetlands had coarser soils and less cordgrass cover than reference wetlands.¹⁶ We began to ask more questions about the site's ability to support cordgrass, and funding from California Sea Grant made possible a detailed analysis of the first mitigation site (about twelve acres, excavated in 1984 and planted to cordgrass in 1985), as well as experimental work in the second site (about seventeen acres, excavated in 1990 and planted to cordgrass in 1991). These studies showed clearly that coarse soils were unable to retain nitrogen, even when fertilized with various organic and inorganic amendments.¹⁷

15. See Lorraine S. Parsons & Joy B. Zedler, *Factors Affecting Reestablishment of an Endangered Annual Plant at a California Salt Marsh*, 7 *ECOLOGICAL APPLICATIONS* 253, 261 (1997).

16. See Kendra L. Swift, *Salt Marsh Restoration: Assessing A Southern California Example* (1988) (unpublished M.S. thesis, San Diego State University) (on file with the San Diego State University Library).

17. See R. Langis et al., *Nitrogen Assessments in a Constructed and a Natural Salt Marsh of San Diego Bay, California*, 1 *ECOLOGICAL APPLICATIONS* 40 (1991); Kevin D. Gibson et al., *Limited Response of Cordgrass (*Spartina foliosa*) to Soil Amendments in a Constructed Salt Marsh*, 4 *ECOLOGICAL APPLICATIONS* 757 (1994).

We also noticed problems with scale insects, which often coated the leaves of plants in the constructed marsh (but not the natural marshes). Subsequent field experiments showed that biweekly additions of nitrogen throughout the growing season could produce tall, robust cordgrass plants that resisted scale insects.¹⁸ Thus, we had a tool for actively managing the cordgrass vegetation, but no mechanism for making the tall cordgrass sustain itself.

At the 1995 annual meeting, when the older of the two mitigation marshes was in its eleventh year, the Corps expressed concern that the site had not yet met the mitigation standards, as ten years was the typical period for compliance. The San Diego Bay site still had to provide tall cordgrass for three years and to show that it was self-sustaining—not requiring fertilizers—to be in compliance. Because we had developed an adaptive management approach, we had accumulated sufficient understanding of the site's development to predict that the mitigation program was not likely to close in the near future.

We developed a list of reasons for the site's failure to produce adequate areas of tall cordgrass vegetation. For example, sedimentation occurred in some cordgrass patches during the 1993 and 1995 floods. In intertidal habitats, a few centimeters of elevation loss or gain affects the vegetation. We also discovered that plant species other than cordgrass are gaining an advantage where the topography has been elevated by sedimentation and also where nitrogen has been added.¹⁹ Furthermore, the younger marsh is experiencing chronic erosion and vegetation loss near its tidal mouth, while the inland end is accreting sediment and shifting to pickleweed, *Salicornia virginica*.²⁰ Little of the habitat remains suitable for robust cordgrass. Thus, at this writing, alternatives for satisfying the mitigation requirements are being considered.

V

RECOMMENDATIONS FOR SUCCESSFUL WETLANDS RESTORATION

Because the above problems are not easily corrected, we strongly recommend that future projects be designed to avoid them. It is clear

18. See Katharyn E. Boyer & Joy B. Zedler, *Damage to Cordgrass by Scale Insects in a Constructed Salt Marsh: Effects of Nitrogen Additions*, 19 ESTUARIES 1 (1996); Katharyn E. Boyer & Joy B. Zedler, *Effects of Nitrogen Additions on the Vertical Structure of a Constructed Cordgrass Marsh* (unpublished manuscript on file with author).

19. See Katharyn E. Boyer & Joy B. Zedler, *Nitrogen Addition Could Shift Species Composition in a Restored California Salt Marsh*, (May 1997) (unpublished manuscript on file with author).

20. See J. Haltiner et al., *Influence of Physical Processes on the Design, Functioning and Evolution of Restored Tidal Wetlands in California (USA)*, 4 WETLANDS ECOLOGY & MGMT. 73 (1997).

that marshes need fine-textured soil, and such substrates should be salvaged and reused in the restoration or creation project. But it is also critical to provide the proper topography. Associated research efforts suggest that habitat for cordgrass and clapper rails should include complex tidal creek networks, not just large channels or tidal basins.²¹ Because cordgrass grows tallest along creek edges, a design that includes many small tidal creeks should maximize chances of obtaining and sustaining suitable nesting habitat. In addition, such designs would improve interaction between marsh and channel organisms. Our recent studies indicate that marshes are important for the support of the fish food web,²² that channels of different morphology support different fish assemblages, and that the smallest tidal creeks have a unique function as nurseries for California killifish, *Fundulus parvipinnus*.²³ These are all good reasons to include complex tidal creek networks in constructed marshes.

VI

CONCLUSIONS ON THE EFFECTIVENESS OF ADAPTIVE MANAGEMENT

Adaptive management has allowed us to document the shortcomings of the site and to recommend alternatives for mitigation compliance. By incorporating science into the project, we helped the mitigators and regulatory staff in four ways: (1) determining which shortcomings of the site were probably responsible for its inability to achieve mitigation standards (the soil is too sandy and too low in nitrogen to support the tall canopies that characterize nesting habitats of natural marshes); (2) establishing corrective measures for improving the quality of potential nest sites (adding nitrogen-rich fertilizer biweekly throughout the growing season produces plants that are tall enough to meet standards); (3) determining that the vegetation could not meet the requirement of self-sustainability within a reasonable time frame (more than fifteen years from project construction); and (4) identifying alternative actions to terminate the mitigation program in year twelve (1997).

21. See Julie S. Desmond, *Species Composition and Size Structure of Fish Assemblages in Relation to Tidal Creek Size in Southern California Coastal Wetlands* (1996) (unpublished M.S. Thesis, San Diego State University) (on file with the San Diego State University Library) [hereinafter Desmond, *Species Composition*]; Julie S. Desmond et al., *The Influence of Tidal Creek Size on Fish Assemblages in Southern California Coastal Wetlands*, (Feb. 1997) (unpublished manuscript on file with author) [hereinafter Desmond, *Fish Assemblages*].

22. See Thomas J. Kwak & Joy B. Zedler, *Food Web Analysis of Southern California Coastal Wetlands Using Multiple Stable Isotopes*, 110 *OECOLOGIA* 262 (1997).

23. See Desmond, *Species Composition*, *supra* note 21; Desmond, *Fish Assemblages*, *supra* note 21.

The associated analyses of topographic complexity and food webs have led to improved designs for future restoration projects.²⁴ In addition, we recommend that experiments be built into future plans so that new methods and cause-effect relationships can be tested. Where knowledge is insufficient to specify exactly how to design and implement restoration and creation projects, we recommend copying the topography of nearby natural reference sites.

Ecosystem management is especially difficult where the landscape is highly modified, where specific objectives must be met, and where agencies must make open-ended commitments to monitoring and correcting problems. The San Diego Bay case required strong commitments from the mitigators, the regulatory staff, and the scientists, as well as the agencies who contributed research funding. Thus, it may serve as a model for successful ecosystem management under difficult conditions.

24. See Joy B. Zedler, Principal Author, *Tidal Wetland Restoration: A Scientific Perspective and Southern California Focus*, Publication No. T-038, California Sea Grant College System, University of California, La Jolla, California (1996).

